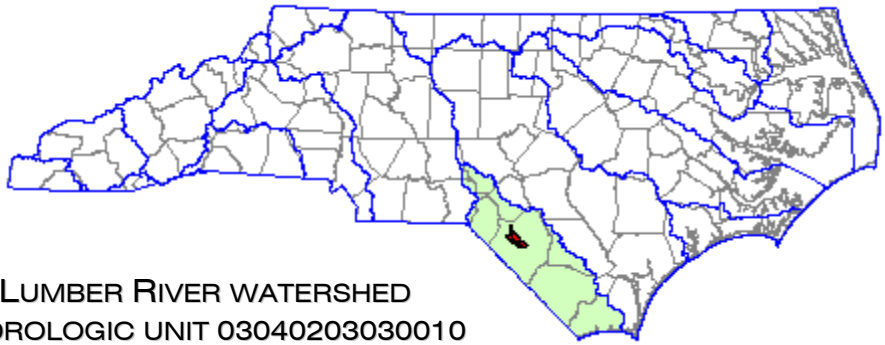
LUMBER RIVER TECHNICAL WATERSHED ASSESSMENT

INITIAL WATERSHED CHARACTERIZATION



LUMBER RIVER WATERSHED
HYDROLOGIC UNIT 03040203030010
BEAR SWAMP WATERSHED
HYDROLOGIC UNIT 03040203050010
ROBESON COUNTY, NORTH CAROLINA

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February 2004

TABLES

FIGURES

APPENDICES

1.0 PURPOSE AND SCOPE

The North Carolina Ecosystem Enhancement Program (EEP) has selected two hydrologic units (HU) within the Lumber River Basin of North Carolina for detailed technical watershed assessments. These two HUs are the Lumber River (HU 03040203030010) and the Bear Swamp (HU 03040203050010) (**Figure 1**). The purpose of this assessment is to characterize these two HUs, identify general problem areas related to ecological functions, determine how to address these problems, and develop a plan that includes specific solutions to the problems. The overall approach includes methods of watershed assessment that focus on ecological functions of the watershed. These watershed assessment methods will require flexibility in the overall approach of the watershed assessment as the project progresses, although the final product of a watershed management plan will remain the same. The watershed management plan will be produced in a format that can be used by government agencies in the formation of their own solution implementation plans.

This report covers the initial characterization of the two HUs and preliminary findings. It is a compilation of existing published data regarding land use, water quality, ecosystem functions, current management measures, and existing restoration and protection needs. Through visual observation of the HUs and analysis of the existing data, the current conditions and functional status of the HUs were defined. Limited interviews with local stakeholders and resource agencies were conducted in this phase of reporting. Sub-watersheds (SWs) of the HUs were identified and classified for future studies. Watershed management goals and potential functional improvement projects were also identified. Extensive field studies were not included in this phase of reporting.

The report is divided into six general sections. Section 2 provides the sources of data and analyses used in the watershed characterization. Section 3 describes the functional analysis approach to watershed assessment. Section 4 details existing conditions in the watersheds and introduces the data from which functional indicators were derived. Section 5 describes the analysis of the functions on a sub-watershed level using these indicators. Finally, Section 6 provides recommendations for further study and analysis.

2.0 RESOURCES AND METHODS

Characterization of these two HUs involved gathering and reviewing existing watershed information from local governments, stakeholders, and state agencies to develop an understanding of what is known regarding existing watershed conditions. The conditions include land use, water quality, habitat, and current management measures. A description of data collection techniques, information sources, and methods of analysis used in the characterization of the HUs follows.

2.1 DATA SOURCES AND TYPES

Existing Geographic Information Systems (GIS) data formed the basis for this technical watershed analysis. Detailed information on the data sources and how the data were used in this

report is included in **Appendix A**. Data sources used to populate the GIS were all in a digital format and the major ones are listed below.

- United States Geological Survey (USGS): Quadrangle maps and digital elevation models (DEMs).
  (*metadata location: http://rockyweb.cr.usgs.gov/elevation/dpi_dem.html*)
- North Carolina Ecosystem Enhancement Program (EEP), (formerly the Wetlands Restoration Program): Data layers included hydrography, hydrologic units, and soils.
  (*metadata location: http://www.cgia.state.nc.us/cgdb/datalist.html*)
- BasinPro Version 3.1, North Carolina Center for Geographic Information and Analysis (NCCGIA): Data layers included various subsets of topography, hydrography, managed lands, threatened and endangered species, and pollution sources.
  (*metadata location: http://www.cgia.state.nc.us/cgdb/datalist.html*).
- North Carolina Department of Transportation (NCDOT) GIS Unit: Data layers were limited to infrastructure, such as roads, county boundaries, etc.
  (*metadata location:*
  http://www.ncdot.org/planning/statewide/gis/DataDist/GISLayersMD.html)
- North Carolina Gap Analysis Program (NCGAP): Land use/land cover.
  (*further information: http://www.basic.ncsu.edu/ncgap.* 2003)
- Federal Emergency Management Agency (FEMA): Floodplains.
  (metadata location: http://www.msc.fema.gov/q3flooda.shtml)
- North Carolina Floodplain Mapping Program: Light Detection and Ranging (LIDAR) detailed topography information.
  (*further information: http://www.ncfloodmaps.com/pubdocs/#lidar*)

Other data, statistics, and descriptions found throughout this document were obtained mostly from publications posted on the World Wide Web by various federal, state, and local agencies. GIS databases, were updated with the most recent Web information available where appropriate(*e.g.*, discharge permits). These publications and all other data sources are listed in the bibliography in Section 7. The data sources and specific files mentioned within the text are not necessarily inclusive of all spatial data analyzed.

2.2 GIS PROCEDURES

2.2.1 Characterization and Watershed Analysis Procedures

Earth Tech compiled all existing data layers and data sets into a GIS using Environmental Systems Research Institute (ESRI) ARCGIS projected in North American Datum 1983 (NAD83), metric units. ESRI ArcView 8.3, and in some cases ArcINFO 8.3 and Spatial Analyst, were used to analyze GIS data. First, the Lumber River and Bear Swamp HUs were used to clip the majority of GIS layers analyzed, to reduce file size and processing time. After clipping, the customized data set was used to generate the following information.

To evaluate stewardship of lands within the Lumber River and Bear Swamp HUs, properties under state or federal protection as of March 2000 were identified within the study area using the BasinPro databases. Without parcel data, other protected lands (county, municipal, or private) could not be identified.

The soil data were acquired from NCCGIA, through EEP, and were published digitally in December 1998. The soil survey polygon coverage was used to distinguish and quantify soil types classified as Non-Hydric, Type A Hydric, or Type B Hydric. The definitions of these three soil classes are given in Section 3.3.2. Quantities and classifications of these three categories were used in the potential projects analysis as described in Section 2.2.3

Land use and land cover data were acquired from NCGAP. This data was derived from Landsat TM images collected from 1991 to 1993. The NCGAP raster data were converted to a polygon shapefile using ArcINFO. The data were then analyzed on a HU and SW basis to distinguish and quantify forested, cleared, wetlands, impervious cover, deciduous forest, evergreen forest, mixed forest, woody wetland, emergent herbaceous wetlands, cultural (residential urban and high and low-density urban), agricultural, and other community types. Polygon shapefiles were generated for each of the above mentioned community types. Each community type was produced by combining different land use/land cover types. This procedure is described in more detail in **Appendix A**).

The stream layer, dated April 2001, was acquired from NCCGIA through EEP in coverage format. It was converted to a line shapefile using ArcView 8.3. Next, the database was updated to include new attributes. The attribute field "DWQ_CLASS" was expanded to apply a DWQ Best Usage classification to all stream segments, because the existing dataset was not complete for ditches and intermittent streams. By definition, unclassified streams generally carry the same classification as their receiving streams. Next, the stream layer was analyzed on a HU and SW basis to distinguish and quantify ditches, perennial streams, intermittent streams, and major streams (Lumber River). For simplicity the "major" stream classification was combined with "perennial" when calculating stream lengths and other indicators described in Section 5.0. Line shapefiles were generated for the stream types listed above. The stream combination procedure is described in **Appendix A**.

Imperviousness of the watershed was determined using the roads and land use layers. The number of lanes for each road section was taken from the NCDOT GIS "universe" line shapefile for Robeson County, current as of June 2003. All roads are two lanes wide except for one location within Pembroke. West 3rd Street (NC 711) is three lanes, and North Odum Street (SR 1340) is four lanes. Two lane roads were assumed to be impervious for a width of 24 feet, three-lane for 36 feet, and four-lane for 48 feet. Buffers were created around all of these road centerlines to reflect these quantities. For example, the two lane roads were buffered for a distance of 12 feet on either side. The buffered roads were then combined with the impervious land use layer. The impervious land use layer is composed of Residential Urban (RU) (50% impervious), Urban Low-Intensity Developed (LI) (80% impervious), and Urban High-Intensity Developed and Transportation (HI) (80% impervious). These percentages were used to calculate the imperviousness of the watersheds with the following equation: ((roads area x 1) + (RU area x 0.5) + (LI area x 0.8) + (HI area x 0.8)).

The watershed was further characterized by mapping the pollution sources within the basin. This was accomplished by creating a point shapefile that identified NPDES permitted discharges. Permitted sources were derived from the BasinPro database (October 2000) and online NPDES

sources (current as of August 2003). In addition, water treatment plants, water wells, water tanks, sewage discharges, sewage treatment plants, sewage pumps (as of June 1998), and Clean Water Management Trust Fund (CWMTF) projects (June 2000) were all identified within the HUs using BasinPro databases.

The preceding procedures were used to generate the mapping for general watershed characterization. Procedures for more detailed analysis are described in the latter part of this document and in **Appendix A** (page A-4).

2.2.2 Sub-watershed Analysis Procedure

Analysis of the hydrology and topography on the USGS Quadrangles (ranging in dates from 1972 to 1982) and LIDAR data (2000) resulted in the delineation of eleven SWs of the hydrologic units ranging in size from 2.5 to 8.1 square miles. The Lumber River and Bear Swamp SW shapefile was created as described in **Appendix A** and used to clip GIS layers for individual calculations. The SW analysis procedure included summarization of existing data (*e.g.,* total area of Woody Wetland polygons) as well as more detailed spatial analysis used to describe the functional condition of the hydrologic units on a SW scale. Data is often reported in percentages, because the SWs vary significantly in size.

Summary calculations included total areas of various combinations of land cover and land use categories for each SW. The creation and quantification processes are described in **Appendix A** for forested, cleared, wetlands, impervious cover, deciduous forest, evergreen forest, mixed forest, woody wetland, emergent herbaceous wetlands, cultural, agricultural, and other community types. Other classifications included total stream length by type (ditches, perennial, intermittent) within a SW, and total length of stream of different DWQ Best Usage classifications within a SW.

The percentage of total stream length protected on both sides by at least a 50- or 300-foot forested buffer was determined for each SW.

Large, high-quality habitat patches and connecting corridors were identified using methods developed by the Division of Coastal Management (Stanfill *et al.* 1999). Briefly, a 300-foot buffer was subtracted from the edges of forested areas to account for edge habitat effects. Polygons with a remaining area greater than or equal to 74 acres inside the buffer were designated “interior patches”. Corridors connecting the interior patches that were 600 feet wide or greater and consisted of forest or mostly forest with minor inclusions of any community except “cultural” were identified. The number of patches, the total interior patch area, and the number of corridors to adjacent patches were determined for each SW. Details of these procedures are given in **Appendix A, page A-10**.

All of the SW values were summarized in a matrix and used to rank functional status. The ranking procedure is described in detail in Section 5.0.

2.2.3 Potential Project Analysis Procedure

Potential stream improvement projects were identified by intersecting the stream and cleared land coverages to obtain a data set of stream segments through cleared land. Potential wetland improvement projects were identified by intersecting the hydric soil and cleared land coverages to obtain a dataset of hydric soils on cleared land. More detail can be found for these procedures in the Lumber River Local Watershed Plan, Phase I, Mitigation Screening Analysis, Section 3, November 2003. Potential wetland improvement projects more than 10 acres in size identified in this manner totaled 126. There were nine potential stream improvement projects each more than 1,500 feet in length.

2.3 FIELD SURVEYS

The complete visual assessment of the HUs is recorded in .pdf format on a CD included with this report. An interactive map of the HUs with each observation point labeled may be found in the file titled "00-index.pdf". Acrobat Reader 5.1 or higher is needed to view this document file. Versions older than 5.1 may result in an error message about Java script and the Site Information files will not pop up automatically. If a newer version of Acrobat Reader is not available, the information may still be viewed by clicking on the individual .pdf for each site. From this map, all completed field forms and photos may be accessed. Blank field forms are also included in **Appendix B.**

Field assessments of each stream crossing were performed throughout the two hydrologic units. The crossings were located and labeled using the GIS developed for the two HUs. The naming convention was set to include the HU number (03 or 05) followed by a site number. A total of 163 sites were located and labeled. The crossings included state roads, county roads, drainage district access roads, and private driveways. Field assessment forms were then developed to assess the condition of the sites. A biologist developed the form to evaluate the riparian buffer from top of bank to the first change in cover type and also the adjacent land use ("Beyond" on the form). A stream morphologist developed the form to evaluate the stream from bed to top of bank. Detailed measurements were beyond the scope of this study. All values are based on visual estimates.

General site information includes the site identification number, stream name, state road number or name, date and time of the observations, and the observers' names. This section also contains general notes on special site conditions and restoration potential.

Channel classification evaluates the overall state of the channel. The valley type, stream type, and potential restored stream type are included. The bankfull width, bankfull depth, width-to-depth ratio, low bank height, and bank height ratio are included in this section. The succession state of the stream channel is also included. The succession state indicates whether the channel is stable, developing instability, or developing stability.

Bed condition evaluates the state of the stream bed. The values include bed material size, the diversity of the bed material of the stream, and the presence of debris. These values indicate whether the stream is being overwhelmed by bank erosion and the presence of bed habitat.

Bank condition evaluates the state of the stream bank. The values include bank material size, vegetative cover, bank erosion potential, toe habitat, and the presence of debris.

The buffer and adjacent land use observations were limited to what was visible from a public right-of-way. Judgments about the presence of hydric soils were based on the ability to observe either standing water or hydrophytic vegetation. No soil samples were examined.

Potential degradation issues were identified based on these field observations, and several assumptions and limitations apply. Again, all judgments as to suitability for improvements were made from a public right-of-way or by viewing aerial photography. The streams were not walked to verify the length of potential improvement and soils were not examined to estimate areas for wetland restoration. No parcel data were examined to determine the number of landowners, and no landowners were contacted or encountered during the observations. It was generally assumed that restoring the historic hydrologic regime of this area would not be feasible, although the majority of the two HUs is prior converted wetland. Most stream restoration was assumed to be Priority II.

Brief descriptions of the sites identified as potential watershed improvement projects are included in **Appendix B**. A map of the HUs showing the location and type of each potential project is shown on **Figures B-1, a** through **c.** An aerial photograph of each potential project with approximate project lengths or areas is shown on **Figures B-2, a** through **t.**

2.4 INTERVIEWS

Extensive interviews were not required in the scope of this phase of the watershed assessment. However, a preliminary list of contacts is provided in **Appendix C**.

2.5 LITERATURE REVIEW

Existing literature was reviewed to aid in the development of the characterization report and the watershed management plan. The World Wide Web, books, and documents were reviewed for information on watershed functions, assessment techniques, best management practices, and current and past activities within the watershed. The information obtained is used throughout the report and will be used in the development of the watershed management plan.

3.0 WATERSHED FUNCTIONS

Addressing ecological impacts in terms of functional losses and replacements on a watershed level is a new approach to watershed planning and implementation in North Carolina since the formation of the EEP in 2003. Watershed functional analysis specific to the ecology of North Carolina is still being developed and no definitive methodology for the approach has been adopted. The approach used in this report is based on preliminary guidance provided to EEP by technical committees charged with developing the functional analysis methodology.

This report addresses three main watershed functions and, to the extent possible with the available data, a number of sub-functions. The three main functions are as follows:

- **Water quality** - the relative levels of chemicals and substances in the water and the ability of the water to support life.
- **Hydrology** - the study of the occurrence, distribution, and movement of water. Hydrology is a function, which also can affect other watershed functions including water quality and habitat. The hydrologic functions of a watershed include both surface water and groundwater interactions.
- **Habitat** - all of the physical, biological, and chemical characteristics necessary to maintain an organism's viability. For purposes of this report, indicators are limited to a few spatial, structural, or qualitative characteristics of terrestrial and aquatic communities that directly or as surrogates describe some of the physical, biological, and chemical characteristics that influence the ability of the watershed to support typical Coastal Plain aquatic and terrestrial animal communities.

Following a well-established model for wetland functional assessment, watershed functions ideally would be evaluated relative to standards defined from a population of least-altered, self-maintaining watersheds in the same region (Smith *et al*. 1995, Rheinhardt *et al*. 1997). These standards would be derived from field indicators that can distinguish anthropogenic alterations. Thus, by differentiating natural variation from variation due to degradation, indices that reflect the relative degree of degradation could be developed to evaluate watershed condition or degree of function. To evaluate gains and losses of watershed function, simple logic models would be developed that represent the most common and fundamental functions.

As noted above, these logic models have not been developed yet for watershed analysis in North Carolina. In **Table 1** below, sub-functions and several suggested indicators of function are listed for each major watershed function, but the actual analysis in Section 5.0 was limited to data currently available in GIS or other databases. The analysis relied on a simple ranking system rather than calculated models indexed to a reference system. The HUs were partitioned into sub-watersheds that were ranked relative to each other, rather than to a standardized reference watershed. The ranking procedures and results are provided in Section 5.0.

Table 1. Watershed Functions and Indicators

Primary Function	Sub-Function	Indicator	*Description*
Water Quality	Elemental Cycling and Spiraling	Living biomass Detrital biomass Hydrologic alterations	Abiotic and biotic processes that convert elements from one form to another within the watershed. These processes include nutrient and elemental cycling, biogeochemical transformation, and export of dissolved organic constituents. Plants, water, and soil microbes drive these processes.
	Removal and Transport	Presence of stream buffers Presence of ponds Channel sinuosity Channel incision	Removal and transport of nutrients, contaminants, sediment, and other elements or compounds from surface waters. Plants, water, soil microbes, and stream morphology drive these processes.
	Retention	Soil surface texture Sub-soil texture Soil organic matter Stream buffers Wetland cover	The ability of the watershed to retain nutrients, contaminants, sediment, and other elements or compounds that are moving towards surface waters. Nutrients, contaminants, and other elements may be physically filtered from the system by binding to fine-textured clayey soils. Plants may also filter these substances as well as sediment.
	Thermal Regulation	Shading of channel Forested buffer	Absorption, storage, and dissipation of thermal energy. Temperature and thermal energy regulate the rate at which abiotic and biotic processes occur. Vertebrate and invertebrate aquatic community composition varies according to the water temperature and the amount of solar irradiation reaching the surface water body.
Hydrology	Sub-surface water storage	Presence of certain geologic formations Soil type Climate Abundance of perennial streams and springs	Availability of water storage beneath the surface. This ability is driven by geologic formations, soil type, and climate. This sub-function is difficult to predict without detailed geologic maps or extensive well data. Abundance of perennial streams and springs may be a surrogate measure.
	Moderation of groundwater flow or discharge	Slope Land cover type Stream buffers	Capacity of a watershed to control the rate of groundwater flow from upgradient sources. This presumably refers to headwater perennial streams and springs.
	Surface Water Flow or Discharge	Channel sinuosity Channel incision Land cover type Available floodplain	Capacity of a watershed to moderate surface water flow and energy from upgradient sources. This is related to the ability of higher-order streams to handle surface runoff and receive waters discharged by tributaries.
	Dynamic surface water storage	Soil permeability Floodplain width Floodplain land cover Presence of wetlands	Capacity of a watershed to detain and absorb moving water from overbank flow for a short duration when flow is out of channel. This may also include overland flow from overbank and upland surface water inputs.
	Long-term surface water storage	Microtopographic features Ponds or lakes Forest cover Soil organic matter Soil permeability	Capacity of a watershed to temporarily store (retain) surface water for long durations. It is associated with standing water not moving over the surface. Water sources may be overbank flow, overland flow, channelized flow from uplands, or direct precipitation. Water may be stored in microtopographic depressions and ponds, taken up by vegetation through evapotranspirative processes, or held in the soil.

Table 1 continued

Primary Function	Sub-Function	Indicator	Description
Habitat	Maintain Characteristic Plant Distribution and Abundance	Forested cover Presence of wetlands Presence of exotic invasive vegetation Number of natural community types	The sub-function of maintaining a characteristic plant distribution and abundance is difficult to define with no reference watershed. It is assumed that habitat function is enhanced by the presence of natural community cover and diverse, mature, and undisturbed plant communities.
	Maintain Characteristic Animal Distribution and Abundance	Trapping, point counts, or other surveys Forested cover Forested patch size Corridors between patches Number of terrestrial and aquatic community types Pools, rootwads, undercut banks, *etc*. for fish cover Rocks, leafpacks, *etc*. for benthos colonization Variety of pools Well-defined riffle-pool sequence Prevalence of nuisance predation Presence of habitat specialists Availability of water	Ability of the watershed to sustain viable, diverse terrestrial and aquatic wildlife communities characteristic of the region. Assumptions are that more diverse natural cover types will result in more diverse communities, large patches of natural cover with many connections to other patches and to water sources are preferable, patches large enough to overcome edge effects are preferable, stable, well-shaded streams are preferable; and structurally complex habitats (*e.g.,* self-sustaining, mixed-age forest stands and stable streams with a defined riffle-pool sequence and a variety of cover for aquatic species) are preferable.
	Physical Habitat Characteristics	Stand age Number of terrestrial and aquatic community types Contiguity of communities	Ability of the watershed to maintain interspersion, connectivity, temporal dynamics and spatial structure of the physical habitat. It suggests a stable, self-sustaining landscape with minimal disturbance. The assumptions and indicators for plant and animal functions listed above also apply to this function.

4.0 WATERSHED DESCRIPTION

This section provides an overview of the Lumber River and Bear Swamp HUs and the surrounding area. Subsections present the watershed's history, socioeconomic conditions and descriptions of the existing physical, biological, and water quality conditions. The topics chosen for inclusion all affect or explain, directly or indirectly, the functional status of the watershed.

4.1 GENERAL HISTORY

Robeson County, named after Revolutionary War hero Colonel Thomas Robeson, was formed in 1787 from Bladen County in southeastern North Carolina. Lumberton, the county seat, was founded sometime prior to 1788 on portions of land then known as Drowning Creek (of which a large portion has now been renamed as the Lumber River) in an area predominantly inhabited by local Lumbee Native American tribes. The area was settled by Scottish settlers, and as a result has a rich Scottish Highland tradition. The nearby town of Pembroke serves as the focal point of the Lumbee Tribe, with 83% of its approximately 2,500 current residents being classified as American Indians in the 2000 census.

Pembroke, the largest town in the HU area, has a rich history as well. Founded in 1895, the town was named in honor of Pembroke Jones, a prominent railroad official, and has served as the focal center of the Lumbee Tribe since its establishment. Pembroke is also the home to the University of North Carolina at Pembroke, which originally was called the Croatan Indian Normal School. It was founded in 1887 to serve the local Lumbee Indian community. From UNC–Pembroke's accreditation in 1923 until 1953, it was the only state funded four-year college for Indians in the nation.

The Lumbee Indians have been a key factor in shaping what is today the Pembroke area of Robeson County. The first documentation of the presence of Native Americans in the area was in 1725 on the Herbert Map, which indicated the presence of the Wacoma tribe in the area of Drowning Creek (Lumber River). It is reasonable to assume that this tribe resided throughout what is today Robeson County. In 1753, Governor Matthew Rowan of North Carolina declared the Drowning Creek area to be "a frontier to Indians", reserving the region for the current Lumbee inhabitants. In 1754, a settlement of 50 families was reported as residing on Drowning Creek. In 1835 the North Carolina state government amended the state constitution, revoking the Lumbee's rights to the land. Although emancipated at the end of the Civil War, the Lumbee Indians were not a federally recognized tribe, and as such received no aid or benefits. Though they were the primary residents of the Pembroke area, and recognized by the state government, it was not until 1956 that the Lumbee Act was passed by congress, fully recognizing the Lumbee Indians as a tribe, but withholding financial benefits. These actions probably contributed to the extreme poverty and poor economy of the area today (Lumbee Tribe of North Carolina 2004).

4.2 SOCIOECONOMIC CHARACTERISTICS

The HUs in this study are wholly contained within Robeson County, so the statistics for the entire county will be used. Statistics for the individual HUs are not readily available.

4.2.1 Population

The population of Robeson County has grown over the last decade, with a net increase of 17 percent (NC Department of Commerce 2003). The population in 2001 was 127,320, making Robeson County the 21st largest county by population in the state of North Carolina. The population density for the county is 134 people per square mile, a figure that has grown continuously since 1970, when the density was 89 persons per square mile (NC State Office of Budget, Planning and Management 2002). The municipal population percentage is 30 percent, which is 20 percent lower than the state average. Robeson County's population is projected to grow 14.3 percent by 2010, with a projected population of 140,932.

Pembroke, the only municipality in the watershed, has a population of 2,399 in 2000 (City-Data.com 2003). About 83 percent of the population is Lumbee Indian. The remainder is white (9.4 percent), black (5.3 percent), and Hispanic (1.1 percent) (City-Data.com 2003).

4.2.2 Economic Activities

The per capita income recorded in 2000 was $17,473, making it rank 97th in the state (out of 100 counties). As of March 2002, the unemployment rate was 12.2 percent, up from the previous year and more than four times the state average, making it one of the highest in the state. The high unemployment rate is primarily due to the poor education of the area's residents, with only 30.7 percent of the residents having a high school education. Approximately 20 percent of the residents live below the poverty line, and over 25 percent of the residents are receiving support of some kind from the government. Those who are employed work primarily in the service (22 percent), manufacturing (21.9 percent), government (20.4 percent), or retail sectors (19.5 percent) (Ashraf 2003).

The two largest manufacturers in the region are Mountaire Farms, Inc., a poultry slaughtering and processing plant, and Campbell Soup Company, which runs a cannery in Robeson County as well. Mountaire Farms employs about 1,500 people, and the cannery employs about 800. Other manufacturers in the area include Kayser-Roth Corporation (hosiery), Elkay Southern Corporation (enameled iron and metal sanitary ware) and Outer Banks (hosiery). Textile production in Robeson County has suffered due to cheaper production costs overseas. One local businessman noted that he had cut his labor force from 800 to 320 at his Lumberton factory because of foreign competition.

According to census data, 0.9 percent (344 people) of Robeson County's population is employed in agriculture. However, NC Department of Agriculture and Consumer Services Agricultural Statistics Division (NCDA) list 1,004 farms in the county (NCDA 2003). Total farm acreage is 285,186 acres with the average farm size 284 acres (2003). The primary crops are tobacco,

cotton, soybeans, corn, and wheat. Cash receipts from crops in 2001 totaled over $77 million (NCAGR 2003).

Livestock is also an important part of the Robeson County economy. Hogs, chickens (broilers), and turkeys are the primary livestock raised. Cash receipts from livestock in 2001 totaled over $113 million (NAGR 2003).

4.2.3 Land Planning and Management

Robeson County has two main protection practices in place. The first is an Open Space (O-S) zoning district. In this district, the land is primarily reserved for flood control, future thoroughfares, public recreation, and any other application that would allow for an open, unobstructed space. The intentions of this district are to encourage the preservation of the land and to promote continued conservation and prevent development. Only the County Commissioners of Robeson County have rights to approve uses for this area.

The second practice in place is a Water Supply Watershed Protection Ordinance, which contains a Watershed Protection Plan. This plan, which encompasses all of Robeson County, sets up a series of provisions and requirements for development within the watershed, which are described below. The lower three-quarters of each HU (the area east of Pembroke) fall within a protected WS-IV water supply watershed.

Subdivision Requirements - Subdivisions have a required lot size as well as a stormwater management plan. This plan must include best management practices to prevent impacts to water quality. If the subdivision is located within the water supply watershed, or within a WS-IV watershed (discussed in Section 4.5.1), an erosion and sediment control plan must also be included. Roads must also avoid watershed buffer areas, and if they do enter a buffer, the impact must be minimized to the greatest extent possible. Lots may not be smaller than half an acre (except for cluster developments), and if there is curb and gutter, no more than 36 percent of the land may be built upon.

Buffers - A minimum of 100 feet of vegetative cover (from streams or water bodies) is required for all projects that are constructed after 1997 in areas with a medium population density or greater. A 30-foot buffer is required for all perennial streams shown on the most current USGS topographical maps. No development is allowed within these buffers except for water dependant structures, public utilities, and roads.

Watershed Protection Permit - A Watershed Protection Permit is required for construction or alteration of a structure within the water supply watershed. Single-family homes that were built before 1997 are exempt. Permits are issued by a Watershed Administrator. The current administrator is Ms. Michelle Frizzell, a title held in conjunction with her job as Planning and Zoning Coordinator. By her estimate, less than 100 Watershed Protection Permits are issued annually.

The Watershed Protection Occupancy Permit is a co-requisite of the Watershed Protection Permit if the structure being built or modified has the intended use of habitation. This permit

must be issued before anyone can live in the structure, and the permit must be issued within 10 days of the completion of the project. The Watershed Administrator is also responsible for the issuing and enforcement of this permit.

The enforcement of this protection act is carried out by the Watershed Administrator. This person is responsible for the issuing of the above described permits as well as general oversight duties. The administrator is in charge of protection of wetlands as well and it is the responsibility of the administrator to bring any situation that might threaten wetlands or endanger water quality to the attention of the overseeing body.

The overseeing body of the protection act is the Robeson County Planning Board, which also serves as the Watershed Review Board. The review board has the power to overturn any ruling by the Administrator if it is determined that there is sufficient hardship to the appealing party. A variance can be granted if the appeal is found to have merit by the board. (Robeson County Board of Commissioners 1988)

Drainage Districts

The Moss Neck drainage district, shown on **Figure 2,** is the only drainage district within the HUs of this study. This drainage district, also referred to as Drainage District Number Two, was founded in the early 1920's as a means to lower the water table of the surrounding farmland. With the water table lowered, a greater variety of crops could be grown in the area. Soon after its founding, however, it fell into disrepair due to Great Depression era economic problems. Silt filled the channels and vegetation grew down into the trenches, rendering the district unfit for its intended purpose. It was not until the late 1970's that the district was reorganized and repaired. The channels were re-dug, the ditches were cleared and mowed, and annual maintenance surveys established.

Since then, there has been regular upkeep on the drainage district. The grass is regularly mowed and vegetation is removed from the channel. Annual maintenance surveys verify that no large debris or landslides have blocked the regular flow of water, and if blockages are found, they are also removed and disposed.

North Carolina Department of Transportation Improvement Program (TIP)

There are three TIP projects related to the study area. Two minor ones occur within the Bear Swamp HU. A 3-mile long widening project (U-3451) is planned from Third Street to NC 710 in Pembroke. The project will impact primarily agricultural lands. The other project is a bridge replacement (B-3367) on SR 1339 over Bear Swamp, which is likely to have some minor wetland impacts.

The Maxton Bypass (R-513) is outside the study area to the southwest, but mitigation for impacts may come from projects identified within the Lumber River and Bear Swamp study areas. The planned four-lane divided facility is 19.9 miles long from Maxton to NC 41. Based on the current alignment consisting of a corridor 144 feet wide (4 lanes plus median and shoulders), potential impacts to existing wetland areas as mapped by NCGAP are estimated to be 37 acres.

According to the mapping, a variety of wetland types could be affected, including seepage and streamhead swamps, floodplain forests, bottomland forests, pocosins, wet flats, and freshwater emergent marshes. The majority of wetland impacts are predicted to be to pocosin woodlands and shrublands. Pocosins are valued for high groundwater recharge and runoff storage capacity, filtration and purification of nutrient-laden water through the deep organic soils, and dense forest cover provided to large mammals such as bear and bobcat.

4.3 PHYSICAL CHARACTERISTICS

Robeson County is in the southeastern Sandhills and Coastal Plain of North Carolina in the coastal region of the state. It has a warm climate with hot summers and mild winters.

4.3.1 Geology and Topography

Both of the HUs are located in the Coastal Plain Physiographic Province. They are underlain by two main geologic groups. The first of these is the Yorktown and Duplin Formations (undivided). The Yorktown Formation is composed of rocks formed from fossiliferous clay and sand, while the Duplin Formation is formed from shelly sand, sandy marl and limestone. The second geologic group is the Black Creek Formation, which is composed of lignitic sand and clay (NCGS 1991).

Topographic information was obtained from LIDAR data produced by the Division of Emergency Management and made available through EEP. **Figure 3a** shows the contour lines. **Figure 3b** is a digital elevation model shown in hillshade mode. The sand rims of the distinctive Carolina bays are shown to be the only features with topographic relief in an otherwise flat landscape. The elevation in the HUs ranges from 140 feet to 200 feet above sea level, for an average channel slope of less than 0.001 percent over the 15-mile long study area.

4.3.2 Soils

Soil information was obtained from the Soil Survey of Robeson County, published by the Natural Resource Conservation Service (formerly the US Department of Agriculture, Soil Conservation Service) in 1978. The soil coverage in BasinPro was used for analysis in this report. An official list of hydric soils for Robeson County was obtained from the local NRCS agent. Detailed descriptions of map units were obtained from the Soil Survey. The majority of soils in the HUs are nearly level to sloping. Generally the well-drained soils occupy broad outer rims of the inter-stream divides next to the drainageways, and the more poorly drained, nearly level soils are father from the drainageways, on the floodplains of streams, and in Carolina bays. Textures range from loams to sand. See **Figure 4** for a complete list of soil map units in the HUs.

Hydric soils make up a large percentage (over 60 percent) of the HUs. See **Table 2** below. Hydric soils are one indicator of the potential presence (current or historic) of wetlands. Important functions of wetlands in watersheds include filtration of sediment, retention of nutrients and other pollutants, and storage of floodwaters. Large intact wetland areas are primarily found within the floodplain of the Lumber River and Bear Swamp. Much of the hydric

soils in the broad interstream divides have been ditched and drained for agriculture. Group A soils are map units that are all hydric or have hydric soils as a major component. In the Lumber River and Bear Swamp watersheds, these include the following soils:

- **Bibb**
- **Byars**
- **Coxville**
- **Johnston**
- **Leon**
- **Lumbee**
- **McColl**
- **Pantego**
- **Plummer**
- **Portsmouth**
- **Rains**
- **Rutledge**
- **Torhunta**

The Johnston and Bibb soils can be found adjacent to the major streams and rivers while the smaller streams are bordered by Lumbee soils. The Rains soils are the predominant hydric soil found in the interstream divides.

Group B soils are map units with inclusions of hydric soils or with wet spots. These include the following soils:

- **Dunbar sandy loam** (hydric inclusions include Coxville and Rains)
- **Johns sandy loam** (hydric inclusion is Lumbee)
- **Lynchburg sandy loam** (hydric inclusion is Rains)

Table 2. Hydric Soils in Lumber River and Bear Swamp Watershed

Soil Type	Lumber River Watershed Area (acres)	Percentage of Watershed Area	Bear Swamp Watershed Area (acres)	Percentage of Watershed Area
Non-Hydric	3975.0	32.1	8569.5	40.9
Hydric Group A	5965.4	48.2	9912.5	47.3
Hydric Group B	2432.3	19.7	2491.4	11.9
Total	12372.7		20973.4	

4.3.3 Land Cover

Land cover and land use in the HUs are shown on **Figure 5**. The percentage of each cover type is summarized in **Table 3** below. Although a variety of natural community types are mapped, the examples seen in the field are mostly disturbed remnants of a once-vast forested wetland complex that covered the HUs. Approximately two-thirds of the combined HUs is now cleared and drained agricultural land with marginal or absent stream buffers. Forested cover is limited mainly to swamp-bottomland complexes along the Lumber River and Bear Swamp. A few isolated forested stands of pines and/or hardwoods also remain. The plant community component

of land cover is described further in Section 3.4. The Town of Pembroke occupies a small area with low-and high-intensity residential and commercial development.

Land cover is integral to watershed function. It can be used as an indicator of several major functions, including water quality (filtration and retention of compounds and particulates, biogeochemical cycling), hydrology (storage, evapotranspiration, attenuation of flow velocities), and habitat (patch size, corridors, biodiversity). Cover types with some impervious surface included occupy 1,240 acres (3.7 percent) of the HUs. These cover types are listed under the "Cultural" category.

Table 3. Land Use and Land Cover

Cover Type	Lumber River (Acres)	Percentage	Bear Swamp (Acres)	Percentage
Natural	**4041**	**32.7**	**5977**	**28.0**
Deciduous Forest	92	0.7	612	2.9
Evergreen Forest	440	3.6	613	2.9
Mixed Forest	925	7.5	1271	6.0
Woody Wetlands	2516	20.3	2970	13.9
Emergent Herbaceous Wetlands	68	0.5	511	2.4
Cultural	**484**	**3.9**	**756**	**3.5**
Residential Urban	287	2.3	462	2.2
Urban Low-Intensity Developed	61	0.5	133	0.6
Urban High-Intensity Developed and Transportation Corridors	136	1.1	161	0.8
Agricultural	**7548**	**61.0**	**14522**	**68.1**
Agricultural Crop Fields	6,010	48.6	11771	55.2
Agricultural Pasture/Hay and Natural Herbaceous	1,097	8.9	1914	9.0
Coniferous Cultivated Plantation (natural/planted)	441	3.6	837	3.9
Other	**299**	**2.4**	**78**	**0.4**
Open Water	250	2.0	45	0.2
Barren; bare rock and sand	49	0.4	33	0.2
Total Watershed Area	**12,372**		**21,333**	

4.3.4 Surface Waters

One named perennial stream (Mill Branch) and numerous tributaries and ditches drain to the Lumber River within the study area HU. The segment of the Lumber River extending from SR 1412 in Scotland County downstream to the North Carolina/South Carolina state line was added to the North Carolina Natural and Scenic River System in 1989. Rivers in the system may be classifed as *natural*, *scenic*, and *recreational*. The segment of the Lumber River within the study area HU is classified as *scenic*, which is defined as largely primitive, undeveloped, and free of impoundments, but accessible by roads. Segments of the Lumber River above and below the

study area HU are also designated as National Wild and Scenic River. The HU is excluded because of lack of adequate state and/or local protection as required by Section 2(a)(ii) of the Wild and Scenic Rivers Act (National Park Service 2002).

Bear Swamp receives five named streams and numerous tributaries and ditches (**Figure 6**). **Table 4** summarizes the total mapped length of streams and ditches, including the Lumber River and Bear Swamp, in each of the HUs. No fieldwork has been done to identify unmapped streams, verify actual intermittent and perennial lengths, or distinguish between streams and ditches.

The two HUs appeared very similar. From field observations, the drainages appear to be Rosgen Stream Types C, DA, E, F, and G. The majority of the streams have been channelized, creating G-type and F-type channels. G-type channels are gullies that are deeper than necessary to carry the expected volumes of water and sediment load. F-type channels are wider than necessary, creating very shallow water depths. Although these two stream types usually have very different characteristics, they appear very similar in these HUs. Bank erosion that is normally associated with these two stream types is not present. This is a result of low stream power and highly vegetated surfaces. Stagnant water was observed in at least one location. The characteristic that was the most consistent was the bed profile. There was little if any profile diversity. There were no distinct differences between riffles and pools. Headwater streams looked no different from streams at the lower ends of the HUs, except for the main swamp waters.

The HUs have been extensively ditched for many years to facilitate farming in low-lying areas. Many of the ditches were observed to be functioning as perennial streams and may support characteristic aquatic and benthic communities.

Table 4. Surface Waters

	Lumber River	Bear Swamp
Perennial Streams	171,965	154,094
Intermittent Streams	126,502	191,762
Ditches	117,421	75,720
Total (feet)	415,888	421,585
Ponds/Lakes (acres)	23.0	23.5

4.3.5 Transportation Infrastructure

The transportation infrastructure is shown on **Figure 7**. A network of secondary roads can be found throughout the HUs. There is no obvious pattern to these roads. Many of them parallel the major streams but there are also numerous stream crossings. US Highway 74 forms the approximate southern boundary of the Lumber River HU. NC 710 is the only other state highway present in the watershed. There are 273 miles of primary and secondary roads that contribute to 799 acres of impervious surface. Construction of these roads and their associated roadside ditches has in many locations, altered the natural flow patterns of the watershed.

Because of the flatness of the land surface the roads often create small sub-watershed boundaries.

4.4 BIOTIC CHARACTERISTICS

4.4.1 Plant Communities

For purposes of this report, all plant community descriptions were taken from published mapping and reports by various agencies. No fieldwork has been conducted to verify map units, which mostly describe mature or undisturbed conditions. Variations in stand age, level of disturbance, understory composition, or other factors were not verified for this report and may be undetectable at the scale of available mapping.

The map units used on the land cover map (**Figure 5**) are from the North Carolina Gap Analysis Project (NCGAP) (McKerrow *et al.,* in preparation). The tables below list the categories of cover mapped in the HUs and also used for description and analysis in this report. The descriptions were taken from draft information provided by NCGAP, which is producing a highly detailed land cover map of North Carolina that is currently being assessed for accuracy to the extent practicable through ground-truthing and expert review. The detailed NCGAP map units were cross-referenced to the broader National Land Cover Database (NLCD) map units (Vogelmann *et al.* 2001) that are used on USGS land cover mapping. They were also cross-referenced to the National Vegetation Classification (NVC) (Natureserve 2003) and to the familiar North Carolina Natural Heritage Program (NCNHP) community types (Schafale and Weakley 1990). A table in **Appendix D** gives the complete cross-referencing for the map units present in the HUs. In addition, the corresponding narrative community descriptions from the NVC are provided following the table (based on Earth Tech's best professional judgment). These narratives describe the typical dominant species composition of the community, along with hydrology, landscape position, and soil type when possible. In lieu of field surveys, these community descriptions can be valuable for assessing habitat functions of the watershed and for predicting associated wildlife communities and potential habitat for threatened and endangered species.

As noted in Section 3.3.3 above, natural communities in the HUs are limited to the swamp-bottomland complexes along the Lumber River and Bear Swamp and a few isolated forested pine and/or hardwood stands. They are listed in **Table 5** below. The swamp-bottomland complexes exist in various degrees of quality in terms of disturbance and diversity. Several recent clearcuts were observed within these complexes. Of the isolated stands, three are considered Natural Heritage Areas. The forested buffers that occur along the smaller drainages fall into the Successional Deciduous Forest category. These buffers are generally not wider than 50 feet, they are frequently disturbed, and low in diversity.

Carolina bays, interstream wetlands characterized by their ovoid shape and deep organic soils, were once a distinctive feature of the landscape in these HUs. Almost all have been cleared and drained for agriculture or pine plantations and are only apparent now on detailed topographic or soil mapping. Ovals of dark organic soils are often visible on aerial photography of agricultural fields. See **Figures 3B** and **4**.

Table 5. General Natural Cover Descriptions

NCGAP Map Unit Name	Description
Deciduous Forest	
Successional Deciduous Forests	Regenerating deciduous trees with a shrub stature. Commonly dominated by sweetgum, tulip poplars and maples.
Coastal Plain Mesic Hardwood Forests	Beech dominated forests with white oak and northern red oak as possible co-dominants. Dry-mesic to mesic forests on slopes and small stream bottoms in the coastal plain.
Coastal Plain Dry to Dry-Mesic Oak Forests	Oak dominated forests of the coastal plain. Includes white oak forests with water oak or northern red oak and hickories as co-dominants.
Evergreen Forest	
Coniferous Regeneration	Regenerating pine stands. Predominantly loblolly pine, but slash and longleaf stands occur as well.
Coniferous Cultivated Plantation (natural / planted)	Managed pine plantations, densely planted. Most planted stands are loblolly, but slash and longleaf occur as well.
Xeric Longleaf Pine	Sandhills including a range of longleaf pine density from predominantly wiregrass, scrub oak dominated to true longleaf pine woodland. This does not include mesic or saturated flatwood types.
Mesic Longleaf Pine	Longleaf pine woodlands without a major scrub oak component. Slash or loblolly pines may be present as well.
Mixed Forest	
Dry Mesic Oak Pine Forests	Mixed forests of the coastal plain and piedmont. Includes loblolly pine with white, southern red and/or post oak and loblolly with water oak.
Coastal Plain Mixed Successional Forest	Generally loblolly mixed with successional hardwoods. Sweetgum, tulip poplar and red maple are common co-dominants in these successional forests.
Shrubland	
Coastal Plain Riverbank Shrubs	Shrub dominated riverbanks, commonly dominated by willows and/or alders.
Woody Wetland	
Seepage and Streamhead Swamps	Includes extensive peat flats in the coastal plain, dominated by swamp tupelo, maples, and Atlantic white cedar alliances. In the sandhills includes streamhead pond pine and bay forests alliances. Saturated hydrology.
Cypress-Gum Floodplain Forests	Swamps dominated by black or swamp tupelo with or without bald cypress. Seasonally to semi-permanently flooded hydrology.
Peatland Atlantic White-Cedar Forest	Dense stands of Atlantic white cedar with saturated hydrology. Can include swamp tupelo, red maple, and pond pines with a moderate shrub and herb layer.
Coastal Plain Oak Bottomland Forest	Bottomland forests dominated by deciduous oak alliances. Oaks represented can include swamp chestnut, cherrybark, willow, and/or overcup oak. Inclusions of loblolly pine temporarily flooded forests occur in patches. Hydrology is temporarily flooded to seasonal.
Coastal Plain Mixed Bottomland Forests	Includes forests dominated by a variety of hardwood species, including sweetgum, cottonwood, red maple.
Wet Longleaf or Slash Pine Savanna	Wet flatwoods and pine savannas, typically dominated by longleaf pines, but slash or pond pines may be the dominant pines.

NCGAP Map Unit Name	Description
Pond-Cypress - Gum Swamps, Savannas and Lakeshores	Cypress dominated swamps and lakeshores. Can include bays dominated by pond cypress or shorelines of coastal plain lakes with a narrow band of cypress.
Pocosin Woodlands and Shrublands	Includes pond pine woodland, low pocosin and high pocosin shrub dominated areas. Canebrakes and bay forests may be present.
Coastal Plain Nonriverine Wet Flat Forests	Loblolly pine - Atlantic white-cedar - red maple - swamp tupelo saturated forests as well as forests dominated by loblolly, sweetgum, and red maple in non-riverine flats.
Floodplain Wet Shrublands	Saturated shrublands of the Coastal Plain, includes buttonbush, swamp-loosestrife, decodon and alders.
Herbaceous Wetland	
Coastal Plain Fresh Water Emergent	Emergent vegetation in fresh water seepage bogs, ponds and riverbeds of the Coastal Plain. Includes alliances dominated by sedges, eelgrass, as well as cane found in unforested cane-brakes.

Nearly two-thirds of the Lumber River and Bear Swamp HUs are covered with agricultural croplands. The map units and descriptions are listed in **Table 6** below. There are no NHP or NVC equivalents for these community types. The most common row crop observed was soybeans. Cotton fields and a few tobacco allotments were also observed. Pastures with livestock were uncommon. Both types of agricultural lands are in large part on prior converted wetlands.

Table 6. Agricultural Cover Descriptions

NCGAP Map Unit Name	Description
Agricultural Crop Fields	Farm fields used for row crops.
Agricultural Pasture/Hay and Natural Herbaceous	Farm fields used for pasture grass or hay production, as well as old fields dominated by native and exotic grasses.

Exotic invasive species including Japanese honeysuckle (*Lonicera japonica*), mimosa (*Albizia julibrissin*), multiflora rose (*Rosa multiflora*), Chinese privet (*Ligustrum sinense*), kudzu (*Pueraria lobata*), and chinaberry (*Melia azedarach*) are present throughout the watershed. Most stream buffers contain some combination of these species in moderate to heavy amounts.

4.4.2 Terrestrial Wildlife Communities

The various forest types classified as Natural cover types in **Table 3** (detailed in **Appendix D)** are important habitat for many wildlife species, providing crucial foraging, nesting, and/or denning areas. Neotropical migratory birds, in particular, are dependent on these areas when they are of sufficient size and quality. These natural cover types comprise a small and often isolated portion of both the Bear Swamp and Lumber River HU. Habitat loss and isolation result from habitat fragmentation of contiguous tracts from agriculture and silviculture activities. Bird species found in these natural wooded areas along the major drainages include Louisiana

waterthrush (*Seiurus motacilla*), Northern parula (*Parula americana*), belted kingfisher (*Megaceryle alcyon*), red-eyed vireo (*Vireo olivaceous*), downy woodpecker (*Picoides pubescens*), Carolina chickadee (*Parus carolinensis*), tufted titmouse (*Parus bicolor*), pine warbler (*Dendroica pinus*), prairie warbler (*Dendroica discolor*), brown headed nuthatch (*Sitta pusilla*), and sharp-shinned hawk (*Accipiter striatus*).

Mammals include the Northern short-tailed shrew (*Blarina brevicauda*) white-footed mouse (*Peromyscus leucopus*), gray squirrel (*Sciurus carolinensis*), Southern flying squirrel (*Glaucomys volans)*, Eastern woodrat (*Neotoma floridana*), and gray fox (*Urocyron cinereoargenteus*). Both the river otter (*Lutra canadensis*) and beaver (*Castor canadensis*) may be found in deciduous forests in close proximity to lotic systems.

Species that prefer open habitat for feeding and nesting can be found in any of the cover types listed in **Table 3** as Cultural, Agricultural, and Other. These cover types are a dominant part of the landscape in both the Bear Swamp and Lumber River HUs. This trend is partly due to continued human development and modern agricultural practices which allow utilization of once marginal undisturbed lands. These and other factors have led to the fragmenting and in some cases complete loss of once contiguous habitats. The faunal species present in these disturbed and barren habitats are opportunistic and capable of surviving on a variety of resources, ranging from vegetation to both living and dead faunal components. The great horned owl (*Bubo virginianus*), barred owl (*Strix varia*) red tailed hawk (*Buteo jamaicensis*), and red-shouldered hawk (*Buteo lineatus*) often forage in Cultural, Agricultural, and Other areas and nest in nearby woodlots.

The European starling (*Sturnus vulgaris*), American robin (*Turdus migratorius*), Eastern bluebird (*Sialis sialia*), and American crow (*Corvus brachyrhynchos*), are common birds that use Cultural, Agricultural and Other habitats to find insects, seeds, or worms. The five-lined skink (*Eumeces inexpectatus*) may bask on sunny tree trunks, fence posts or bare rock in Cultural, Agricultural and Other areas. The Virginia opossum (*Didelphis virginiana*) and raccoon (*Procyon lotor*) are true opportunists often visiting Cultural, Agricultural, and Other habitats to forage.

Many species are highly adaptive and may utilize the edges of forests and clearings or prefer a mixture of habitat types. Edge habitats are prevalent along the riparian to agriculture transition zones located along the Lumber River and Bear Swamp corridors. Eastern cottontail (*Sylvilagus floridanus*), White-tailed deer (*Odocoileus virginianus*), black rat snake (*Elaphe obsoleta*), blue jay (*Cyanocitta cristata*), song sparrow (*Melospiza melodia*), eastern towhee (*Pipilo erythropthalmus*), and Eastern bluebird (*Sialis sialia*) are all common species that can be found utilizing these edge habitats. Nomenclature and habitat characteristics follow American Ornithologists' Union (2002), Conant and Collins (1998), Martof *et al.* (1980), and Webster *et al.* (1985).

4.4.3 Aquatic Communities

The Bear Swamp and Lumber River HUs are located in the Coastal Plain ecoregion, where stream complexes consist of slow-moving blackwater streams and low-lying swamps. The larger

waterbodies are meandering and often lined with swamps and bottomland hardwoods. For the smaller streams in most of the Lumber River and Bear Swamp HUs this riparian corridor has, been reduced to a narrow band of vegetation that parallels the water bodies and associated floodplains as they cut a course across this predominantly agricultural landscape. Many wetlands have been ditched and drained so the land they occupy can be utilized for agriculture. Many swamp streams often stop flowing in the summer and are stained by tannic acid. These streams have limited ability to assimilate oxygen-consuming waste. Swamp streams often have naturally low dissolved oxygen and pH values. Coastal Plain soils are deep sands that have high groundwater storage capacity. Because of the flat topography and high groundwater supply, there are few reservoirs in the Coastal Plain. No natural lakes are found in the study area.

Rivers in Coastal Plain watersheds typically support viable populations of redfin pickerel (*Esox americanus*), white catfish (*Ameiurus catus*), and American eel (*Anguilla rostrata*). Swamp waters in this area typically support viable populations of pirate perch (*Aphredoderus sayanus*), swampfish (*Chologaster cornuta*), and bowfin (*Amia calva*). Nomenclature and habitat conditions follow Menhinick (1991) and Rohde *et al*. (1994). The Lumber River near Pembroke is reported to have a diverse population of intolerant benthic macroinvertebrate species. These species include the stoneflies *Paragnetina kansensis, P. fumosa,* and *Pteronarcys dorsata* and the caddisflies *Chimarra, Brachycentrus numerosus,* and *Micrasema wataga.* The Asiatic clam, *Corbicula fluminea*, is also present in this area. Unusual taxa reported from Bear Swamp include the stonefly *Shipsa rotunda* and the caddisfly *Rhyacophila* near *lobifera* (NCDENR 2004b).

4.4.4 Endangered Species

Plants and animals with a federal classification of Endangered (E), Threatened (T), Proposed Endangered (PE), and Proposed Threatened (PT) are protected under provisions of Section 7 and Section 9 of the Endangered Species Act of 1973, as amended.

The USFWS lists 3 species under federal protection for Robeson County as of February 25, 2003 (USFWS 2003). These species are listed in **Table 7**. Complete species accounts are given in **Appendix E**. Four documented occurrences of red-cockaded woodpecker are on record at NHP as occurring within the HUs. These occurrences are documented in designated Natural Neritage Areas and little suitable habitat exists in either the Lumber River or Bear Swamp HUs outside of these protected areas. Because of current agricultural and timber management practices, open, older (80 to 120 years) stands of longleaf and loblolly pines that provide suitable nesting habitat for the red-cockaded woodpecker do not exist.

However, potential habitat for both the American alligator and Michaux's sumac is likely present within both the Lumber River and Bear Swamp HUs. The American alligator may be found in the slow moving waters of some of the large streams and the Lumber River. One of the several specific soil types Michaux's sumac requires, Norfolk, is present in the basin. Michaux's sumac thrives in areas where some form of disturbance has provided an open area. Most of the plant's remaining populations are on highway rights-of way, roadsides, or on the edges of artificially maintained clearings that are common in both the Lumber River and Bear Swamp HUs.

Table 7. Species Under Federal Protection in Robeson County

Common Name	Scientific Name	Status
Vertebrates		
Red-cockaded woodpecker	*Picoides borealis*	Endangered
American alligator	*Alligator mississippiensis*	Threatened
Vascular Plants		
Michaux's sumac	*Rhus michauxii*	Endangered

Federal Species of Concern (FSC) are not legally protected under the Endangered Species Act and are not subject to any of its provisions, including Section 7, until they are formally proposed or listed as Threatened or Endangered. **Table 8** shows FSC species listed for Robeson County and whether habitat is present in the HUs. No FSC species are currently recorded as occurring in the HU according to NHP records.

Table 8. Federal Species of Concern

Common Name	Scientific Name	Habitat Present
Vertebrates		
Bachman's sparrow	*Aimophila aestivalis*	Y
Carolina gopher frog	*Rana capito capito*	Y
Pinewoods darter	*Etheostoma mariae*	Y
Southeastern Myotis	*Myotis austroriparius*	Y
Rafinesque's big-eared bat	*Corynorhinus (=Plecotus) rafinesquii*	Y
Southern hognose snake	*Heterodon simus*	Y
Townes' clubtail	*Stylurus townesi*	Y
Vascular Plants		
Awned meadowbeauty	*Rhexia aristosa*	Y
Bog spicebush	*Lindera subcoriacea*	Y
Carolina bogmint	*Macbridea caroliniana*	Y
Dwarf burhead	*Echinodorus parvulus*	Y
Georgia indigo-bush	*Amorpha georgiana* var. *georgiana*	Y
Sandhills milkvetch	*Astragalus michauxii*	N
Venus flytrap	*Dionaea muscipula*	Y

Organisms that are listed as Endangered (E), Threatened (T), or Special Concern (SC) on the North Carolina Natural Heritage Program lists of rare plant and animal species (Amoroso 2002, LeGrand *et al.* 2001) are afforded state protection under the State Endangered Species Act and the North Carolina Plant Protection and Conservation Act of 1979. A total of forty-two species on the State list are listed for Robeson County. This list is included in **Appendix E**. According to NHP records, occurrences of Mabee's salamander, a triaenode caddisfly, Georgia calamint, and woody goldenrod have been documented in the HUs.

4.5 WATER QUALITY

4.5.1 Best Usage Classifications

Surface waters in North Carolina are assigned a classification by the Division of Water Quality that is designed to maintain, protect, and enhance water quality within the state. The streams located in the Lumber River and Bear Swamp HUs are classified as either *HQW*, *WS-IV, B, Sw, and Class C* as shown in **Table 9** below and on **Figure 9**. High Quality Water (HQW) protection management strategies are intended to prevent degradation of water quality below present levels from both point and non-point sources. HQW requirements for new wastewater discharge facilities and facilities which expand beyond their currently permitted loadings address oxygen-consuming wastes, total suspended solids, disinfection, emergency requirements, volume, nutrients (in nutrient sensitive waters) and toxic substances. For non-point source pollution, development activities which require a Sedimentation and Erosion Control Plan in accordance with rules established by the NC Sedimentation Control Commission or an approved local erosion and sedimentation control program, and which drain to and are within one mile of HQWs, are required to control runoff from the development using either a low density or high density option. The low-density option requires a 30-foot vegetated buffer between development activities and the stream, whereas the high-density option requires structural stormwater controls. This rule does not require leaving a relatively untouched vegetated buffer; clearing and grading are allowed up to the channel banks as long as the area is re-vegetated. In addition, the Division of Land Resources requires more stringent erosion controls for land-disturbing projects within one mile of and draining to HQWs.

The purpose of the Water Supply Watershed Protection Program is to provide a proactive drinking water supply protection program for communities. Local governments administer the program based on state minimum requirements. There are restrictions on wastewater discharges, development, landfills and residual application sites to control the impacts of point and non-point sources of pollution. There are five water supply classifications (WS-I to WS-V) that are defined according to the land use characteristics of the watershed. The WS-I classification carries the greatest protection for water supplies. WS-V watersheds have the least amount of protection and do not require development restrictions. Those watersheds classified as WS-II through WS-IV require local governments having jurisdiction within the watersheds to adopt and implement land use ordinances for development that are at least as stringent as the state's minimum requirements. A 30-foot vegetated setback is required on perennial streams in these watersheds.

A classification of WS-IV is given to waters used as water supply sources for drinking, culinary, or food processing purposes where a WS-I, WS-II, or WS-III classification is not feasible. WS-

IV waters are generally located within moderately to highly developed watersheds or protected areas. No categorical restrictions on discharges are involved with WS-IV. WS-IV critical areas require agricultural best management practices (BMP's) while protected areas within WS-IV do not require BMP's. Another difference between WS-IV critical and protected areas is that no new landfills can be built in critical areas whereas in protected areas landfills are allowed (NCDENR 2003a). WS-IV waters are also protected for Class C uses.

Class C waters are protected for aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. There are no restrictions on watershed development activities. *Class B* classification is classified for primary recreation. The supplemental classification *Sw* is recognized as swamp waters that will naturally be more acidic (have lower pH values) and have lower levels of dissolved oxygen (NCDENR 2003a).

Table 9. Best Usage Classifications

Waterbody	Description	Class
Lumber River	RR Bridge near Pembroke to Lumberton	WS-IV B Sw HQW
Lumber River	Gum Swamp confluence to RR Bridge near Pembroke	B, Sw, HQW
Mill Branch	Source to Lumber River	C
Jacks Branch	Source to Lumber River	WS-IV, Sw
Bear Swamp	Source to SR 1515	C, Sw
Little Bear Swamp	Source to Bear Swamp	C, Sw
Bear Swamp	SR1515 to Lumber River	WS-IV, Sw
Watering Hole Swamp	Source to Bear Swamp	WS-IV, Sw
Moss Neck Swamp	Source to SR 1576	C, Sw
Moss Neck Swamp	SR 1576 to Bear Swamp	WS-IV, Sw
Kersey Branch	Source to Bear Swamp	WS-IV, Sw

4.5.2 NPDES Discharges

Point source discharges in North Carolina are regulated through the National Pollutant Discharge Elimination System (NPDES) program administered by the NCDENR DWQ. A NPDES permit must be obtained to discharge pollutants from a point source directly into waters of the United States. Point sources may include direct industrial discharge and municipal wastewater containing pollutants such as human wastes, toxic chemicals and metals, fecal coliform, oil and grease, pesticides, and food wastes.

One individual wastewater discharge permit has been issued within the HUs in this assessment. This permit (NC0027103) is issued to the Town of Pembroke for their wastewater treatment

facility that discharges a maximum of 1,330,000 gallons per day into the Lumber River (NCDENR 2004a). The location of this discharge is shown on **Figure 9**.

NPDES Wastewater Discharge General Permits are issued for one of five given state-wide activities such as the discharge of wastewaters associated with sand dredging or discharge of wastewaters associated with petroleum-based groundwater remediation. There are no wastewater general discharge permits within the study area. (NCDENR 2001).

The NPDES stormwater management program regulates point source discharges of stormwater from specific activities that have been identified as having significant pollution potential (NCDENR 2003c). Two general stormwater permits have been issued within the study area (NCDENR 2002b) and are listed below in **Table 10**. Their locations are mapped on **Figure 9**.

Table 10. NPDES Stormwater Discharge General Permits

COC Number	Facility	Address
NCG020502	Buie Land Company Inc/Tara S	2042 Buie Philadelphus Rd
NCG210141	Fleetwood Homes Of NC Inc-#41	349 E. Railroad Ave

4.5.3 Water Quality Monitoring

Benthic macroinvertebrates have been monitored in the Lumber River and Bear Swamp HUs along the Lumber River at SR 1003 and at Bear Swamp. The Lumber River is rated "Excellent" and has not changed significantly with respect to its ability to support a diverse benthic community since sampling began (NCDENR 2004b). Bear Swamp in July 2001 was not rated and community composition according to NCDWQ at that time did not suggest major degradation (NCDENR 2002a). Bear Swamp recently was assigned a water quality rating of "Natural" (NCDENR 2004b). Data collected at Bear Swamp suggest that water quality is representative of natural swamp conditions, which cannot be measured or rated on the same scale as streams. Biologists reported that despite low dissolved oxygen the community in Bear Swamp was still diverse and suggests good water quality. The full DWQ draft report of existing water quality data in the Bear Swamp and adjacent Lumber River HUs is included in **Appendix F**.

4.5.4 303 (d) Waters

North Carolina's §303(d) List (NCDENR 2002c) is an accounting of all impaired waterbodies. An impaired waterbody is one that does not meet water quality standards. Use support is evaluated for specific categories including aquatic life, fish consumption, and water supply. Waters placed on this list require the establishment of total maximum daily loads (TMDLs) intended to guide the restoration of water quality. The source of impairment might be from point

sources, non-point sources, and atmospheric deposition (NCDENR 2003b). Mercury levels in fish tissue samples led to a fish consumption advisory. As a result, all waters in the Lumber River basin are classified as Impaired. None of the tributaries are specifically listed though there is no reason to believe that migration of fish with high mercury levels from the main stem into the tributaries is limited. No other causes of impairment leading to 303(d) listing are evident in the HUs (NCDENR 2002c). A final TMDL document was approved for the Lumber River in October 2000, but was not available on the DENR website.

4.5.5 Non-Point Source

Unlike pollution from industrial and sewage treatment, non-point source (NPS) pollution comes from many non-discrete sources. As runoff from rainfall or snowmelt moves over the earth's surface, natural and man-made pollutants are picked up, carried, and ultimately deposited into lakes, rivers, wetlands, and groundwater. NPS pollution includes fertilizers, herbicides, and insecticides from farms and residential areas; hydrocarbons and chemicals from urban runoff and industrial sites; sediments from construction sites, land clearing, and eroding stream banks; bacteria and nutrients from livestock, animal wastes, and faulty septic systems; and atmospheric deposition. The effects of NPS pollutants on water resources vary, and in many instances, may not be fully understood. These pollutants generally have harmful effects on drinking water supplies, recreation, wildlife, and fisheries (USEPA 1994).

The Lumber River Basinwide Water Quality Plan outlines several documented sources of non-point pollution in the sub-basin. These include, but are not limited to clearcutting the riparian area on Bear Swamp (NCDENR 2003b). Potential sources of NPS pollution in the subbasin include atmospheric deposition from vehicles; overland erosion; erosion from streambanks; fertilizers, herbicides, and insecticides from residential and agricultural areas; and hydrocarbon and chemical runoff from industrial and residential driveways and parking lots.

4.5.6 Existing Watershed Improvement Programs

There are several existing watershed improvement programs within the Lumber River Basin that can affect the Lumber River and Bear Swamp HUs. The programs range from those originating from the federal Clean Water Act to ones for local landowners and volunteers who have committed to the protection of water quality and biological diversity. A list of the programs can be found below in **Table 11**. The local Natural Resource Conservation Service (NRCS) office has been utilizing all of the United States Department of Agriculture's (USDA) programs throughout the watershed under the direction of the Robeson County Conservation District. The county is currently focused on reducing non-point source pollution and riparian corridor conservation. Many of the other programs focus on obtaining easements on land for its protection and preservation. A complete summary of the programs can be found in **Appendix F**.

Table 11 Existing Watershed Improvement Programs

Federal
Clean Water Act - Section 319 Program
State
NC Agriculture Cost Share Program
Ecosystem Enhancement Program
Clean Water Management Trust Fund
NC Construction Grants and Loans Program
North Carolina Stream Watch
North Carolina Wild and Scenic River System
Regional/Local
Conservation Trust for North Carolina
Lumber River Council of Government: Surface Water Initiatives of the Lumber River COG

5.0 SUB-WATERSHED FUNCTIONAL ANALYSIS

5.1 PROCEDURES

The Lumber River and Bear Swamp HUs were partitioned into SWs for the functional analysis. The delineation resulted in a total of 3 SWs in the Lumber River HU and 8 SWs in the Bear Swamp HU. **Figure 10** shows the delineated SWs and their drainage areas.

The next step in the analysis process involved examining the watershed functions and sub-functions developed by the Ecosystem Enhancement Program committees. Indicators (**Table 1)** of the status of these functions were developed for the functions and sub-functions from existing data in the GIS or other public databases. Some of the indicators are simple values that are obtained from attribute tables in the GIS, while others are derived from overlays and calculations using the data in the GIS. See **Table G-1** in **Appendix G** for the raw data values and **Appendix A** for descriptions of the GIS source data and calculations. **Figures 11, 12,** and **13** depict some of these indicators.

Percentages of total area or length were calculated to relativize the comparison of conditions among SWs. Percentages are based on total surface water length (including ditches) in a SW or total SW area. A SW-indicator matrix was populated with the appropriate indicator values. See **Table G-2** in **Appendix G.** These indicators included the following:

- Percent area of different cover types (forest, wetlands, and impervious)
- Percentage of surface waters classified as ditches
- Percentage of surface waters protected by forested buffers
- Number of wildlife corridors (forested areas at least 600 feet wide connecting large patches of forest)

- Area and number of interior patches (forested patches that are at least 74 acres in size after buffering inward 300 feet to account for edge effects)

The values for each indicator in the matrix were assigned a rating of 1, 2, or 3 for High, Medium, or Low functional status based on best professional judgment. The indicator ratings for each SW were summed to obtain a cumulative functional status score for each of the three major functions. The indicator ratings summed for each major function were as follows:

Water Quality

- percentage of 50-foot buffer protected stream
- percentage of 300-foot buffer protected stream
- percentage of impervious area
- percentage of forested area
- percentage of wetland area

Hydrology

- percentage of ditches
- percentage of 50-foot buffer protected stream
- percentage of 300-foot buffer protected stream
- percentage of impervious area
- percentage of forested area
- percentage of wetland area

Habitat

- percentage of forested area
- percentage of wetland area
- percentage of interior area
- number of patches classified as interior area
- number of wildlife corridors

The indicator ratings and cumulative scores are also shown in **Table G-2.** A summary of results is shown below in **Table 12.** The cumulative scores were sorted in order from lowest cumulative score (highest functional status) to highest cumulative score (lowest functional status). The list of SW cumulative scores was analyzed in rank order to discern groupings of SWs with similar scores. A rating of High (1), Medium (2), or Low (3) was assigned to the score. An overall cumulative functional status score for each SW was also determined by summing the ratings of the 9 indicators. The overall scores were rated and found to be consistent with the individual function ratings.

Table 12. Sub-Watershed Ratings

		% Ditches	% Stream Buffered 50 ft	% Stream Buffered 300 ft	% Impervious	% Forested	% Wetlands	% Interior Area	No. of Patches	No. of Corridors	Cumulative Score Water Quality	Rating	Cumulative Score Hydrology	Rating	Cumulative Score Habitat	Rating	Cumulative Score Overall	Rating
Water Quality			x	x	x	x	x				x							
Hydrology		x	x	x	x	x	x						x					
Habitat						x	x	x	x	x					x			
HU	**SW**																	
BS	10	1	1	1	1	1	1	1	1	1	5	1	6	1	5	1	9	1
L	3	2	1	1	1	1	1	1	2	2	5	1	7	1	7	1	12	1
BS	8	2	2	2	1	2	2	1	2	1	9	1	11	2	8	1	15	2
L	1	2	2	2	2	1	2	2	1	2	9	1	11	2	8	1	16	2
L	2	3	2	2	3	2	2	1	1	2	11	2	14	3	8	1	18	2
BS	11	1	2	2	2	2	2	2	3	3	10	2	11	2	12	2	19	2
BS	7	1	2	2	2	3	2	3	3	2	11	2	12	2	13	2	20	2
BS	9	2	3	3	2	3	2	3	2	3	13	3	15	3	13	2	23	3
BS	5	2	3	3	2	2	3	3	3	3	13	3	15	3	14	3	24	3
BS	4	3	3	3	1	3	3	3	3	3	13	3	16	3	15	3	25	3
BS	6	3	2	3	3	3	3	3	3	3	14	3	17	3	15	3	26	3

An attempt was made to include indicators from the Visual Assessment (**Appendix B** and enclosed CD), such as bank height ratio, buffer width, and bed diversity, although the Visual Assessment was not originally conceived as a sampling exercise. The data collected at the observation points were reduced to a mean SW value for numerical data such as bank height ratio. For class data such as buffer type or width, a most frequent or median class for each sub-watershed was determined. The rating procedure described above was applied but did not result in a clear discrimination of conditions among sub-watersheds. Sampling only at public road crossings resulted in an inadequate representation of the range of conditions present in the sub-watersheds and biases in the results were evident. For example, a sub-watershed could have only a couple of public road crossings over a stream with adequate buffers, whereas the majority of streams in the sub-watershed may run unbuffered through inaccessible private property. The Visual Assessment was useful mainly to confirm general landscape conditions implied by the GIS data and to identify the locations of degraded areas visible from the road.

5.2 RESULTS

SWs 3 and 10 received an overall functional status rating of High, as well as rating High for all three individual functions. These two SWs are located at the downstream end of the Lumber River and Bear Swamp HUs respectively. They are characterized by relatively higher amounts of forest cover, buffered stream, and terrestrial habitat connectivity than the other SWs in these

HUs. The swampy conditions have spared these SWs from extensive drainage improvements and development.

Functional status for SWs 4, 5, and 6, of the Bear Swamp HU was rated Low overall and Low for each of the three individual functions. SWs 4 and 5 are characterized by extensive agricultural land cover with minimal buffer protection for streams. Because of a drier hydrologic regime due to the headwater position of these SWs, clearing has been more extensive and forested buffers are nearly absent, resulting in the lower functional status ratings. SW 6 includes the Town of Pembroke, which gives it the highest amount of impervious area (10%) in the two HUs. There are a total of three habitat patches in these three SWs, but no connecting corridors. An additional stressor to SW 5 is the Moss Neck drainage district covering part of its area.

SW 9 in the Bear Swamp HU received a Medium rating for the habitat function, but rated Low overall. This SW is entirely within the Moss Neck Drainage District.

The remaining SWs-1, 2, 7, 8, and 11- received and overall functional status rating of Medium. The results for the three individual functions were mixed, with only SWs 7 and 11 consistently rating Medium. These SWs are less homogeneous than those above that clearly rated High or Low. SWs 1 and 2 are in the Lumber River HU. They include wide buffers and numerous large habitat patches wetlands, but they also include large agricultural areas (SW1) and part of the Town of Pembroke (SW 2). SW 2 also has a relatively high percentage of surface drainages classified as ditches.

In developing these ratings, it was assumed that the highest level of water quality function would be achieved with 100 percent forested cover, 100 percent buffer protection, and no impairment. Under these assumptions, none of the SWs may be considered fully functional. However, these assumptions do not take into account the range of variation within which full function may be achieved, nor do they account for the possibility that sustainability may be achieved at lower levels of function. Existing water quality data obtained by DWQ show the water quality in these HUs supports its uses, except for the mercury impairment. These data were not included in the functional analysis because the mercury impairment is basin-wide and the existing monitoring stations do not provide sufficient coverage at the SW level.

Hydrology functional status was assessed by evaluating relative areas of forested area and cleared or impervious area, length of stream protected by a forested buffer, length of ditches, and area of wetlands. As noted above, the values for forested area and buffered streams are less than fully functional, given the same assumptions. Wetlands are present throughout the HUs, though well below the historic level of cover, and presumably are performing storage and flow moderation functions. However, without a reference watershed, it is difficult to state with the available data whether the area of wetlands provides a high level of these functions. Gage data or accounts of flood damage may provide more insight into this function.

Habitat functions were assessed by evaluating relative areas of forest and cleared land, area of wetlands, size of forest interior patches, and presence of suitable corridors between the large patches for wildlife movement. Again, with the same assumptions noted previously, the relative amount of forest cover suggests a low level of function. A few forest patches with greater than

74 acres of interior area are present throughout the SWs, with the majority occurring in SWs 1, 2, and 10. Not all patches connect to other large patches. The patches are separated mainly by agricultural land, though, which affords more mobility than residential or urban cover. Some of the patches are registered Natural Heritage Areas harboring endangered species. The ability of the SWs to support a variety of species, including habitat specialists and wide-ranging species, is assumed to be degraded. However, without reference standards or a census of the wildlife population, it is difficult to judge the severity or implications of this loss of function.

6.0 FINDINGS AND RECOMMENDATIONS

6.1 SUMMARY OF WATERSHED ISSUES

Even though adequate forested buffers are nearly absent from the entire study area, the water quality is relatively high according to existing DWQ studies. The land cover in the HUs is mainly row crops, but nutrient loading from agricultural chemicals is not currently causing a violation of water quality standards. The conversion of agricultural fields to residential and commercial developments was observed in the HUs, so future increases in impervious surface could potentially cause a decline in functional status for water quality, hydrology, and habitat. SWs 2 and 6, which include the Town of Pembroke, currently have 8 % and 10% impervious cover respectively. Ten percent is considered the threshold beyond which water quality may be expected to degrade. Point source discharges are permitted in 3 locations, with no history of compliance issues.

Bank erosion is not a major concern because of the low-gradient, slow-moving streams. An active pasture with livestock in a stream was observed at only one location.

Flooding is controlled by the nearly universal channelization of streams in the HUs. Only the Lumber River and the lower reaches of Bear Swamp seem to have escaped alteration. The resulting lower water table has facilitated the conversion of wetlands to agricultural and residential uses, and it is unlikely that this will be reversed on a large scale. This factor is the single greatest limitation to full restoration of the SWs.

Channelization has led not only to large-scale loss of terrestrial habitat, but to the loss of in-stream habitat as well. Although the creation of numerous ditches that now may be functioning as perennial streams has increased the amount of available aquatic habitat in a sense, the habitat diversity is very low. The straight, often trapezoidal channels lack natural pattern geometry and profile sequences, resulting in an absence of pools and riffles that normally would support different suites of species. Woody debris and detritus are also low because of regular mowing of the banks or very narrow buffers. Water temperature increases with a lack of shade thereby impacting the ability for different species to inhabit a particular area.

The loss of terrestrial habitat to agricultural conversion has marginalized some habitat specialists such as the red-cockaded woodpecker. Other species, such as black bear or certain neotropical migrant birds, that prefer very large areas of forest are excluded altogether from a landscape such as that currently found in the HUs. The majority of the HUs is now mainly suitable habitat for opportunistic species that can thrive in marginal habitat and coexist with humans.

The problem of habitat may be one of scale. Although the HUs themselves do not offer a variety of habitat types in large tracts, there may be areas adjacent to the HUs that in a larger watershed context can sustain a diverse population of characteristic Coastal Plain species.

6.2 GOALS OF FURTHER STUDY

Further study in the HUs should be conducted to verify the findings of the GIS-based functional analysis and to obtain information about the HUs that cannot be determined from the GIS data. The additional information should be used to further refine the focus areas and determine where and what type of watershed improvements should be implemented to provide the greatest overall benefit to the watershed.

Specifically, efforts should be directed to verify buffer conditions and stream morphology and to determine the effect the inadequate buffers and extensive ditching shown on GIS have on in-stream habitat and water quality. Landscape conditions should also be assessed to identify potential runoff or nutrient loading problem areas and to provide for possible correlations with the water quality monitoring data.

Additional studies should include an assessment of the potential to improve terrestrial habitat connectivity. Areas where the establishment of stream buffers or reforestation of wetlands would connect or extend existing high-quality habitat should be identified.

Constraints to potential restoration of hydrologic functions should be addressed as well. Generally, given the current land uses and history of hydrologic alterations, it is anticipated that, although it would provide improvements to watershed functions, the potential for hydrologic restoration will be minimal throughout most of the SWs.

6.3 FOCUS AREAS

The assessment of the SWs on the basis of ecological indicators proved useful in determining which area of the HUs should be the focus of further studies. The SWs with the lowest functional status ratings (4, 5, and 6) have deficiencies observed in the field that may easily lend themselves to improvement through BMPs or other potential watershed improvement projects.

Although water quality data do not indicate any serious problems in the HUs, SW 2 in the Lumber River HU and SW 6 in the Bear Swamp HU are at or near the threshold for expected decline in water quality due to increased impervious surface. Preventing further degradation and providing a cushion to absorb future impacts to the Lumber River and Bear Swamp is the recommended strategy.

In the Bear Swamp HU, SWs 4, 5, and 6 received a Low functional status rating and should be the focus of watershed improvement efforts. Establishing forested buffers is the most apparent need and would serve to protect surface waters and improve terrestrial habitat connectivity. These SWs fall outside of the protected WS-IV water supply watershed, and there are no other municipal ordinances that would protect streams in this area. Drainage district issues could be

avoided in SWs 4 and 6 and part of 5. SW 9 also received a Low rating, but its status as a drainage district may restrict the implementation of watershed improvements. SW 7 received a Medium rating, but its position downstream of Pembroke makes it worth further study for inclusion in an overall management strategy for attenuation of runoff and nutrient loading in waters received by the lower reaches of Bear Swamp. A particularly promising watershed improvement opportunity was identified in SW 7 at the confluence of Watering Hole Swamp and Bear Swamp. The channel flows through a cow pasture with adequate room for restoring geometry. The topography seems to be compatible with full wetland restoration and enhancement without flooding adjoining properties. Water quality, hydrology, and habitat functions could all be improved at this location.

Although none of the three Lumber River HUs received a Low functional status rating, a focus on preserving the existing waterway and adjacent swamps and bottomland is recommended in SW 2. About half of the SW is within the protected WS-IV water supply watershed. Although this segment of the Lumber River is designated a State Natural and Scenic River, there are no protective easements to prevent development along the banks. Part of the Town of Pembroke is within SW 2, and contributes to the 8% impervious surface. As the town grows, increased impervious surface could stress the Lumber River. A comprehensive strategy to manage runoff from the town and protect the integrity of the existing swamps along the Lumber River is recommended. Also, restoration of contributing streams and establishment of buffers where these form corridors from large forested patches to the Lumber River would increase the habitat function of SW 2.

6.4 MONITORING PLAN

A water quality monitoring plan has been proposed by DWQ for the HUs. The objective is mainly to determine whether the excellent water quality that is known to exist at previously established monitoring points exists throughout the HUs. The complete plan with proposed monitoring locations and rationale is included in **Appendix H**.

6.5 FIELD ASSESSMENT STRATEGY

Field assessment methods were chosen that will provide measures of the functional indicators related to the perceived problems of inadequate buffer protection and habitat degradation. Several locations in each focus area SW will be selected for data collection. Degraded sites identified through the Visual Assessment and the GIS analysis will be included. Other sites will be chosen based on surrounding land use characteristics, so that different land uses within each focus area SW will be represented. Sites that appear by GIS analysis to have potential for expanding or connecting available high quality habitat will also be investigated.

In-stream habitat will be assessed using a standard Habitat Assessment Field Data Sheet for Coastal Plain streams developed by DWQ. The form covers several categories including habitat types and quantity for benthos and fish, substrate conditions, bed diversity, and flow conditions. The sheet also covers a number of stream morphology, buffer, and landscape condition measurements that will help address the relationship of these conditions to habitat and water quality degradation.

Measurements such as bank height ratio will be added to provide additional information about how well the streams are performing hydrologic functions. If wetlands are present in the buffer zone or adjacent landscape, a wetland rating form will be filled out.

A field method for assessing biogeochemical function in Coastal Plain stream buffers has been developed by researchers at East Carolina University. Earth Tech has had preliminary discussions with EEP about working with ECU to implement the methodology for this study in the Lumber River and Bear Swamp HUs. This methodology would directly address the goal of assessing the effect of inadequate buffers on water quality. If this method does not meet the approval of EEP, some other simple nutrient loading model will be explored.

The EEP has also mentioned the potential for collaboration with NCGAP to assess habitat connectivity issues. If this does not work out, a minimum assessment would include the identification of cleared wetlands or riparian areas that have the potential to connect or expand existing high-quality habitat while at the same time improving hydrology or water quality functions in the watershed.

Additional documentation at each site will include photographs, sketches, GPS coordinates, and notes on the potential for restoration and/or BMPs.

Analysis of parcel data will be useful at this phase of the watershed assessment, especially in SW 2 where the focus is on protection of existing high quality habitat. The information on protected parcels from the initial GIS analysis will be updated as necessary. Parcels adjacent to any protected parcels will be targeted for a field assessment to evaluate terrestrial and aquatic habitat quality and the potential to expand, preserve, or protect existing high quality habitat. Watershed improvement projects identified through other field assessments will be screened to determine the number of landowners involved. Large tracts owned by developers or timber companies will be identified and evaluated for potential functional losses to the watershed if the current land use should change.

The data collected from this detailed assessment will be used to refine the preliminary SW ratings based on the GIS analysis and to evaluate the links between the suspect indicators and DWQ water quality data. Critical areas will be identified where functional deficiencies are the greatest and where implementation of watershed improvements such as stream or wetland restoration and best management practices will have the greatest impact on water quality and watershed functions.

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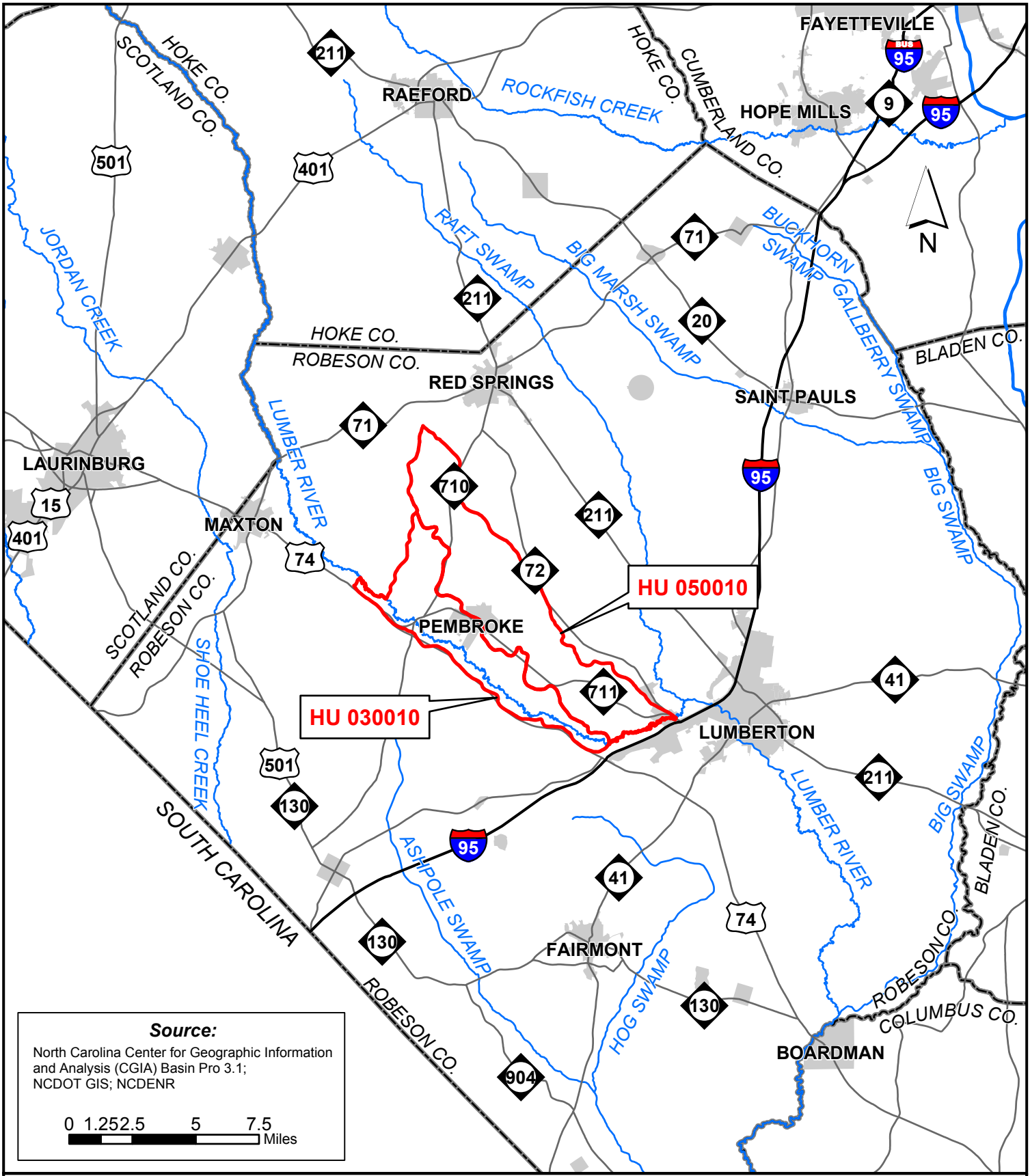

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1; NCDOT GIS; NCDENR

0 1.252.5 5 7.5 Miles

NCDENR

Ecosystem Enhancement Program

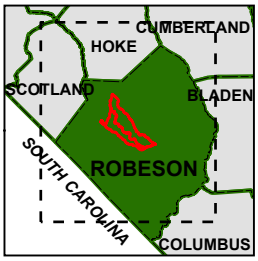

FIGURE 1
VICINITY MAP

Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\f01_vic_lwp.mxd 2/04

HOKE CO.
ROBESON CO.
Long Swamp
Juniper Branch
Gum Branch
Wilkes Branch
Richland Swamp
Raft Swamp
Little Raft Swamp
Panther Branch
Tennile Swamp
Saddletree Swamp
Rocky Branch
Burnt Swamp
Mill Branch
Holy Swamp (Holly Swamp)
White Oak Branch
Moss Neck Swamp
Bear Swamp
Double Branch
Back Swamp
Lumber River
Lukkey Branch
Cypress Branch
Jordan Swamp
Gum Swamp
Little Juniper Branch
Little Bear Swamp
Mill Branch
Old Field Swamp
Hog Swamp
Powell Branch
Jacks Branch
Kersey Branch
Little Jacob Branch
R-2593
U-3451
R-513
R-2558
I-2305
B-3367
SEABOARD COASTLINE R/R
Red Springs
Rennert
Pembroke
Lumberton
McDonald
Old Red Springs Rd.
McArthur Rd.
Island Grove Rd.
Melinda Rd.
W L Moore Woods Rd.
Whistling Rufus Rd.
Philadelphus Rd.
Red Oak Rd.
Hezekiah Rd.
SR 1561
Union Chapel Rd.
Locklear Rd.
Moss Neck Rd.
N Chicken Rd.
Deep Branch Rd.
Lowe Rd.
Pine Log Rd.
HU 050010
HU 030010
71
710
211
72
74
301
95
41
1
2
3
4

LEGEND

FACILITY		STEWARD
1	Prospect Playground	Robeson County
2	ADM Indian Culture Tourist Center	State of North Carolina
3	Pembroke Community Park	Town of Pembroke
4	WRC NcNeill's Bridge Access Area	State of North Carolina

TIP Bridge Project

TIP Road Project

Moss Neck Drainage District

NCDENR
Ecosystem Enhancement Program

Source:
North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1;
NCDOT GIS Unit; NCDENR

0 0.75 1.5 3 Miles

CUMBERLAND
HOKE
SCOTLAND
BLADEN
ROBESON
SOUTH CAROLINA
COLUMBUS

FIGURE 2
LAND PLANNING AND MANAGEMENT
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

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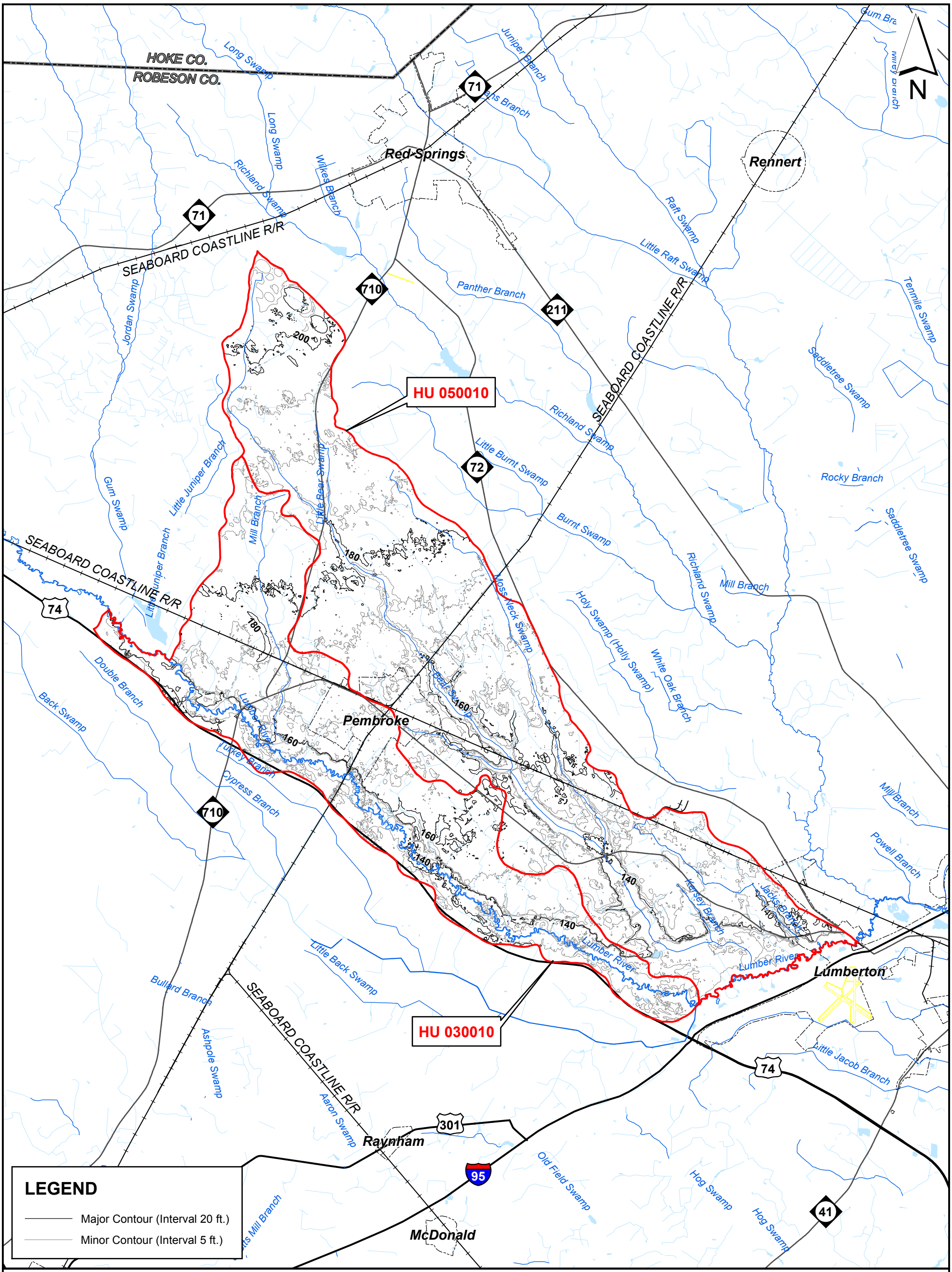

NCDENR
Ecosystem Enhancement Program

Source:
North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1;
NCDOT GIS Unit; NCDENR; LIDAR Data.

0 0.75 1.5 3 *Miles*

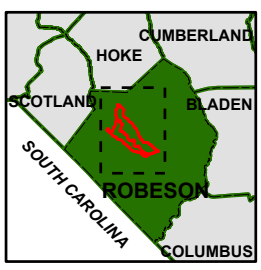

FIGURE 3a
TOPOGRAPHY - ELEVATION
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\f03a_topo.mxd 2/04

HOKE CO.
ROBESON CO.
Red Springs
Rennert
Pembroke
Lumberton
Raynham
McDonald
SEABOARD COASTLINE R/R
HU 050010
HU 030010
71
710
211
72
74
301
95
41
N

LEGEND

- Airport
- Railroad
- US Route
- NC Route
- Secondary Route
- Local Street or Other Public Road

NCDENR
Ecosystem Enhancement Program

Source:
North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1;
NCDOT GIS Unit; NCDENR; LIDAR Data.

0 0.75 1.5 3 *Miles*

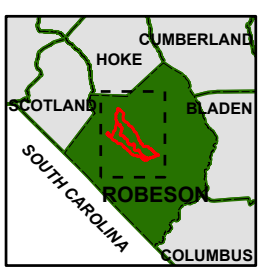

FIGURE 3b
TOPOGRAPHY - HILLSHADE
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\F03b_topo.mxd 2/04

HOKE CO.
ROBESON CO.
SEABOARD COASTLINE R/R
Red Springs
71
71
710
211
72
HU 050010
SEABOARD COASTLINE R/R
74
Pembroke
Lumber River
SEABOARD COASTLINE R/R
SEABOARD COASTLINE R/R
HU 030010
Lumberton
74
41
301
Raynham
95
McDonald
N

LEGEND

Non-Hydric Soils

- Borrow Pit
- Duplin sandy loam, 0 to 2 percent slopes
- Faceville fine sandy loam, 0 to 2 percent slopes
- Goldsboro loamy sand, 0 to 2 percent slopes
- Kalmia loamy sand, 0 to 2 percent slopes
- Lakeland sand, 0 to 6 percent slopes
- Marlboro sandy loam, 0 to 2 percent slopes
- Norfolk and Faceville soils, 6 to 10 percent slopes
- Norfolk loamy sand, 0 to 2 percent slopes
- Norfolk loamy sand, 2 to 6 percent slopes
- Pactolus loamy sand
- Pocalla loamy sand, 0 to 3 percent slopes
- Udorthents, loamy
- Wagram loamy sand, 0 to 6 percent slopes
- Wagram loamy sand, 6 to 10 percent slopes
- Wakulla sand, 0 to 6 percent slopes
- Water

LEGEND

Type-A Hydric Soils

- Bibb soils
- Byars loam
- Coxville loam
- Johnston soils
- Leon sand
- Lumbee sandy loam
- McColl loam
- Pantego fine sandy loam
- Plummer and Osier soils
- Portsmouth loam
- Rains sandy loam
- Rutlege loamy sand
- Torhunta loam

LEGEND

Type-B Hydric Soils

- Dunbar Sandy Loam
- Johns sandy loam
- Lynchburg sandy loam

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1; NCDOT GIS; NCDENR

0 0.75 1.5 3 Miles

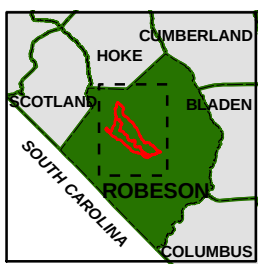

FIGURE 4
SOILS
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\F04_soils.mxd 2/04

HOKE CO.
ROBESON CO.
SEABOARD COASTLINE R/R
Red Springs
71
710
211
72
74
HU 050010
HU 030010
Pembroke
Lumber River
Lumberton
41
301
95
N

LEGEND

- Agricultural Crop Fields
- Agricultural Pasture/Hay and Natural Herbaceous
- Barren; bare rock and sand
- Coastal Plain Dry to Dry-Mesic Oak Forests
- Coastal Plain Fresh Water Emergent
- Coastal Plain Mesic Hardwood Forests
- Coastal Plain Mixed Bottomland Forests
- Coastal Plain Mixed Successional Forest
- Coastal Plain Nonriverine Wet Flat Forests
- Coastal Plain Oak Bottomland Forests
- Coatal Plain Riverbank Shrubs
- Coniferous Cultivated Plantation (natural/planted)
- Coniferous Regeneration
- Cypress-Gum Floodplain Forests
- Dry Mesic Oak Pine Forests
- Mesic Longleaf Pine
- Open Water

LEGEND

- Peatland Atlantic White-Cedar Forests
- Pocosin Woodlands and Shrublands
- Pond-Cypress, Gum Swamps, Savannas and Lakeshore
- Residential Urban
- Seepage and Streamhead Swamps
- Successional Deciduous Forests
- Urban High-Intensity Developed and Transportation Corridors
- Urban Low-Intensity Developed
- Wet Longleaf or Slash Pine Savanna
- Xeric Longleaf Pine

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1; NCDOT GIS; NCGAP; NCDENR

0 0.75 1.5 3 *Miles*

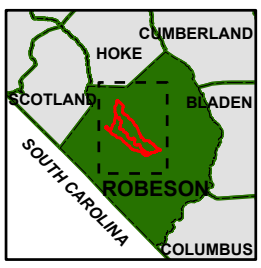

FIGURE 5
LAND USE / LAND COVER
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\F05_landuse.mxd 2/04

HOKE CO.
ROBESON CO.

N

HU 050010

HU 030010

Bear Swamp
Little Bear Swamp
Moss Neck Swamp
Mill Branch
Lumber River
Watering Hole Swamp
Jacks Branch
Kersey Branch
Ut

LEGEND

Perennial Streams
Intermittent Streams
Ditches

Elevation (In Study Area)

Value

High : 253 ft

Low : 91 ft

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1;
USGS DEMs; NCDENR

0 0.75 1.5 3 *Miles*

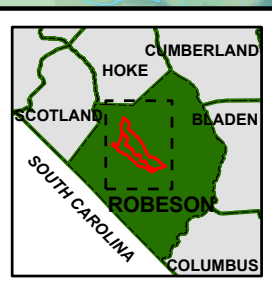

FIGURE 6
SURFACE WATERS
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\F06_watersUS.mxd 2/04

HOKE CO.
ROBESON CO.
Red Springs
Rennert
Pembroke
Raynham
McDonald
Lumberton
SEABOARD COASTLINE R/R
R-2593
U-3451
SR 1561
R-513
B-3367
R-2558
I-2305
HU 050010
HU 030010
Old Red Springs Rd.
McArthur Rd.
Island Grove Rd.
Melinda Rd.
W L Moore Woods Rd.
Whistling Rufus Rd.
Red Oak Rd.
Hezekiah Rd.
Philadelphus Rd.
Union Chapel Rd.
Locklear Rd.
Moss Neck Rd.
N Chicken Rd.
Deep Branch Rd.
Lowe Rd.
Pine Log Rd.
Long Swamp
Juniper Branch
Wilkes Branch
Richland Swamp
Jordan Swamp
Raft Swamp
Little Raft Swamp
Panther Branch
Tennile Swamp
Saddletree Swamp
Little Bear Swamp
Mill Branch
Little Juniper Branch
Gum Swamp
Little Burnt Swamp
Burnt Swamp
Rocky Branch
Moss Neck Swamp
Holy Swamp (Holly Swamp)
White Oak Branch
Rear Swamp
Double Branch
Back Swamp
Lumber River
Turkey Branch
Cypress Branch
Little Back Swamp
Bullard Branch
Aaron Swamp
Old Field Swamp
Hog Swamp
Little Jacob Branch
Power Branch
Jacks Branch
Kersey Branch
71
72
74
211
710
301
95
41
N

LEGEND

- Railroad
- Airport
- TIP Road Project
- TIP Bridge Project
- US Route
- NC Route
- Secondary Route
- Local Street or Other Public Road

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1;
NCDOT GIS Unit; NCDENR

0 0.75 1.5 3 *Miles*

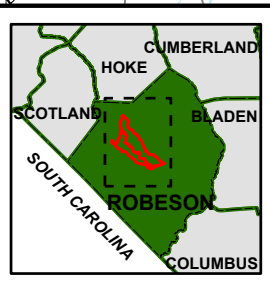

FIGURE 7
TRANSPORTATION INFRASTRUCTURE
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

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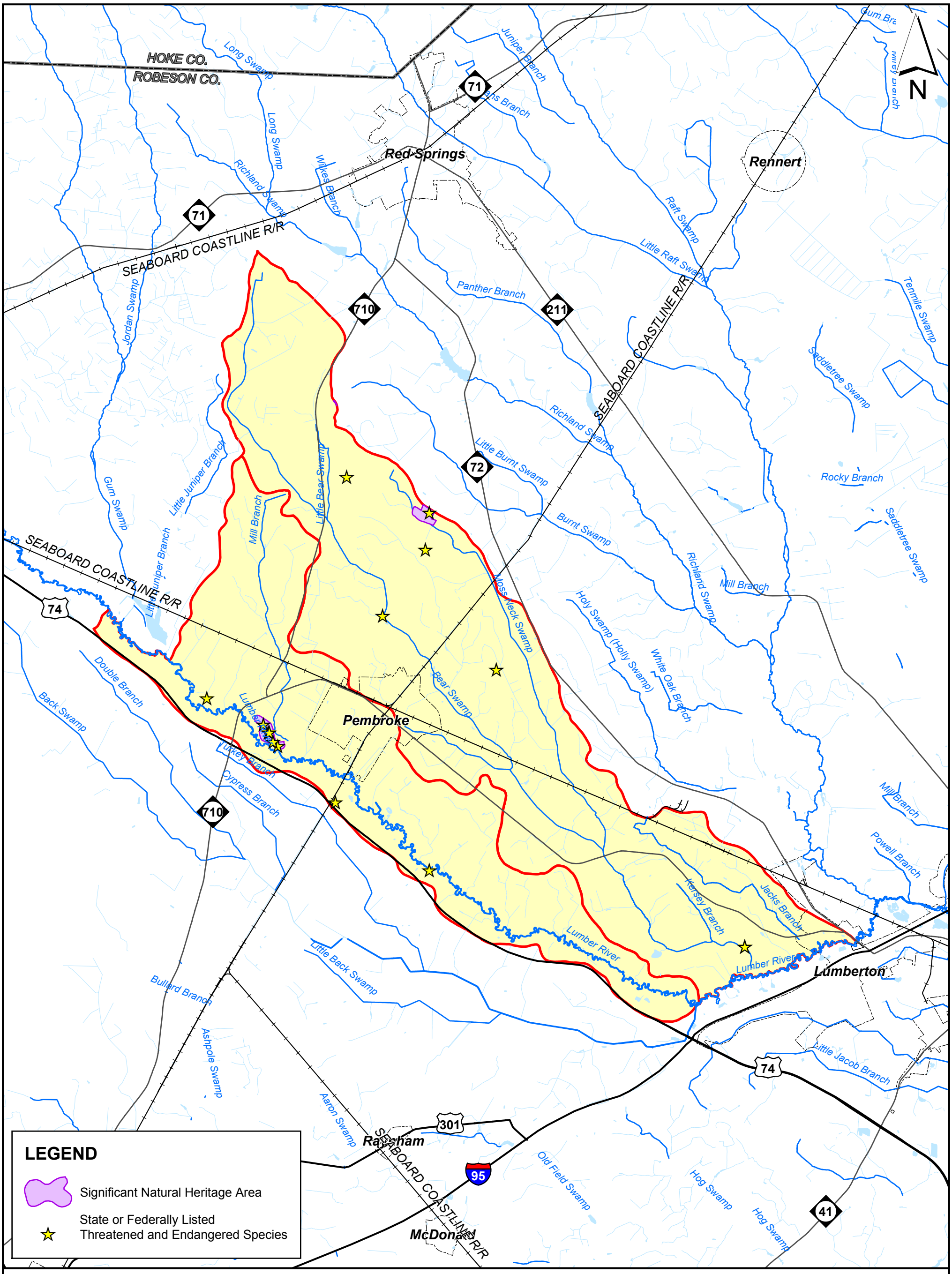

FIGURE 8
THREATENED AND ENDANGERED SPECIES
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

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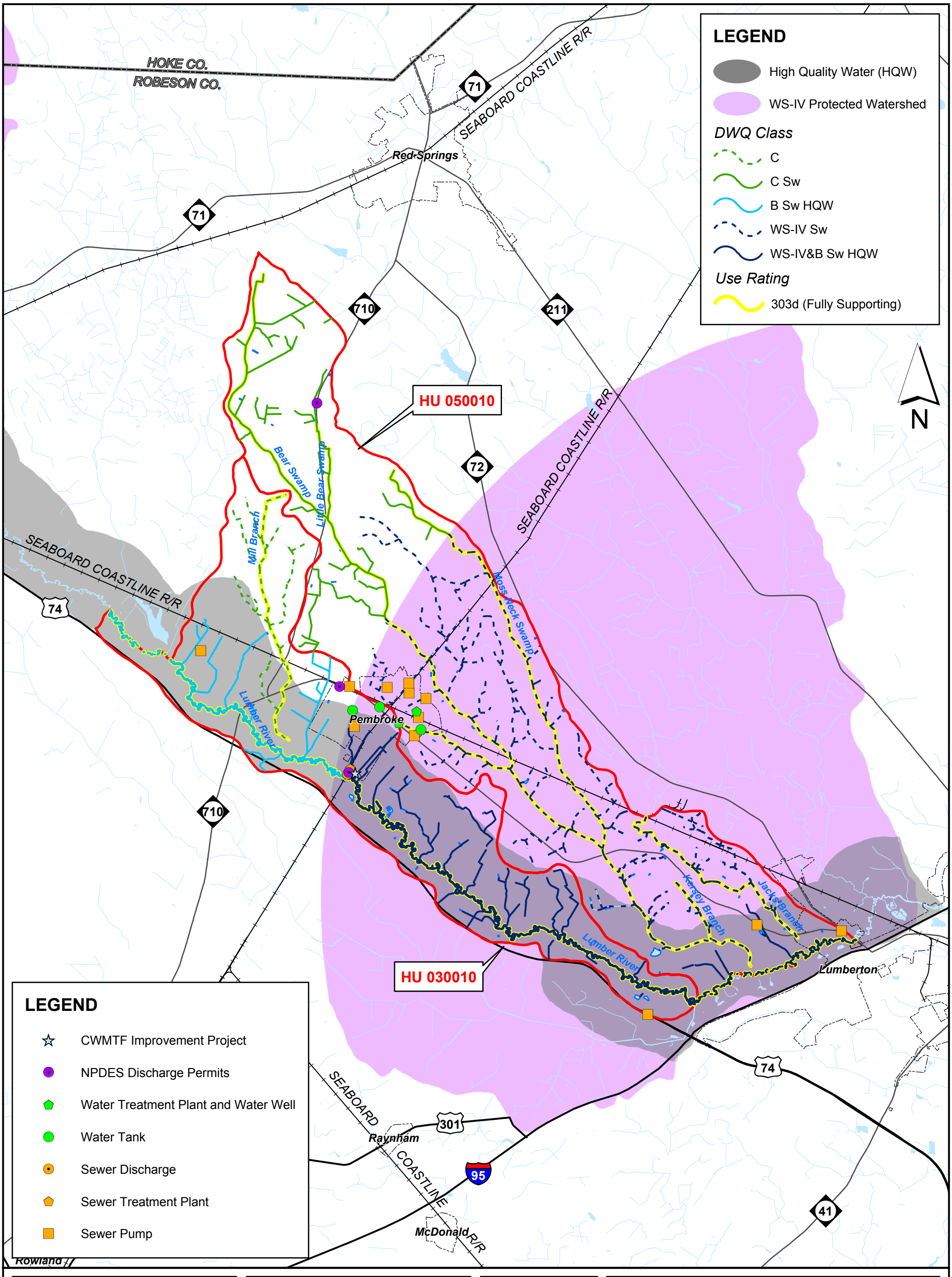

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1; NCDOT GIS Unit; NCDENR

0 0.75 1.5 3 Miles

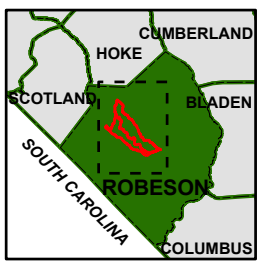

FIGURE 9
WATER QUALITY
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

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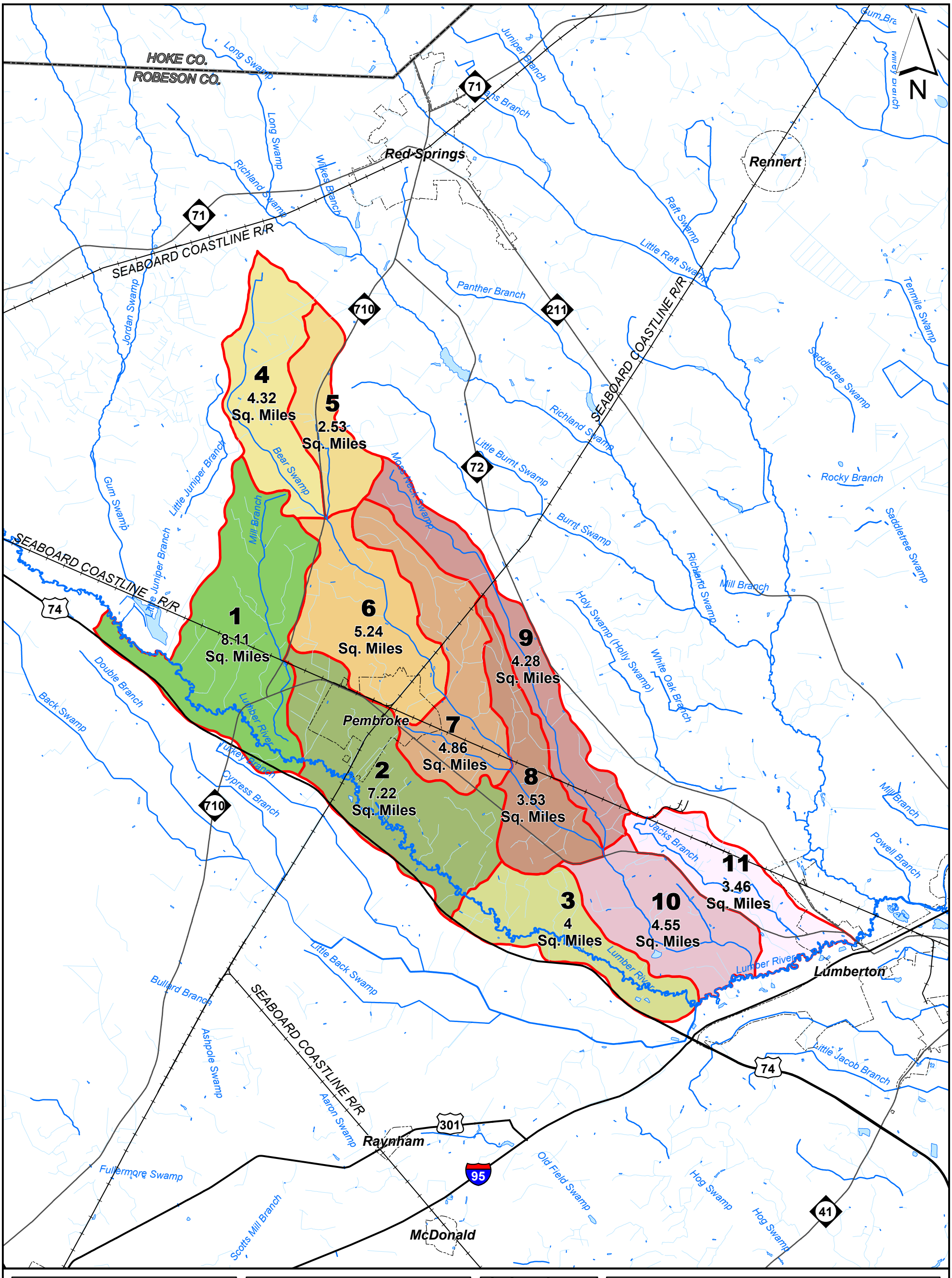

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1; NCDOT GIS Unit; NCDENR

0 0.75 1.5 3 *Miles*

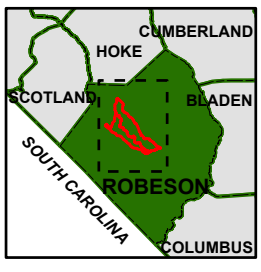

FIGURE 10
SUB-WATERSHED UNIT DIVISIONS
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

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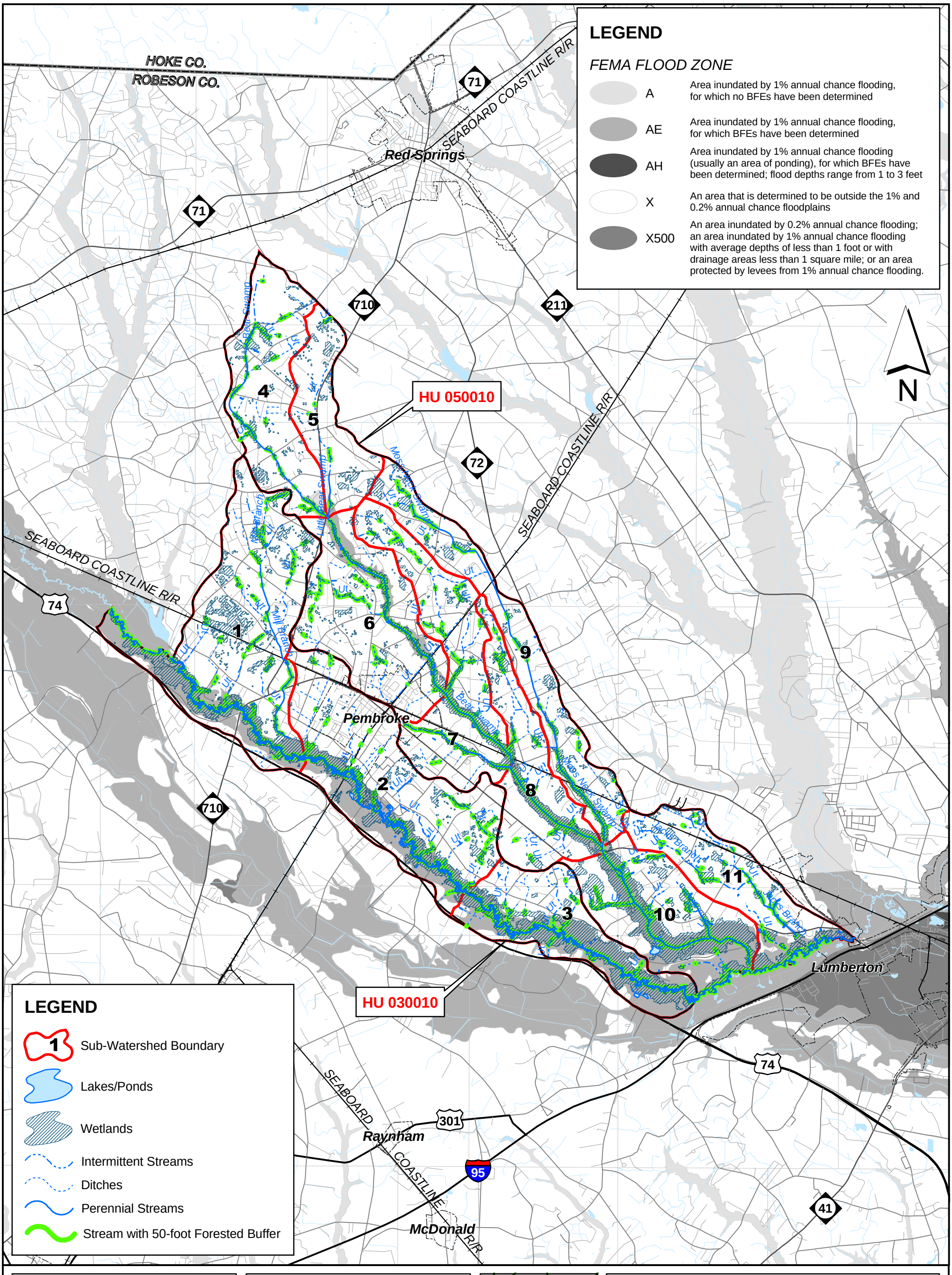

NCDENR

Ecosystem Enhancement Program

FIGURE 11 - HYDROLOGY AND WATER QUALITY FUNCTION INDICATORS

(50-FOOT FORESTED BUFFER)

Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\F11_wat-ind50.mxd 2/04

LEGEND

FEMA FLOOD ZONE

A	Area inundated by 1% annual chance flooding, for which no BFEs have been determined
AE	Area inundated by 1% annual chance flooding, for which BFEs have been determined
AH	Area inundated by 1% annual chance flooding (usually an area of ponding), for which BFEs have been determined; flood depths range from 1 to 3 feet
X	An area that is determined to be outside the 1% and 0.2% annual chance floodplains
X500	An area inundated by 0.2% annual chance flooding; an area inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from 1% annual chance flooding.

HOKE CO.
ROBESON CO.
Red Springs
SEABOARD COASTLINE R/R
Pembroke
Lumberton
Raynham
McDonald
Rowland
HU 050010
HU 030010
Little Bear Swamp
Mossy Neck Swamp
Mill Branch
Jacks Branch
Ut

LEGEND

- Sub-Watershed Boundary
- Lakes/Ponds
- Wetlands
- Intermittent Streams
- Ditches
- Perennial Streams
- Stream with 300-foot Forested Buffer

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1;
Federal Emergency Management Agency (FEMA) National Flood Insurance Program;
NCDOT GIS Unit; NCDENR

0 0.75 1.5 3 *Miles*

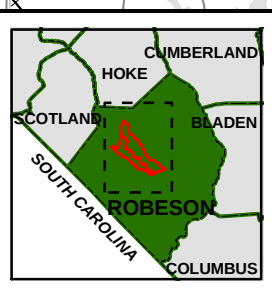

FIGURE 12 - HYDROLOGY AND WATER QUALITY FUNCTION INDICATORS
(300-FOOT FORESTED BUFFER)

Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\F12_wat-ind300.mxd 2/04

HOKE CO.
ROBESON CO.
Red Springs
Rennert
Pembroke
Raynham
McDonald
Lumberton
SEABOARD COASTLINE R/R
71
710
211
72
74
301
95
41
N
HU 050010
HU 030010
1
2
3
4
5
6
7
8
9
10
11

LEGEND

- 1 — Sub-Hydrological Unit
- Interior Patches > 74 Acres
- Forested Community
- Agricultural Crop Fields
- Agricultural Pasture/Hay and Natural Herbaceous
- Other Cover Types
- 600-foot wide Forested Corridor

NCDENR
Ecosystem Enhancement Program

Source:

North Carolina Center for Geographic Information and Analysis (CGIA) Basin Pro 3.1; NCDOT GIS Unit; NCDENR

0 0.75 1.5 3 *Miles*

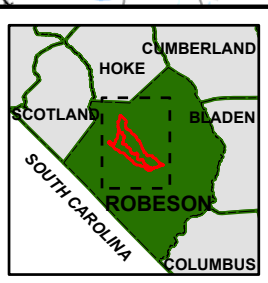

FIGURE 13
HABITAT FUNCTION INDICATORS
Lumber River Local Watershed Plan
Watershed Characterization
HU 030010 & HU 050010
Robeson County, North Carolina

Q:\69796\GIS\Figs_LWP_Rev\F13_hab-ind.mxd 2/04

FILE	GEO_TYPE	PATH	f1_vic	f2_steward	f3a_topo	f3b_topo	f4_soils	f5_landuse	f6_waterUS	f7infr	f8_waterqual	f9_subshed	f10_T&Espec	f11_wat-ind	f12_wat-ind	f13_habcor	process only*	SOURCE1	SOURCE 2	CREATED FROM	DESCRIPTION	ADDED FIELDS	CREATION/UPDATE PROCESSES
lumberbear_hu.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\Shapef	X	X	X	X	X	X	X	X	X	X	X	X	X	X		WRP			Boundary for HU 030010 (Lumber River) and HU 050010 (Bear Swamp)	SUBSHED_N	Populated **SUBSHED_N** with appropriate HU name (Bear Swamp or Lumber River)
countybnd.shop	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X	X	X	X	X	X	X	X	X	X	X	X	X	X		BasinPro 3.1			Statewide county boundaries	None	None
interstate highway.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X	X	X	X	X	X		X	X	X	X	X	X	X		NCDOT GIS			Interstate highways within Robeson County	None	None
primary roads.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X															BasinPro 3.1			Statewide primary roads	None	None
major rivers.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X															BasinPro 3.1			Statewide major rivers	None	None
hydromaj.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X															BasinPro 3.1			Statewide major hydrography	None	None
municipalbnd.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X	X	X	X				X								BasinPro 3.1			Statewide municipal boundaries	None	None
railrd_robe.shp	Line	Q:\69796\GIS\Spatial\NAD83m\NCDOT\Infr		X	X	X	X	X		X	X	X	X	X	X	X		NCDOT GIS			Railroads within Robeson County	None	None
roads_robe.shp	Line	Q:\69796\GIS\Spatial\NAD83m\NCDOT\Infr		X			X	X		X	X	X	X	X	X	X		NCDOT GIS			Roads within Robeson County	None	None
contour1ft.shp	Line	Q:\69796\GIS\Spatial\NAD83f\LIDAR			X													Earth Tech	LIDAR (North Carolina Floodplain Mapping Program)		1-foot contours for HU using LIDAR data.	Cont_Type	Made point files from xyz data, used spatial analyst to create elevation grids from point files and breaklines. Used spatial analyst to create 1-foot contours from elevation grids. Added cont_type attribute to specify even contours, every 5 feet, and every 10 feet.
hs3270 - hs3810 (Note 1)	Raster	Q:\69796\GIS\Spatial\NAD83f\LIDAR\HillshadeGrids\				X												Earth Tech	LIDAR (North Carolina Floodplain Mapping Program)	hs3270-hs3810	Hillshade grids created from LIDAR Data.		Made point files from xyz data, used spatial analyst to create elevation grids from point files and breaklines. Created hillshade grids from elevation grids, using default values.
soils_swh.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef					X											Earth Tech	WRP	combination of various Robeson County soil survey polygon coverages	Soil survey within HU 030010 and HU 050010	SUBSHED_N; SUBSHED_ID; Area_m; SOILS_DE	Converted from GIS coverage file to shapefile using ArcInfo. Intersected with lumberbear_sw.shp for sub-HU analysis. **SUBSHED_N** populated with corresponding HU; **SUBSHED_ID** poplulated with sub-HU number; Area_m populated by calculating area of polygon shapes in sq meters; **SOILS_DE** populated with soil type descriptions which match **DSL_NAME** abbreviation (source for definitions: Soil survey book - Robeson County, NC CGIA metadata for soils - Robeson County).
ponds_swh.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef					X	X	X		X			X	X	X		Earth Tech	WRP	hydro_03 polygon coverage	Water bodies withing HU 030010 and HU 050010	None	Created from hydro_03.shp; clipped using lumberbear_hu.shp.
hydro_03_ln.shp	Line	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef		X	X	X	X	X	X	X	X	X	X	X	X	X		WRP			Hydrography coverage file (arc)	None	None
hydro_03_pl.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef		X	X	X	X	X	X	X	X	X	X	X	X	X		WRP			Hydrography coverage file (polygon)	None	None
lcgap_swh.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\GAP\shapef						X										Earth Tech	NCGAP	lc_ncgap grid file	Landuse/land cover within HU 030010 and HU 050010	SUBSHED_N; SUBSHED_ID: Area_m; LULC_DE	Converted from GIS grid file to shapefile using ArcInfo. Intersected with lumberbear_sw.shp for sub-HU analysis. **SUBSHED_N** populated with corresponding HU; **SUBSHED_ID** populated with sub-HU number; Area_m populated by calculating area of polygon shapes in sq meters; **LULC_DE** populated with land use/land cover descriptions which match **GRIDCODE** (source for definitions: GAP).
ditches_swh.shp	Line	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef						X						X	X			Earth Tech	WRP	hydro_03 arc coverage	Ditches with HU 030010 and HU 050010	SUBSHED_N; SUBSHED_ID; LENGTH_M	Converted from GIS coverage file to shapefile using ArcView. (Selected fields **MAJOR1=50 AND MINOR1=414** within coverage (represents ditches according to WRP codes), saved selected features as current shapefile.) Intersected with lumberbear_sw.shp for sub-HU analysis. **SUBSHED_N** populated with corresponding HU; **SUBSHED_ID** populated with sub-HU number; **LENGTH_M** populated by calculating length of polylines in meters
hydrol_swh.shp	Line	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef						X						X	X			Earth Tech	BasinPro3.1	lumber.shp	Lumber River banks, Perennial and Intermittent streams within HU 030010 and HU 050010	SUBSHED_N; SUBSHED_ID; LENGTH_M; SWHNum; Status	Clipped from lumber.shp, using LRHU_SW.shp. Added Status field: Perennial = **MINOR1**=412; Intermittent = MINOR1=412&MINOR2orMINOR3=610; Ditch = MINOR1=414; River = MINOR1=605or606; Carolina Bay = MINOR1=205; Shoreline = MINOR1=200. **SUBSHED_N** populated with corresponding HU; **SUBSHED_ID** populated with sub-HU number; **LENGTH_M** populated by calculating length of polylines in meters

FILE	GEO_TYPE	PATH	f1_vic	f2_steward	f3a_topo	f3b_topo	f4_soils	f5_landuse	f6_waterUS	f7infr	f8_waterqual	f9_subshed	f10_T&Espec	f11_wat-ind	f12_wat-ind	f13_habcor	process only*	SOURCE1	SOURCE 2	CREATED FROM	DESCRIPTION	ADDED FIELDS	CREATION/UPDATE PROCESSES
wakulla (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) Wakulla area	None	None
rowland (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) Rowland area	None	None
rennert (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) Rennert area	None	None
sw_lumberton (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) SW Lumberton area	None	None
pembroke (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) Pembroke area	None	None
nw_lumberton (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) NW Lumberton area	None	None
mcdonald (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) McDonald area	None	None
maxton (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) Maxton area	None	None
red_springs (grid)	DEM	Q:\69796\GIS\Spatial\NAD83m\USGS\DEM							X									USGS			Digital Elevation Model (DEM) Red Springs area	None	None
airport_robe.shp	Line	Q:\69796\GIS\Spatial\NAD83m\NCDOT\Infr			X	X				X								NCDOT GIS			Airports	None	None
tippt_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\NCDOT\Other								X								Earth Tech	NCDOT GIS	tippt.shp	TIP bridge projects within HU 030010 and HU 050010	None	Clipped using lumberbear_sw.shp.
tipln.shp	Line	Q:\69796\GIS\Spatial\NAD83m\NCDOT\Other								X								NCDOT GIS			TIP roadway projects within North Carolina	None	None
cwmft_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\CWMTF									X							Earth Tech	BasinPro 3.1	cwmtf.shp	Clean Water Management Trust Fund (CWMTF) improvement project	None	Clipped using lumberbear_sw.shp.
pollut_perm.shp	Point	Q:\69796\GIS\Spatial\NAD83m\Shapef									X							Earth Tech	BasinPro 3.1	npdes1.shp (BasinPro 3.1) and NPDES	NPDES waster permit location	COC_Number; Facility	Point location shapefile created using NPDES permit information from BasinPro 3.1 and NPDES databases (see Section 7.0 Bibliography) Populated **COC_Number** with NPDES permit number; populated **Facility** with facilty name/business name of permit holder.
wtreat_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Infrastructure									X							Earth Tech	BasinPro 3.1	pollut.shp	Water treatment plants within HU 030010 and HU 050010	None	Clipped using lumberbear_sw.shp.
wwells_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Infrastructure									X							Earth Tech	BasinPro 3.1	wtreat.shp	Water wells within HU 030010 and HU 050010	None	Clipped using lumberbear_sw.shp.
wtanks_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Infrastructure									X							Earth Tech	BasinPro 3.1	wtanks.shp	Water tanks within HU 030010 and HU 050010	None	Clipped using lumberbear_sw.shp.
sdish_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Infrastructure									X							Earth Tech	BasinPro 3.1	sdish.shp	Sewer discharges within HU 030010 and HU 050010	None	Clipped using lumberbear_sw.shp.
streat_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Infrastructure									X							Earth Tech	BasinPro 3.1	streat.shp	Sewer treatment plants within HU 030010 and HU 050010	None	Clipped using lumberbear_sw.shp.
spumps_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Infrastructure									X							Earth Tech	BasinPro 3.1	spumps.shp	Sewer pumps within HU 030010 and HU 050010	None	Clipped using lumberbear_sw.shp.
hydrol_hu.shp	Line	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef									X							Earth Tech	WRP	hydro_03 arc coverage	Hydro within HU 030010 and HU 050010	None	Converted to from Arc coverage polygon file to shapefile using ArcInfo. Clipped using lumberbear_hu.shp.
hqworwdwq.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State									X							BasinPro 3.1			DWQ High Quality Water (HQW) and Outstanding Resource Water (ORW) watersheds	None	None
wsw.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State									X							BasinPro 3.1			Water supply watersheds with DWQ classifications (Aug 03, 1992)	None	None
LRHU_SW.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\Shapef										X	X	X	X	X		Earth Tech	WRP	lumberbear_hu.shp	HU 030010 and HU 050010 divided into 9 sub-HUs	SUBSHED_N; SUBSHED_ID; Area_m; Area_ac; Area_mi	Created by deliniating HU 030010 and HU 050010 divided into 9 sub-HUs. Populated **SUBSHED_N** with appropriate HU name (Bear Swamp or Lumber River); populated **SUBSHED_ID** with an number 1-9 which identifies the polygon as one of the 9 sub-HUs; populated Area_m by calculating area of polygons in sq meters; populated Area_ac by calculating area of polygons in acres; populated Area_mi by calculating area of polygons in sq miles.
nheo_hu.shp	Point	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Natural											X					Earth Tech	BasinPro 3.1	nheo.shp	Threatened and endangered species	None	Clipped using lumberbear_sw.shp.

FILE	GEO_TYPE	PATH	f1_vic	f2_steward	f3a_topo	f3b_topo	f4_soils	f5_landuse	f6_waterUS	f7infr	f8_waterqual	f9_subshed	f10_T&Espec	f11_wat-ind	f12_wat-ind	f13_habcor	process only*	SOURCE1	SOURCE 2	CREATED FROM	DESCRIPTION	ADDED FIELDS	CREATION/UPDATE PROCESSES
snha_hu.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Natural											X					Earth Tech	BasinPro 3.1	snha.shp	Significant natural heritage area (NHP Program)	SUBSHED_N; SUBSHED_ID; Area_m; Area_ac; Area_mi	Intersected with lumbervear_sw.shp for sub-HU analysis. Populated **SUBSHED_N** with appropriate HU name (Bear Swamp or Lumber River); populated **SUBSHED_ID** with an number 1-9 which identifies the polygon as one of the 9 sub-HUs; populated Area_m by calculating area of polygons in sq meters; populated Area_ac by calculating area of polygons in acres; populated Area_mi by calculating area of polygons in sq miles.
lcgap_wet_swh	Polygon	Q:\69796\GIS\Spatial\NAD83m\GAP\shapef												X	X			Earth Tech	WRP	lcgap_swh.shp	Wetlands within HU 030010 and HU 050010	NONE	Created from lcgap_swh.shp by selecting wetland polygons. Wetlands are a combination of communities where **GRIDCODE**=15 (Seepage and Streamhead Swamps), 30 (Cypress-Gum Floodplain Forests), 41 (Peatland Atlantic White-Cedar Forests), 49 (Coastal Plain Oak Bottomland Forests), 50 (Coastal Plain Mixed Bottomland Forests), 67 (Wet Longleaf or Slash Pine Savanna), 78 (Pond-Cypress. Gum Swamps, Savannas and Lakeshore), 87 (Pocosin Woodlands and Shrublands), 158 (Coastal Plain Nonriverine Wet Flat Forests), 380 (Coastal Plain Fresh Water Emergent).
rip50_swh.shp	Line	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef												X				Earth Tech	WRP	ditches_sw.shp	Lengths of ditches, intermittent and perennial (including Lumber River) with a 50-feet forested (riparian) buffer on both sides of stream (within HU 030010 and HU 050010)	LENGTH_M; LENGTH_FT	Updated linear quantities for LENGTH_M and **LENGTH_FT**. See appendix for creation process.
FloodZones.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\FEMA												X	X			FEMA			FEMA floodplains/floodzones for Eastern North Carolina	NONE	NONE
rip300_swh.shp	Line	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef													X			Earth Tech	WRP	ditches_sw.shp	Lengths of ditches, intermittent and perennial (including Lumber River) with a 300-feet forested (riparian) buffer on both sides of stream (within HU 030010 and HU 050010)	LENGTH_M; LENGTH_FT	Updated linear quantities for **LENGTH_M** and **LENGTH_FT**. See appendix for creation process.
hab_corr_buff.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\Shapef														X		Earth Tech			600 feet wide, forested habitat corridors which connect continuous forests >= 74 acres (see lcgap_forest_sw.shp)	Rating; Connection	Populated **Rating** and **Connection** fields. See appendix for creation process.
for_74ac.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\Shapef														X		Earth Tech	GAP	lcgap_forest_sw.shp	74+ acre continuous forested habitats within HU 030010 and HU 050010	AREA_M; AREA_AC; REL_SW; HABITAT_ID	Updated area quantities for **AREA_M** and **AREA_AC**. See appendix for creation process and field definition/updates.
lcgap_forest_swh.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\GAP\shapef														X		Earth Tech	GAP	lcgap_sw.shp	Forested communities within within HU 030010 and HU 050010	Area_M; Area_AC; Dissolve	Updated area quantities for **Area_M** and **Area_AC**. Populated **Dissolve** field with a value of "1" (for a common dissolve value). See appendix for forested community definitions and creation process.
lmcos_hu.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBSHU\Managed		X														Earth Tech	BasinPro	lmcos.shp	Managed lands within HU 030010 and HU 050010 (shapefile provide from BasinPro oranization)	SUBSHED_N	Intersected with lumberbear_hu.shp. SUBSHED_N populated with corresponding HU

General Notes

Refer to appendix for other files used in intermediate steps.

All files are projected in NAD 83, North Carolina, metric coordinates.

In column SOURCE1, Earth Tech is listed as primary source of data when a GIS file is created by Earth Tech or

Specific Notes

1. These files are not included on the CD.

Natural Communities Processing

SUB-WS NATURAL COMMUNITY ANALYSIS

Purpose: Make shapefile that distinguishes natural communities within each subwatershed.

Sources: lcgap_hu.shp – land cover from GAP, within HU 050010 and HU 030010.

Method:

- TOOLS, GEOPROCESSING WIZARD, INTERSECT TWO LAYERS: lcgap_forest_hu.shp as the input layer, lumberbear_sw.shp as the overlay layer.

Output: Shapefile: lcgap_sw.shp

FORESTED COMMUNITIES

Purpose: Make shapefile containing all forested natural communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all forested communities. Forested communities are made up of the following:

GRIDCODE	DESCRIPTION
15	Seepage and Streamhead Swamps
20	Coniferous Regeneration
21	Coniferous Cultivated Plantation (natural/planted)
30	Cypress-Gum Floodplain Forests
41	Peatland Atlantic White-Cedar Forests
42	Xeric Longleaf Pine
49	Coastal Plain Oak Bottomland Forests
50	Coastal Plain Mixed Bottomland Forests
63	Coastal Plain Mesic Hardwood Forests
67	Wet longleaf or Slash Pine Savanna
78	Pond-Cypress, Gum Swamps, Savannas and Lakeshore
87	Pocosin Woodlands and Shrublands
97	Mesic Longleaf Pine
138	Coastal Plain Dry to Dry-Mesic Oak Forests
158	Coastal Plain Nonriverine Wet Flat Forests
382	Dry Mesic Oak Pine Forests
383	Coastal Plain Mixed Successional Forest

- Export the selected data set as a new shapefile: lcgap_forest_sw.shp.

Output: Shapefile: lcgap_forest_sw.shp

CLEARED COMMUNITIES

Purpose: Make shapefile containing all cleared natural communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all cleared communities. Cleared communities are made up of the following:

GRIDCODE	DESCRIPTION
20	Coniferous Regeneration
36	Successional Deciduous Forests
173	Coastal Plain Riverbank Shrubs
180	Agricultural Crop Fields
202	Residential Urban
203	Urban Low-Intensity Developed
204	Urban High-Intensity Developed and Transportation Corridors
205	Agricultural Pasture/Hay and Natural Herbaceous
214	Barren; Bare Rock and Sand
380	Coastal Plain Fresh Water Emergent

- Export the selected data set as a new shapefile: lcgap_cleared_sw.shp.

Output: Shapefile: lcgap_cleared_sw.shp

WETLAND COMMUNITIES

Purpose: Make shapefile containing all wetland communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all wetland communities. Wetland communities are made up of the following:

GRIDCODE	DESCRIPTION
15	Seepage and Streamhead Swamps
30	Cypress-Gum Floodplain Forest
41	Peatland Atlantic White-Cedar Forests
49	Coastal Plain Oak Bottomland Forests
50	Coastal Plain Mixed Bottomland Forests
67	Wet-Longleaf or Slash Pine Savanna
78	Pond-Cypress, Gum Swamps, Savannas and Lakeshore
87	Pocosin Woodlands and Shrublands
158	Coastal Plain Nonriverine Wet Flat Forests
173	Coastal Plain Riverbank Shrubs
380	Coastal Plain Fresh Water Emergent

- Export the selected data set as a new shapefile: lcgap_wet_sw.shp.

Output: Shapefile: lcgap_wet_sw.shp

IMPERVIOUS COMMUNITIES*

Purpose: Make shapefile containing all impervious communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all impervious communities. Impervious communities are made up of the following:

  GRIDCODE DESCRIPTION
  202 Residential Urban
  203 Urban Low-Intensity Developed
  204 Urban High-Intensity Developed and Transportation Corridors
- Export the selected data set as a new shapefile: lcgap_imperv_sw.shp.

Output: Shapefile: lcgap_imperv_sw.shp

*Note: Is not representative of road surfaces (see page A-15 for complete description of calculation).

DECIDUOUS FOREST COMMUNITIES

Purpose: Make shapefile containing all deciduous forest communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all deciduous forest communities. Deciduous forest communities are made up of the following:

  GRIDCODE DESCRIPTION
  36 Successional Deciduous Forests
  63 Coastal Plain Mesic Hardwood Forests
  138 Coastal Plain Dry to Dry-Mesic Oak Forests
- Export the selected data set as a new shapefile: lcgap_decfor_sw.shp.

Output: Shapefile: lcgap_decfor_sw.shp

EVERGREEN FOREST COMMUNITIES

Purpose: Make shapefile containing all deciduous forest communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all evergreen forest communities. Evergreen forest communities are made up of the following:

  GRIDCODE DESCRIPTION

42	Xeric Longleaf Pine
97	Mesic Longleaf Pine
20	Coniferous Regeneration

- Export the selected data set as a new shapefile: lcgap_everfor_sw.shp.

Output: Shapefile: lcgap_everfor_sw.shp

MIXED FOREST

Purpose: Make shapefile containing all mixed forest communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all mixed forest communities. Mixed forest communities are made up of the following:

GRIDCODE	DESCRIPTION
382	Dry Mesic Oak Pine Forest
383	Coastal Plain Mixed Successional Forest
173	Coastal Plain Riverbank Shrubs

- Export the selected data set as a new shapefile: lcgap_mixfor_sw.shp.

Output: Shapefile: lcgap_mixfor_sw.shp

WOODY WETLANDS

Purpose: Make shapefile containing all woody wetland communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all woody wetland communities. Woody wetland communities are made up of the following:

GRIDCODE	DESCRIPTION
15	Seepage and Streamhead Swamps
30	Cypress-Gum Floodplain Forests
41	Peatland Atlantic White-Cedar Forests
49	Coastal Plain Oak Bottomland Forests
50	Coastal Plain Mixed Bottomland Forests
67	Wet Longleaf or Slash Pine Savanna
78	Pond-Cypress, Gum Swamps, Savannas and Lakeshore
87	Pocosin Woodlands and Shrublands
158	Coastal Plain Nonriverine Wet Flat Forests

- Export the selected data set as a new shapefile: lcgap_woodwet_sw.shp.

Output: Shapefile: lcgap_woodwet_sw.shp

EMERGENT HERBACEOUS WETLANDS

Purpose: Make shapefile containing all emergent herbaceous wetland communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all emergent herbaceous wetlands. Emergent herbaceous wetlands are made up of the following:

GRIDCODE	DESCRIPTION
380	Coastal Plain Fresh Water Emergent

- Export the selected data set as a new shapefile: lcgap_emherbwet_sw.shp.

Output: Shapefile: lcgap_emherbwet_sw.shp

CULTURAL

Purpose: Make shapefile containing all cultural communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all cultural communities. Cultural communities are made up of the following:

GRIDCODE	DESCRIPTION
202	Residential Urban
203	Urban Low-Intensity Developed
204	Urban High-Intensity Developed and Transportation Corridors

- Export the selected data set as a new shapefile: lcgap_cultr_sw.shp.

Output: Shapefile: lcgap_cultr_sw.shp

AGRICULTURAL

Purpose: Make shapefile containing all agricultural communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all agricultural communities. Agricultural communities are made up of the following:

GRIDCODE	DESCRIPTION
180	Agricultural Crop Fields
205	Agricultural Pasture/Hay and Natural Herbaceous
21	Coniferous Cultivated Plantation (natural/planted)

- Export the selected data set as a new shapefile: lcgap_agric_sw.shp.

Output: Shapefile: lcgap_agric_sw.shp

OTHER

Purpose: Make shapefile containing all *other* communities within subwatersheds.

Sources: lcgap_sw.shp – land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- SELECTION, SELECT BY ATTRIBUTES: using lcgap_sw.shp where the field "GRIDCODE" equals all *other* communities. *Other* communities are made up of the following:

GRIDCODE	DESCRIPTION
8	Open Water
214	Barren; bare rock and sand

- Export the selected data set as a new shapefile: lcgap_other_sw.shp.

Output: Shapefile: lcgap_other_sw.shp

Habitat Functions

74+ ACRE CONTINUOUS FOREST

Step 1

Purpose: Combine all forested community types into a single community, which represents all forested communities.

Sources: lcgap_forest_sw.shp – forested land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- Open the attribute table of lcgap_forest_sw. Using the OPTIONS pull-down, choose ADD FIELD (Name: DISSOLVE; Type: Short Integer; Precision: 5).
- Right-click on the "DISSOLVE" field heading, choose CALCULATE VALUE. In the script-box (below the prompt "Dissolve=") key-in the value of "1", followed by selecting the "OK" button. This will populate all records with a value of "1" under the "DISSOLVE" field.
- TOOLS, GEOPROCESSING WIZARD, DISSOLVE FEATURES BASED ON AN ATTRIBUTE: lcgap_forest_sw.shp as the input layer, "DISSOLVE" as the attribute on which to dissolve.

Output: shapefile: forest_74ac.shp. (shapefile is a single non-contiguous polygon representing all forested communities.)

Step 2

Purpose: Separate the single non-contiguous polygon (representing forested communities) into individual polygons.

Sources: forest_74ac.shp – forested land cover, subdivided within HU 050010 and HU 030010.

Method:

- Using ArcInfo, convert forest_74ac.shp to a covereage. Attributes do not need to be maintained, so can use command 'shapearc'. This builds the coverage as polygons, adding topology by default. There may be internal polygons that are not forested.
- Convert the coverage back to a shapefile, replacing forest_74ac.shp.
-

Output: shapefile: forest_74ac.shp. (shapefile is multiple polygons)

Step 3

Purpose: Create 300ft wide road buffers around road centerlines. This represents "buffer zones" between forested habitats that are created by roads.

Sources: roads_robe.shp – NCDOT roads within Robeson County.

Method:

- TOOLS, GEOPROCESSING WIZARD, CLIP ONE LAYER BASED ON ANOTHER: roads_robe.shp as the input layer to clip, lumberbear_hu.shp as the polygon clip layer. Output dotroads_hu.shp
- TOOLS, BUFFER WIZARD: features of a layer: dotroads_hu.shp. Buffer this shapefile with a 300ft wide buffer.

Output: shapefile: dotroads_buff300.shp.

Step 4

Purpose: Delete road "buffers" from forested areas, to create forested polygons separated by roads.

Sources: lcgap_forest_sw.shp – forested land cover from GAP, subdivided within HU 050010 and HU 030010.

Method:

- TOOLS, GEOPROCESSING WIZARD, INTERSECT TWO LAYERS: lcgap_forest_sw.shp as the input layer, dotroads_buff300.shp as the overlay layer. Output shapefile: for_74ac.shp
- SELECTION, SELECT BY ATTRIBUTES: using for_74ac.shp where the field "DISSOLVE" = "1". Delete these elements.

Output: shapefile: for_74ac.shp

Step 5

Purpose: Add an area (sq. meters) field to the database of for_74ac.shp and populate the field with quantities.

Sources: for_74ac.shp – forested land cover from GAP, with road "buffers" removed, subdivided within HU 050010 and HU 030010.

Method:

- Open the attribute table of for_74ac.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: AREA_M; Type: Double; Precision: 0).
- Populate the new "AREA_M" field with quantities in sq. meters. Right click on the "AREA_M" field heading; choose CALCULATE VALUE. Select the ADVANCED check box. Next, in the script-box (below the prompt "Pre-Logic VBA Script Code") key-in the following:

  Dim dblArea as double
  Dim pArea as IArea
  Set pArea = [shape]
  dblArea = pArea.area

  In the next script-box (below the prompt "Area_m") key-in "dblArea". Finish the process by selecting the "OK" button. This will calculate and populate all records with a sq. meters value in the "AREA_M" field.

Step 6

Purpose: Add an area (acres) field to the database of for_74ac.shp and populate the field with quantities.

Sources: for_74ac.shp – forested land cover from GAP, with road "buffers" removed, subdivided within HU 050010 and HU 030010.

Method:

- Open the attribute table of for_74ac.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: AREA_AC; Type: Double; Precision: 0).
- Populate the new "AREA_AC" field with quantities in acres. Right click on the "AREA_AC" field heading; choose CALCULATE VALUE. Next, in the script-box (below the prompt "Area_ac") key-in [Area_m]/4046.825 . Finish

the process by selecting the "OK" button. This will calculate and populate all records with a sq. meters value in the "AREA_AC" field, by converting the quantities in the "AREA_M" field to acres.

Step 7

Purpose: Modify for_74ac.shp to contain only forested polygons >= 74 acres.
Sources: for_74ac.shp – forested land cover from GAP, with road "buffers" removed, subdivided within HU 050010 and HU 030010.
Method:

- SELECTION, SELECT BY ATTRIBUTES: using for_74ac.shp where the field "AREA_AC" < "74". Delete these elements.

Step 8

Purpose: Assign an identifying number to each forested polygon.
Sources: for_74ac.shp – forested land cover from GAP, with road "buffers" removed, subdivided within HU 050010 and HU 030010.
Method:

- Open the attribute table of for_74ac.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: HABITAT_ID; Type: Short Integer; Precision: 5).
- Using editor, enter unique incremental values for each forested polygon. Identify each polygon with this value, starting north to south/east to west.

Step 9

Purpose: Add relevant subwatershed number to forested polygons.
Sources: for_74ac.shp – forested land cover from GAP, with road "buffers" removed, subdivided within HU 050010 and HU 030010.
Method:

- Open the attribute table of for_74ac.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: REL_SW; Type: TEXT; Length: 15).
- Using editor, enter the subwatershed identifying number (lumberbear_sw.shp, field: SUBSHED_ID) which contains all or part of the forested polygon. For instance, if the polygon is entirely contained within subwatershed "4", enter "04" in the field REL_SW. If the polgon is contained in both subwatershed "4", "5" and "6", enter "04 05 06" in the field REL_SW.

HABITAT CORRIDORS

With the completion of all steps, hab_corr_buff.shp will represent potential corridors that may be used to traverse between 74+-acre forested patches. These corridors should easily identify which forested patches they connect, and have a rating assigned which generally identifies natural communities within.

Step 1

Purpose: Create a shapefile that shows a centerline path of potential "habitat corridors", that will permit movement between 74+ acre habitat areas.

Sources: for_74ac.shp – forested land cover from GAP, with road "buffers" removed, subdivided within HU 050010 and HU 030010.

Method:

- Create a new line shapefile named hab_corr.shp.
- Using editor, create new features within hab_corr.shp that represent centerlines of corridors that connect the polygons of for_74ac.shp to each other. Use the following guidelines when considering path locations:
    - Upon completion, corridors will be 600ft wide (a 300-ft wide buffer of your corridor centerline). When choosing these locations, consider the width of the corridor and what natural communities will be contained within it.
    - The most desirable corridors contain only forested communities.
    - Avoid any area where cultural communities will appear within a 300' wide buffer of your corridor centerline.
    - Less desirable corridors (but still taken into consideration) contain very small amounts of other natural communities. However, the major community appearing within the corridor should be forested.

Step 2

Purpose: Create a shapefile that is a 300-ft buffer of the corridor centerline (600-ft wide corridor).

Sources: hab_corr.shp – centerlines of habitat corridors within HU 050010 and HU 030010.

Method:

- TOOLS, BUFFER WIZARD, select hab_corr.shp as the features of a layer you want to buffer. Create buffers AT A SPECIFIED DISTANCE of 300 feet. BUFFER DISTANCE UNITS should be selected as feet. Save buffers IN A NEW LAYER, naming them hab_corr_buff.shp.

Output: Shapefile: hab_corr_buff.shp

Step 3

Purpose: Modify hab_corr_buf.shp to ensure the ends of corridors that connect the forested polygons are "flush" with the edges of forest (not overlapping).

Sources: hab_corr_buff.shp – 600-ft wide habitat corridors within HU 050010 and HU 030010.

Method:

- Using editor, CUT POLYGON FEATURES of hab_corr_buff.shp, where ends of the corridors overlap the forested areas. Delete the overlapping areas. A helpful tool when cutting these edges is the SNAPPING function under EDITOR. Enable snapping to the VERTEX, EDGE, and END of for_74ac.shp. This will allow you to "snap" to exact edges of forested areas, when trimming the corridors.

Step 4

Purpose: Assign a "rating" to each of the newly created habitat corridors. Also, identify the forested polygons that each corridor connects.

Sources: hab_corr_buff.shp – 600-ft wide habitat corridors within HU 050010 and HU 030010.

Method:

- Open the attribute table of hab_corr_buff.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: Rating; Type: Text; Length: 5).
- Using editor, enter a value of "A" or "B" into the field RATING. The following defines the values of "A" and "B":
    - VALUE "A" represents a habitat corridor that contains entirely forested communities.
    - VALUE "B" represents a habitat corridor that contains a majority of forested communities, with small appearances of other natural communities.

Step 5

Purpose: Identify which forested habitat polygons are connected by the appropriate habitat corridors.

Sources: hab_corr_buff.shp – 600-ft wide habitat corridors within HU 050010 and HU 030010.

Method: Open the attribute table of hab_corr_buff.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: Connection; Type: Text; Length: 10). Using editor, enter a values into the field CONNECTION based on which forested habitats they connect. For example, if a habitat corridor connects habitat "4" and "5" (HABITAT_ID value from for_74ac.shp), enter "04 05" into the CONNECTION field.

Other Impervious Surfaces

IMPERVIOUS ROAD SURFACES

Step 1

Purpose: Create a shapefile of NCDOT "universe" road centerlines for analysis/processing within HU 050010 and HU 030010.

Sources: universe_robe.shp – NCDOT "universe" roads within Robeson County. The database file corresponding to this shapefile contains information, such as number of lanes, that is not contained within normal NCDOT road shapefiles such as roads_robe.shp.

Method:

- TOOLS, GEOPROCESSING WIZARD, CLIP ONE LAYER BASED ON ANOTHER: universe_robe.shp as the input layer to clip, lumberbear_hu.shp as the polygon clip layer.

Output: shapefile: universe_hu.shp.

Step 2

Purpose: Buffer road centerlines, with widths depending on number of lanes.

Sources: universe_robe.shp.

Method:

- Look at the LANES field. Select roads that are two lanes. Create temporary buffer file with 12 feet either side of center line. Same procedure for three lanes (18-foot buffer), and four lanes (24-foot buffer).
- Intersect the three temporary files together, to get file with all appropriate buffer distances – temp234lane_un.shp

Step 3

Purpose: Combine impervious roads with (partially) impervious land use types.

Sources: temp234lane_un.shp & lcgap_cultr.shp

Method:

- Intersect temp234lane_un.shp & lcgap_cultr.shp > temp234cult.shp

Step 4

Purpose: Calculate areas for Sub-Watersheds.

Sources: temp234cult.shp & LRHU_SW.shp

Method:

- Intersect temp234cult.shp & LRHU_SW.shp > imperv_swh.shp
- Open the attribute table of imperv_swh.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: AREA_M; Type: Double; Precision: 0).
- Populate the new "AREA_M" field with quantities in sq. meters. Right click on the "AREA_M" field heading; choose CALCULATE VALUE. Select the ADVANCED check box. Next, in the script-box (below the prompt "Pre-Logic VBA Script Code") key-in the following:

  Dim dblArea as double
  Dim pArea as IArea

Set pArea = [shape]
dblArea = pArea.area

In the next script-box (below the prompt "Area_m") key-in "dblArea". Finish the process by selecting the "OK" button. This will calculate and populate all records with a sq. meters value in the "AREA_M" field.

Step 5

Purpose: Calculate quantities of imperviousness for Sub-Watersheds.

Sources: imperv_swh.shp

Method:

- Open attribute table for imperv_swh.shp
- Use 'Select by attributes' to select grid-code = 0 (roads)
- Summarize on SWHLetter field, select AREA_M/sum.
- Save to sumimproad.dbf
- Same process for grid-code = 202 (Res Urban (RU)), 203 (Urban Low-Int. Dev (LI)) and 204 (Urban High-Int. Dev and Transportation (HI)).
- Copy data from dbf files into summary file. Use following calculation to determine amount impervious:

  ((roads x 1) + (RU x 0.5) + (LI x 0.8) + (HI x 0.8)).

Hydrography

STREAM TYPES

Step 1

Purpose: Create a hydrology shapefile containing streams within sub_HUs of HU 050010 and HU 030010.

Sources: hydrol_hu.shp – WRP Hydrology within HU 050010 and HU 030010.

Method:

- TOOLS, GEOPROCESSING WIZARD, INTERSECT TWO LAYERS: Use hydrol_hu.shp as the input layer to intersect, use lumberbear_sw.shp as the polygon overlay layer.

Output: shapefile: hydrol_sw.shp.

Step 2

Purpose: Add length (meters) field to the database of hydrol_sw.shp and populate the field with quantities.

Sources: hydrol_sw.shp – WRP Hydrology within sub HUs of HU 050010 and HU 030010.

Method:

- Open the attribute table of hydrol_sw.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: LENGTH_M; Type: Double; Precision: 0).
- Populate the new "LENGTH_M" field with quantities in linear meters. Right click on the "LENGTH_M" field heading; choose CALCULATE VALUE. Select the ADVANCED check box. Next, in the script-box (below the prompt "Pre-Logic VBA Script Code") key-in the following:

  Dim dblLength as double
  Dim pCurve as ICurve
  Set pCurve = [shape]
  dblLength = pCurve.Length

  In the next script-box (below the prompt "Area_m") key-in "dblLength". Finish the process by selecting the "OK" button. This will calculate and populate all records with a linear meters value in the "LENGTH_M" field.

Step 3

Purpose: Add a length (feet) field to the database of hydrol_sw.shp and populate the field with quantities.

Sources: hydrol_sw.shp – WRP Hydrology within sub HUs of HU 050010 and HU 030010.

Method:

- Open the attribute table of hydrol_sw.shp. Using the OPTIONS pull-down, choose ADD FIELD (Name: LENGTH_FT; Type: Double; Precision: 0).
- Populate the new "LENGTH_FT" field with quantities in linear feet. Right click on the "LENGTH_FT" field heading; choose CALCULATE VALUE. Next, in the script-box (below the prompt "Length_ft") key-in [Length_m]* 3.28083 . Finish the process by selecting the "OK" button. This will calculate and populate all records with a linear feet value in the

"LENGTH_FT" field, by converting the quantities in the "LENGTH_M" field to feet.

Step 4

Purpose: Add attributes that distinguish between stream types (ditches, perennial, intermittent, and major).

Sources: hydrol_sw.shp – WRP Hydrology within sub HUs of HU 050010 and HU 030010.

Method:

- Add field 'Status' (text, 20 characters).

Ditches

- SELECTION, SELECTION BY ATTRIBUTES, (layer=hydrol_sw, method=create a new selection), fields "MAJOR1" = "50" AND "MINOR1" = "414".
- Calculate Status = ditch

Intermittent streams

- SELECTION, SELECTION BY ATTRIBUTES, (layer=hydrol_sw, method=create a new selection), fields "MAJOR1" = "50" AND "MINOR1" = "412" AND "MAJOR2" = "50" AND "MINOR2" = "610".
- Calculate Status = intermittent

Perennial streams

- SELECTION, SELECTION BY ATTRIBUTES, (layer=hydrol_sw, method=create a new selection), fields "MAJOR1" = "50" AND "MINOR1" = "412" AND "MAJOR2" = "-99999". (NOTE: the entry "-99999" for the field "MAJOR2" is irrelevant in the sense of data, but choosing it as part of your selection set ensures that you do not select intermittent streams, since "MAJOR1" and "MINOR1" selections are the same for both perennial and intermittent.)
- Calculate Status = perennial

Major streams (Lumber River), right and left banks

- SELECTION, SELECTION BY ATTRIBUTES, (layer=hydrol_sw, method=create a new selection), fields "MAJOR1" = "50" AND ["MINOR1" = "605" OR "MINOR1" = "606". (NOTE: You are selecting both left and right BANKS, not centerline, so this must be taken into account when deriving quantities)
- Calculate Status = river

STREAMS WITH RIPARIAN BUFFERS (50FT/300FT)

The files listed in Step 5 should display all stream portions that have 50-feet (or 300-feet) forested buffers on both sides of the stream portion. Linear quantities have been updated in these files for summarizing data.

Step 1

Purpose: Create a polygon shapefile that contains forested communities within riparian buffer limits of HU 050010 and HU 030010.

Sources:

hyb50f.shp – WRP polygon file containing 50-feet buffers around streams
hyb300ft.shp – WRP polygon file containing 300-feet buffers around streams.

Method:

- TOOLS, GEOPROCESSING WIZARD, CLIP ONE LAYER BASED ON ANOTHER: Use hyb50f_hu.shp (or hyb300f_hu.shp) as the input layer to clip, lcgap_forest_sw.shp as the polygon clip layer.

Output: shapefile: rip_50ft.shp (or rip_300ft.shp).

Step 2

Purpose: Delete portions of the polygon files (rip_50ft.shp and/or rip_300ft.shp) that do not represent forested buffers on BOTH sides of the streams.

Sources:

rip_50f.shp – Polygon shapefile containing 50-feet forested buffers around streams.
rip_300ft.shp – Polygon shapefile containing 300-feet forested buffers around streams.

Method:

- Display rip_50ft.shp (or rip_300ft.shp) on top of lcgap_forest_sw.shp. If the buffer is continuous (no holes, and extends to the buffer on both sides) then this is 'forested buffer' for the specified distance.
- Using editor, you must MANUALLY select and cut the polygon features of rip_50ft.shp (or rip_300ft.shp) to make 'rectangles' containing continuous forest. Cut the polygons at a 90 degree angle from the stream. Delete the polygons that have holes or are not continuous. When completed, the remaining polygons will display the appropriate riparian buffers.

Step 3

Purpose: Create a line shapefile(s) that represent stream portions that have 50-feet forested buffers (or 300 feet forested buffers) on BOTH sides of the stream.

Sources:

rip_50f.shp – Polygon shapefile containing 50-feet forested buffers around streams.
rip_300ft.shp – Polygon shapefile containing 300-feet forested buffers around streams.

Method:

- TOOLS, GEOPROCESSING WIZARD, CLIP ONE LAYER BASED ON ANOTHER: Use hydrol_sw.shp as the input layer to clip, use rip_50ft.shp as the polygon clip layer.

Output: shapefile: rip50_swh.shp.

- TOOLS, GEOPROCESSING WIZARD, CLIP ONE LAYER BASED ON ANOTHER: Use hydrol_sw.shp as the input layer to clip, use rip_300ft.shp as the polygon clip layer.

Output: shapefile: rip300_swh.shp.

Step 4

Purpose: Calculate linear quantities in meters, for rip50ft_swh.shp and rip300ft_swh.shp

Sources: Line shapefiles that contain streams with a 50-feet forested buffer on both sides (or 300-feet buffer): rip50ft_swh.shp (or rip300ft_swh.shp)

Method:

- Right click on the "LENGTH_M" field heading; choose CALCULATE VALUE. Select the ADVANCED check box. Next, in the script-box (below the prompt "Pre-Logic VBA Script Code") key-in the following:

  Dim dblLength as double
  Dim pCurve as ICurve
  Set pCurve = [shape]
  dblLength = pCurve.Length

  In the next script-box (below the prompt "Area_m") key-in "dblLength". Finish the process by selecting the "OK" button. This will calculate and populate all records with a linear meters value in the "LENGTH_M" field.

Step 5

Purpose: Calculate linear quantities in feet.

Sources: Line shapefiles that contain streams with a 50-feet forested buffer on both sides (or 300-feet buffer): rip50ft_swh.shp (or rip300ft_swh.shp)

Method:

- Open attribute table for rip50ft_swh.shp. Right-click on 'Status' field, and Summarize. Check the length_m/sum field, save as sum_rip50.dbf.
- Open sum_rip50.dbf. Copy values into summary Excel table. For the 'River' quantity, divide by half, as this is both sides of the river.
- Convert meter values to feet.
- Repeat Step 5 method for rip300ft_swh.shp.

Site ID #:	05-015
Figure #:	B-2a
Stream Name:	Little Bear Swamp
Road Name:	W L Moore Woods Rd
State Road #:	SR 1606
Stream Type:	Perennial
T&E Habitat:	
Notes:	1/4 mile from a *Picoides borealis* record
Mitigation Potential:	Stream Restoration

This straightened, unbuffered, 2,000-foot reach of Little Bear Swamp flows through agricultural fields. Full restoration of the 1,000-foot reach north of SR 1606 may be partially constrained by residences on the banks near the road. However, the full 2,000-foot length could potentially be meandered through the soybean fields with at least a 100-foot forested buffer. Reforestation of this reach would create a continuous buffer of at least 6,000 feet along the lower half of Little Bear Swamp to its confluence with Bear Swamp.

Site ID #:	05-019
Figure #:	B-2b
Stream Name:	Moss Neck Swamp
Road Name:	Frank St
State Road #:	
Stream Type:	Intermittent
T&E Habitat:	*Picoides borealis, Rhus michauxii*
Notes:	Moss Neck Savanna NHA, 2 *Picoides borealis* records in vicinity, may be *Rhus michauxii* habitat
Mitigation Potential:	Wetland Preservation, Stream Preservation

This site includes a reach of Moss Neck Swamp, an unnamed tributary to Moss Neck Swamp, and the Moss Neck Savanna Natural Heritage Area. It falls within the Moss Neck Swamp Drainage District. As a Natural Heritage Area, the savanna and 7,000 feet of associated streams are high priorities for protection through preservation if they are not already. Depending upon the current status of the Drainage District, the channelized streams may be considered for restoration or enhancement.

Site ID #: 05-021
Figure #: B-2c
Stream Name: Bear Swamp
Road Name: Red Bank Rd
State Road #: NC 710
Stream Type: Perennial
T&E Habitat:
Notes:
Mitigation Potential: Wetland Enhancement, Stream Enhancement

A church and surrounding residences would limit activities at this site, but Bear Swamp would benefit by the establishment of a forested buffer along the left bank and some structures for channel stabilization. This site is near the confluence with Little Bear Swamp, which also is without a buffer, but residences may be even more constraining in the vicinity of the confluence.

Site ID #: 05-049, 05-050, 05-051, 05-052, 05-053
Figure #: B-2d
Stream Name: Ut Bear Swamp
Road Name: Gough Road, 1st St, W Railroad St, Clifton St, Vance St,
State Road #:
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

This 4,000-foot reach winds through a semi-urban area of Pembroke, with a mixture of residential lots and cultivated fields. There appears to be room to restore meanders and 50-foot buffers on each bank.

Site ID #: 05-055
Figure #: B-2e
Stream Name: Bear Swamp
Road Name: Union Chapel Rd
State Road #: SR 1563
Stream Type: Perennial
T&E Habitat:
Notes:
Mitigation Potential: Wetland Restoration, Stream Enhancement

A pond has been dug off-line of Bear Swamp and the fill used to extend the areas of usable lawn. Wetland restoration of 2-3 acres would be possible if the landowner were willing to fill the pond, grade to the previous natural elevation, and plant trees. Also, an area of the bank is currently stabilized with concrete rubble. Replacement of this rubble with natural structures along with re-establishment of the riparian buffer may provide some enhancement credit.

Site ID #: 05-066, 05-067, 05-068
Figure #: B-2f, B2g
Stream Name: Watering Hole Swamp, Bear Swamp
Road Name: Joseph H, Jones Rd, Chicken Rd
State Road #: SR 1571, SR 1003
Stream Type: Perennial
T&E Habitat:
Notes:
Mitigation Potential: Wetland Restoration, Stream Restoration

This 5,000-foot reach of Watering Hole Swamp appears to provide the best opportunity for traditional stream and wetland restoration in the two HUs. The reach upstream of Jones Road may only yield enhancement, but there is room to meander the stream if further studies show merit. Downstream of Jones Road, Watering Hole Swamp flows through an active cow pasture into Bear Swamp just upstream of N. Chicken Road. The pasture is wide enough and slopes up enough to bordering properties that a full Priority1 stream restoration may be possible without causing hydrologic trespass, which in turn would make wetland restoration possible throughout the pasture, or enhancement in areas where wetland hydrology already exists. Aerial photography shows forest or scrub vegetation on the lower end of the pasture, but this area was all cleared at the time of the field observation. Sub-division construction is in progress on a former agricultural field upslope of the right bank.

Site ID #: 05-071
Figure #: B-2h
Stream Name: Ut Bear Swamp
Road Name: Moss Neck Rd
State Road #: SR 1567
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

This 1,500-foot reach of stream flows through cleared agricultural fields. The stream is carried by culverts under the railroad and Moss Neck Road. There are no other apparent constraints to meandering the stream and establishing at least a 50-foot buffer on each bank.

Site ID #: 05-088
Figure #: B-2i
Stream Name: Ut Bear Swamp
Road Name: Pine Log Rd
State Road #: SR 1549
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

This 2,000-foot reach flows through agricultural fields. Four parallel ditches drain to it. Establishment of a forested buffer would connect a large forested patch at the headwaters of the stream to the Bear Swamp corridor.

Site ID #: 05-092
Figure #: B-2j
Stream Name: Bear Swamp
Road Name: Deep Branch Rd
State Road #: SR 1339
Stream Type: Perennial
T&E Habitat: *Alligator mississippiensis*
Notes:
Mitigation Potential: Wetland Restoration, Wetland Enhancement

This site is just upstream of the confluence of Bear Swamp with the Lumber River. A species on the state list of rare species was recorded here. A recent clearcut was observed on the upstream side of Deep Branch Road, making the site suitable for wetland restoration or enhancement.

Site ID #: 03-030
Figure #: B-2k
Stream Name: Lumber River
Road Name: NC 710
State Road #: NC 710
Stream Type: Perennial
T&E Habitat:
Notes:
Mitigation Potential: Wetland Preservation, Stream Preservation

Only a fraction of the Lumber River within the study HU was visible from road crossings. However, this site is probably fairly representative of the conditions along the river throughout the HU. The main channel is bordered by a well-developed swamp forest of variable width. Near the road crossing the entire buffer width is about 500 feet, but it approaches 5,000 feet in some places. The buffer is compromised in this particular location by a parking lot and boat ramp that extend to the standing water at the edge of the swamp forest.

The reaches of the Lumber River that have a wider buffer most likely include some bottomland hardwood forest on slightly higher elevations. Most of the land where this wetland community would have occurred has been drained and cleared for agriculture or other development, and recent clearcutting of this community was observed in other locations along the Lumber River.

The Lumber River above and below the study HU is designated a National Wild and Scenic River. Permanent protection of this reach through preservation would qualify it for the same designation, as well as maintain the current relatively high level of water quality, habitat, and hydrologic functions.

Site ID #: 03-037
Figure #: B-2l
Stream Name: Ut Lumber River
Road Name: Deep Branch Rd
State Road #: SR 1339
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

At this site, approximately 1,500 feet of stream could be meandered through an agricultural field. Establishment of a riparian buffer would provide a continuous forested connection to the Lumber River just downstream of Deep Branch Road.

Site ID #: 03-038
Figure #: B-2m
Stream Name: Lumber River
Road Name: SR1554
State Road #: SR 1554
Stream Type: Perennial
T&E Habitat:
Notes:
Mitigation Potential: Wetland Enhancement, Wetland Preservation

The discussion of Site 03-030 is applicable to this site. An increase in the buffer width along the right bank would be desirable.

Site ID #: 03-042
Figure #: B-2n
Stream Name: Ut Lumber River
Road Name: Hazel Rd
State Road #: SR 1632
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

This site is constrained along its upper reaches by residential development, although even there it could benefit by some restoration techniques. Beyond the development, about 5,000 feet of stream flows with no apparent constraints through a cleared field to the confluence with the Lumber River.

Site ID #: 03-045
Figure #: B-2o
Stream Name: Ut Lumber River
Road Name: N Chicken Rd
State Road #: SR 1003
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

This stream flows through agricultural fields with minimal apparent constraints to restoration or establishment of a full buffer. It is separated from Site 03-051 by a large forested patch.

Site ID #: 03-050
Figure #: B-2p
Stream Name: Lumber River
Road Name: N Chicken Rd
State Road #: SR 1003
Stream Type: Perennial
T&E Habitat: *Alligator mississippiensis*
Notes: FSC caddisfly recorded here
Mitigation Potential: Wetland Enhancement

The forest bordering the left bank of the Lumber River has been clearcut on both sides of N. Chicken Road at this site. As with the other reaches of the Lumber River, this area may be considered for preservation.

Site ID #: 03-051
Figure #: B-2q
Stream Name: Ut Lumber River
Road Name: Deep Branch Rd
State Road #: SR 1339
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

This site connects upstream through a large forested patch with Site 03-045. Downstream it joins the Lumber River. Restoration of this stream and establishment of a forested buffer would provide a continuous corridor to the Lumber River.

Site ID #: 03-052
Figure #: B-2r
Stream Name: Ut Lumber River
Road Name: Deep Branch Rd
State Road #: SR 1339
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Stream Restoration

This site may be constrained by residences, but there may be opportunity for buffer enhancement.

Site ID #: 03-059
Figure #: B-2s
Stream Name: Ut Lumber
Road Name: Deep Branch Rd
State Road #: SR 1339
Stream Type: Intermittent
T&E Habitat:
Notes:
Mitigation Potential: Wetland Restoration, Stream Restoration

This reach flows through agricultural fields and a clearcut before joining the Lumber River. Constraints to meandering the channel and establishing a full buffer appear minimal. Downstream of Deep Branch Road, wetland restoration or enhancement may be possible on the clearcut area.

Site ID #: 03-061
Figure #: B-2t
Stream Name: Lumber River
Road Name: SR 1550
State Road #: SR 1550
Stream Type: Perennial
T&E Habitat:
Notes:
Mitigation Potential: Stream Enhancement

A retreat center has been built on the banks of the Lumber River at this site. Vegetation has been cleared to the water's edge and concrete rubble is piled along the banks. It may be possible to stabilize the banks with natural structures, and re-establishment of a 50-foot tree buffer appears feasible with landowner cooperation. Again, the discussion under site 03-030 is applicable here.

Alphabetical Contact Listing

	Contact Name	Company Name	Title	Work Phone	Ext.	Fax Number
A						
	Almon, Jane	Earth Tech	Project Manager	(919) 854-7745		(919) 854-6259
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B						
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	Breeding, Rob	DWQ Watershed Assessment Team	Environmental Specialist	(919) 733-5083	592	
D						
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F						
	Frizzell, Michelle	Planning and Zoning Dept	Watershed Administrator	(910) 671-6285		
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J						
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K						
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L						
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P						
	Perry, James	Lumber River Council of Governments	Chief Administrator	(910) 618-5533	3029	(910) 618-5576
	Price, Robert	Moss Neck Drainage District	Attorney	(910) 422-8282		
R						
	Rivenbark, Chris	NCDOT PDEA	(919) 715-1460			
	Ross, Cheryl	Lumber River Council of Governments	Water Resource Planner	(910) 618-5533	3042	(910) 618-5576
S						
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W						
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	Windley, Kenneth	Robeson County	Manager	(910) 671-3022		

NLCD Code	Gap Map Unit Name	NC GAP Map Code	NVC Alliance Code	NVC Alliance Name	NHP Equivalent
11	Open Water	8			
21	Human-Dominated	202	VIII.Z.1.C.x.10*	Residential Coniferous Woodland	
	Human-Dominated	202	VIII.Z.1.C.x.11*	Residential Mixed Woodland	
	Human-Dominated	202	VIII.Z.1.C.x.6*	Residential Deciduous Forest	
	Human-Dominated	202	VIII.Z.1.C.x.7*	Residential Coniferous Forest	
	Human-Dominated	202	VIII.Z.1.C.x.8*	Residential Mixed Forest	
	Human-Dominated	202	VIII.Z.1.C.x.9*	Residential Deciduous Woodland	
22	Human-Dominated	203	VIII.Z.1.C.x.1*	Urban, low intensity development	
23	Human-Dominated	204	VIII.Z.1.C.x.2*	Urban, high intensity development	
31	Barren; Bare rock and sand	214			
41	Dry-mesic Oak Forests	138	I.B.2.N.a.35	QUERCUS NIGRA FOREST ALLIANCE	
	Mesic Hardwood Forests	63	I.C.3.N.a.3	JUNIPERUS VIRGINIANA - QUERCUS (STELLATA, VELUTINA, MARILANDICA) FOREST ALLIANCE	
	Successional Forests	36	I.B.2.N.a.24	LIRIODENDRON TULIPIFERA FOREST ALLIANCE	
	Successional Forests	36	III.A.2.N.a.1	LIGUSTRUM SINENSE SHRUBLAND ALLIANCE	
42	Managed or Modified Forests	21	I.A.8.N.b.16	PINUS TAEDA FOREST ALLIANCE	
	Mesic Longleaf Pine	97	II.A.4.N.a.1	PINUS PALUSTRIS / QUERCUS SPP. WOODLAND ALLIANCE	Mesic Pine Flatwoods
	Timber Plantations	21	I.A.8.C.x.9	PINUS TAEDA PLANTED FOREST ALLIANCE	
	Xeric Longleaf Pine	42	II.A.4.N.a.1	PINUS PALUSTRIS / QUERCUS SPP. WOODLAND ALLIANCE	Xeric Sandhill Scrub, Pine/Scrub Oak Sandhill, Coastal Fringe Sandhill
43	Managed or Modified Forests	383	I.C.3.N.b.5	PINUS TAEDA - LIRIODENDRON TULIPIFERA TEMPORARILY FLOODED FOREST ALLIANCE	
51	Riverbank Shrublands	173	III.B.2.N.d.5	SALIX CAROLINIANA TEMPORARILY FLOODED SHRUBLAND ALLIANCE	
81	Herbaceous Alien-dominated Vegetation	205	V.A.5.N.c.3	ANDROPOGON VIRGINICUS HERBACEOUS ALLIANCE	
	Herbaceous Alien-dominated Vegetation	205	III.B.2.N.a.11	PUERARIA MONTANA VINE-SHRUBLAND ALLIANCE	
	Herbaceous Alien-dominated Vegetation	205	V.A.5.N.c.8	FESTUCA SPP. HERBACEOUS ALLIANCE	
82	Human-Dominated	180	VIII.Z.1.C.y.1*	Agricultural Barren - Plowed / Fallow	
91	Coastal Plain Nonriverine Wet Flat Forests	158	I.B.2.N.g.9	TAXODIUM DISTICHUM - NYSSA BIFLORA - (NYSSA AQUATICA) SATURATED FOREST ALLIANCE	
	Coastal Plain Seepage and Streamhead Swamps	15	I.B.2.N.g.4	LIQUIDAMBAR STYRACIFLUA SATURATED FOREST ALLIANCE	
	Cypress-gum Floodplain Forests	30	I.B.2.N.e.22	TAXODIUM DISTICHUM - NYSSA (AQUATICA, BIFLORA, OGECHE) SEASONALLY FLOODED FOREST	
	Cypress-gum Floodplain Forests	30	I.B.2.N.e.8	NYSSA (AQUATICA, BIFLORA, OGECHE) FLOODPLAIN SEASONALLY FLOODED FOREST ALLIANCE	
	Cypress-gum Floodplain Forests	30	I.B.2.N.f.2	NYSSA AQUATICA - (TAXODIUM DISTICHUM) SEMIPERMANENTLY FLOODED FOREST ALLIANCE	
	Cypress-gum Floodplain Forests	30	I.B.2.N.f.3	TAXODIUM DISTICHUM SEMIPERMANENTLY FLOODED FOREST ALLIANCE	
	Mixed Hardwood Bottomland Forests	50	I.B.2.N.e.6	LIQUIDAMBAR STYRACIFLUA - (ACER RUBRUM) SEASONALLY FLOODED FOREST ALLIANCE	
	Oak Bottomland Forests	49	I.B.2.N.d.17	QUERCUS (PHELLOS, NIGRA, LAURIFOLIA) TEMPORARILY FLOODED FOREST ALLIANCE	
	Oak Bottomland Forests	49	I.B.2.N.e.13	QUERCUS LYRATA - (CARYA AQUATICA) SEASONALLY FLOODED FOREST ALLIANCE	
	Oak Bottomland Forests	49	I.C.3.N.b.4	PINUS TAEDA - LIQUIDAMBAR STYRACIFLUA - NYSSA BIFLORA TEMPORARILY FLOODED FOREST	
	Oak Bottomland Forests	49	I.C.3.N.b.8	PINUS TAEDA - QUERCUS (PHELLOS, NIGRA, LAURIFOLIA) TEMPORARILY FLOODED FOREST	
	Oak Bottomland Forests	49	III.B.2.N.e.8	VITIS ROTUNDIFOLIA - AMPELOPSIS ARBOREA - CAMPSIS RADICANS SEASONALLY FLOODED VINE SHRUBLAND	
	Peatland Pocosins	87	III.C.2.N.e.1	ZENOBIA PULVERULENTA - LYONIA LUCIDA - ILEX (CORIACEA, GLABRA) SATURATED SHRUBLAND	
	Peatland Pocosins	87	III.A.2.N.j.2	LYONIA LUCIDA - ILEX GLABRA SATURATED WOODED SHRUBLAND ALLIANCE	
	Wet Longleaf or Slash Pine Savanna	67	II.A.4.N.f.6	PINUS PALUSTRIS - PINUS (ELLIOTTII, SEROTINA) SATURATED WOODLAND ALLIANCE	Wet Pine Flatwoods
92	Coastal Plain Depression Ponds and Lakeshore Marshes	380	V.B.2.N.h.3	WOODWARDIA VIRGINICA SEASONALLY FLOODED HERBACEOUS ALLIANCE	
92	Coastal Plain Riverbed and Streambed Vegetation	380	V.C.2.N.a.102	NYMPHAEA ODORATA - NUPHAR SPP. PERMANENTLY FLOODED TEMPERATE HERBACEOUS ALLIANCE	
	Coastal Plain Riverbed and Streambed Vegetation	380	V.D.2.N.g.1	LIPOCARPHA MICRANTHA - MICRANTHEMUM UMBROSUM SEASONALLY FLOODED HERBACEOUS ALLIANCE	
	Herbaceous Alien-dominated Vegetation	380	V.A.5.N.l.4	PHRAGMITES AUSTRALIS SEMIPERMANENTLY FLOODED HERBACEOUS ALLIANCE	
	Misc. Aquatics	380	V.B.2.N.h.100	POLYGONUM SPP. (SECTION PERSICARIA) SEASONALLY FLOODED HERBACEOUS ALLIANCE	
	Misc. Aquatics	380	V.C.2.N.a.14	POTAMOGETON SPP. - CERATOPHYLLUM SPP. - ELODEA SPP. PERMANENTLY FLOODED HERBACEOUS ALLIANCE	

Alliance: QUERCUS NIGRA FOREST ALLIANCE (I.B.2.N.a.35)
Summary: This community is a result of disturbance and/or fire suppression of upland pinelands of the southeastern Coastal Plain and adjacent Piedmont areas. This association occurs especially on mesic or dry-mesic sites, especially on loamy or other fine-textured soils (in contrast to the *Quercus hemisphaerica* Forest Alliance (A.53), which occurs primarily on coarse-textured sands in drier situations). Other oaks (e.g., *Quercus falcata, Quercus phellos, Quercus hemisphaerica*) may be intermixed, as well as *Liquidambar styraciflua*, remnant *Pinus palustris*, weedy *Pinus elliottii var. elliottii*, or *Pinus taeda*. In the Upper Gulf Coastal Plain of Georgia, some examples may contain *Fagus grandifolia, Liriodendron tulipifera, Carya alba*, and *Cornus florida* in the subcanopy
High-ranked species: No information

Alliance: LIRIODENDRON TULIPIFERA FOREST ALLIANCE (I.B.2.N.a.24)
Summary: The canopy of this semi-natural upland association is dominated by *Liriodendron tulipifera*. *Acer rubrum* is common in the understory along with *Quercus* spp. These early successional forests often follow cropping, clearcut logging, or other severe disturbance, and are successional to mixed *Quercus - Carya* forests. They are potentially widespread. The oak in these stands will frequently be multi-stemmed, resulting from coppicing. Lesser amounts of *Pinus virginiana* and *Pinus echinata* may be present in severely disturbed sites.
High-ranked species: No information

Alliance: LIGUSTRUM SINENSE SHRUBLAND ALLIANCE (III.A.2.N.a.1)
Summary: Upland areas heavily infested with *Ligustrum sinense*.
High-ranked species: No information

Alliance: PINUS TAEDA FOREST ALLIANCE (I.A.8.N.b.16)
Summary: This mid-Atlantic coastal upland loblolly pine forest occurs on the Outer Coastal Plain and on barrier islands in sheltered backdunes protected from salt spray and overwash. The substrate is rapidly drained, nutrient-poor sands or sandy loams. This community is dominated by *Pinus taeda*, which can be the sole canopy component or can be associated with *Quercus falcata, Acer rubrum, Prunus serotina var. serotina*, and *Sassafras albidum*. The tall-shrub layer is comprised of *Morella cerifera (= Myrica cerifera)* and *Vaccinium corymbosum*. Vines and lianas are always present in abundance; *Vitis rotundifolia* is most common, but *Toxicodendron radicans, Smilax rotundifolia, Smilax glauca*, and *Parthenocissus quinquefolia* are usually present in abundance as well. The herbaceous layer may be sparse, particularly if shrubs and vines are dense, but *Chasmanthium laxum* may be fairly abundant in this community. Other herbs include *Panicum amarum var. amarulum, Eupatorium hyssopifolium*, and *Elephantopus nudatus*. In southern Virginia and North Carolina, *Quercus virginiana* and *Gelsemium sempervirens* may also be present, but *Quercus virginiana* is never abundant and when present is usually restricted to the understory.
High-ranked species: No information

Alliance: PINUS PALUSTRIS / QUERCUS SPP. WOODLAND ALLIANCE (II.A.4.N.a.1)
Summary: This broadly defined association represents fire-suppressed (or otherwise ecologically disturbed) former *Pinus palustris*-dominated sandhills ranging throughout the Coastal Plain east of the Mississippi River. Unlike most natural *Pinus palustris*-dominated sandhills, the overstory of stands covered by this association support a mixture of *Pinus palustris, Pinus echinata*, and *Pinus taeda*. In addition, sandhill oak species may be found in the canopy and subcanopy with greater frequency than natural stands. Predominant oak species include *Quercus incana, Quercus falcata, Quercus laevis*, and/or *Quercus margarettiae*. However, vegetation in any given stand may vary somewhat depending upon the severity of previous disturbance, including the length of fire exclusion. Related natural sandhill vegetation supporting mixed pines in the overstory are covered by other associations. Wetland, mesic, and/or flatwoods fire-suppressed *Pinus palustris* stands are covered in the *Pinus palustris* Woodland Alliance (A.520).
High-ranked species: No information

Alliance: PINUS TAEDA PLANTED FOREST ALLIANCE (I.A.8.C.x.9)
Summary: This association represents young, monospecific plantation stands of *Pinus taeda*. The core concept of these stands are those which support dense, often perfect rows of planted *Pinus taeda* or otherwise dense, young stands which are managed and maintained for the extraction of forest products

(usually pulpwood). In most cases these stands support almost no other tree species in the overstory, and typically very little understory. This association rarely exceeds 20-40 years of age on most timberlands. Stands are typically established with mechanical planting, but may also be established through other means. Excluded from this association are plantation stands which have "broken up" with age to approximate a more natural structure. Dense planting in rows, if successful, tends to result in nearly complete canopy closure which persists until the stand has either been regenerated or transitions into a different association. Herbaceous ground cover of any kind tends to be sparse due to reduction during site preparation, the typically dense canopy cover, and to the fact that many young plantations are infrequently burned at best.

In the Coastal Plain of South Carolina, these include mature loblolly plantations, often with *Prunus serotina* in the understory, that have been prescribed burned (based on seven plots at Savannah River Site). In the Ouachita Mountains planted loblolly is found with a variable amount of *Quercus alba, Quercus falcata, Quercus marilandica, Quercus stellata*, and *Quercus velutina*; on drier sites *Pinus echinata, Carya alba*, and *Carya texana*; and *Acer rubrum, Liquidambar styraciflua*, and *Quercus nigra* on wetter sites. The understory can be thick especially after thinning and/or burning. Common understory species are *Vaccinium pallidum, Vaccinium arboreum, Vaccinium stamineum, Cornus florida, Ulmus alata*, and others. Vines are an important component, including *Berchemia scandens, Vitis* spp., *Smilax* spp., and *Toxicodendron radicans*. In dense stands the herbaceous layer is suppressed by dense needle litter. In thinned and burned stands the plantations are often grazed. Herbaceous species can include *Solidago ulmifolia, Chasmanthium sessiliflorum, Schizachyrium scoparium, Danthonia spicata, Tephrosia virginiana, Lespedeza* spp., *Symphyotrichum patens (= Aster patens), Eupatorium* spp., and others. In Oklahoma, associates include *Rhus copallinum, Hypericum densiflorum, Liquidambar styraciflua*, and *Toxicodendron radicans*.

High-ranked species: No information

Alliance: PINUS PALUSTRIS / QUERCUS SPP. WOODLAND ALLIANCE (II.A.4.N.a.1)

Summary: This broadly defined association represents fire-suppressed (or otherwise ecologically disturbed) former *Pinus palustris*-dominated sandhills ranging throughout the Coastal Plain east of the Mississippi River. Unlike most natural *Pinus palustris*-dominated sandhills, the overstory of stands covered by this association support a mixture of *Pinus palustris, Pinus echinata*, and *Pinus taeda*. In addition, sandhill oak species may be found in the canopy and subcanopy with greater frequency than natural stands. Predominant oak species include *Quercus incana, Quercus falcata, Quercus laevis*, and/or *Quercus margarettiae*. However, vegetation in any given stand may vary somewhat depending upon the severity of previous disturbance, including the length of fire exclusion. Related natural sandhill vegetation supporting mixed pines in the overstory are covered by other associations. Wetland, mesic, and/or flatwoods fire-suppressed *Pinus palustris* stands are covered in the *Pinus palustris* Woodland Alliance (A.520).

High-ranked species: No information

Alliance: PINUS TAEDA - LIRIODENDRON TULIPIFERA TEMPORARILY FLOODED FOREST ALLIANCE (I.C.3.N.b.5)

Summary: This broadly defined, successional wetland forest is dominated by *Pinus taeda* and *Liriodendron tulipifera*, but many other canopy species are usually present. *Lindera benzoin* is a typical shrub, and *Carex crinita* is a typical herb. More information is needed on the detailed floristics of this association. It develops in river floodplain alluvial terraces along streams following major disturbances such as blowdowns, logging, and agriculture.

High-ranked species: No information

Alliance: SALIX CAROLINIANA TEMPORARILY FLOODED SHRUBLAND ALLIANCE (III.B.2.N.d.5)

Summary: This carolina willow shrubland type is found widely throughout the southeastern United States. This is a broadly defined type for riverside and streamside thickets dominated by *Salix caroliniana*. Further information is needed to characterize this type.

High-ranked species: No information

Alliance: ANDROPOGON VIRGINICUS HERBACEOUS ALLIANCE (V.A.5.N.c.3)

Summary: This association includes vegetation that occurs on old fields, pastures, and rocky sites which is dominated by *Andropogon virginicus var. virginicus*. This is a very common and wide-ranging

association. Additional components include typical pioneer species; these and other associated species will vary with geography and habitat.
High-ranked species: No information

Alliance: PUERARIA MONTANA VINE-SHRUBLAND ALLIANCE (III.B.2.N.a.11)
Summary: This vine-dominated vegetation is dominated by *Pueraria montana var. lobata*, a fast-growing vine native to Asia. The species was introduced into the United States in 1885, primarily as an ornamental and as a potential source for cattle forage. It was subsequently widely used for erosion control in the southeastern United States. This association occupies a variety of sites throughout most physiographic provinces in the Southeast, ranging in size from less than a hectare to 5-10 hectares or more. It chokes out existing vegetation. Edges of examples of this vegetation may consist of small to large trees in the process of being overwhelmed by kudzu. More than 2 million acres of forest land in Alabama, Georgia, Mississippi, Tennessee, North Carolina, and South Carolina are estimated to be infested with kudzu. This association is also known to occur north to central Kentucky, Virginia, and Maryland, and as far west as eastern Texas and Oklahoma.
High-ranked species: No information

Alliance: LOLIUM (ARUNDINACEUM, PRATENSE) HERBACEOUS ALLIANCE (V.A.5.N.c.8)
Summary: This association includes grassland pastures and hayfields, more-or-less cultural, though sometimes no longer actively maintained. The dominant species in this type are the European 'tall or meadow fescues,' of uncertain and controversial generic placement. *Lolium pratense* and *Lolium arundinaceum* are two closely related species which were traditionally treated as *Festuca pratensis (= Festuca elatior)* and *Festuca arundinacea*, and could alternately be treated as *Schedonorus pratensis* and *Schedonorus arundinaceus*. These communities are sometimes nearly monospecific but can also be very diverse and contain many native species of grasses, sedges, and forbs. This vegetation is currently defined for the southern Appalachians, Ozarks, Ouachita Mountains, and parts of the Piedmont and Interior Low Plateau, but it is possible throughout much of the eastern United States and southern Canada.
High-ranked species: No information

Alliance: TAXODIUM DISTICHUM - NYSSA BIFLORA - (NYSSA AQUATICA) SATURATED FOREST ALLIANCE (I.B.2.N.g.9)
Summary: Stands of this forest are dominated by *Taxodium distichum, Nyssa biflora, Acer rubrum*, and *Magnolia virginiana*. It is known from Big Gum Swamp Wilderness, Osceola National Forest and may also occur directly to the north at Pinhook Swamp, Osceola National Forest and Okefenokee Swamp National Wildlife Refuge. It occurs in a large, poorly drained flat area, with some poorly defined creeks which are tributaries of the Middle Fork St. Mary's River. The site is along the flat divide between the Atlantic drainage (St. Mary's River) and Gulf drainage (Suwannee River).
High-ranked species: CHASMANTHIUM NITIDUM (G3)

Alliance: LIQUIDAMBAR STYRACIFLUA SATURATED FOREST ALLIANCE (I.B.2.N.g.4)
Summary: These forests occur on flat, low seepage areas in the southeastern Coastal Plain. The soil is a very poorly drained clay loam with organic material or peat development. This environment is nearly constantly saturated, but it is only rarely flooded. These forests have well-developed canopy, subcanopy, shrub, herbaceous, and vine/liana strata. The canopy is dominated by *Liquidambar styraciflua, Quercus laurifolia*, and *Acer rubrum*. These species are dominant in the subcanopy as well, along with *Magnolia virginiana, Ilex opaca var. opaca*, and *Carpinus caroliniana*. Other species that may be present in these strata include *Ulmus americana, Ulmus alata*, and *Salix nigra*. The shrub layer contains *Acer rubrum, Magnolia virginiana, Ilex decidua, Arundinaria gigantea*, and other species. Herbaceous dominants include *Saururus cernuus, Carex debilis, Carex intumescens, Carex lonchocarpa, Dichanthelium* sp., and *Hypericum* sp. Other herbaceous species of this community are *Asclepias perennis, Boehmeria cylindrica, Onoclea sensibilis, Viola affinis, Viola X primulifolia, Commelina communis, Mitchella repens, Leersia lenticularis*, and others. This community currently is known only from the Mid-Atlantic Coastal Plain.
High-ranked species: No information

Alliance: TAXODIUM DISTICHUM - NYSSA (AQUATICA, BIFLORA, OGECHE) SEASONALLY FLOODED FOREST ALLIANCE (I.B.2.N.e.22)

Summary: These forests occur in sloughs and on alluvial flats on soils with a percentage of silt. This type is found in the Atlantic Coastal Plain and is possibly more widespread. This association is dominated by *Taxodium distichum* and *Fraxinus pennsylvanica*. *Quercus laurifolia, Quercus lyrata, Acer rubrum, Liquidambar styraciflua, Planera aquatica*, and *Fraxinus caroliniana* are usually present, as are other tree species of generally higher bottomland communities including *Celtis laevigata, Ulmus americana, Platanus occidentalis*, and *Acer negundo*. The canopy is closed and the subcanopy layer generally is well-developed. The shrub layer is sparse and the herbaceous layer ranges from sparse to moderately dense depending upon duration of flooding. *Acer rubrum* is the strong dominant in the subcanopy with *Planera aquatica, Carpinus caroliniana, Ulmus alata, Ilex decidua*, and *Celtis laevigata* typical in this stratum as well. *Itea virginica* and *Cephalanthus occidentalis* are typical in the shrub layer. A variety of vines are possible within occurrences of this community. These include *Vitis rotundifolia, Vitis aestivalis, Bignonia capreolata, Campsis radicans, Berchemia scandens, Trachelospermum difforme*, and *Mikania scandens*. The most commonly occurring herbs are *Asclepias perennis, Boehmeria cylindrica, Pilea pumila, Saururus cernuus, Commelina virginica, Justicia ovata, Phanopyrum gymnocarpon, Carex lupulina, Leersia lenticularis, Ludwigia alternifolia*, and *Chasmanthium latifolium*. This forest type is documented in North Carolina and South Carolina; global distribution needs assessment.
High-ranked species: No information

Alliance: NYSSA (AQUATICA, BIFLORA, OGECHE) FLOODPLAIN SEASONALLY FLOODED FOREST ALLIANCE (I.B.2.N.e.8)
Summary: This association represents swamp forests along upper tidal reaches of rivers in portions of the outer Atlantic Coastal Plain ranging from southeastern Virginia and North Carolina to South Carolina, in which *Nyssa biflora, Nyssa aquatica*, and *Taxodium distichum* may dominate singly, codominate in various combinations, or share dominance with *Acer rubrum, Fraxinus pennsylvanica*, and/or *Liquidambar styraciflua*. Typical subcanopy trees are *Nyssa biflora, Acer rubrum, Fraxinus pennsylvanica, Liquidambar styraciflua, Ulmus americana*, and *Quercus laurifolia*. Woody vines are frequent and climb into the canopy; they include *Decumaria barbara, Toxicodendron radicans ssp. radicans, Campsis radicans, Smilax walteri*, and *Berchemia scandens*. Shrub and herb layers are variable but generally contain a mixture of species characteristic of both marshes and swamps. Typical shrubs are *Fraxinus caroliniana, Itea virginica, Amelanchier canadensis, Leucothoe racemosa, Lyonia ligustrina var. foliosiflora, Alnus serrulata*, and *Morella cerifera (= Myrica cerifera var. cerifera)*. Characteristic herbaceous species include *Saururus cernuus, Peltandra virginica, Triadenum walteri, Boehmeria cylindrica, Lycopus rubellus, Bidens discoidea, Carex seorsa, Carex stipata var. maxima, Cicuta maculata, Glyceria septentrionalis, Ranunculus sceleratus, Lobelia cardinalis, Sphenopholis pensylvanica, Decodon verticillatus, Galium obtusum, Polygonum setaceum, Osmunda regalis var. spectabilis, Scutellaria lateriflora, Hydrocotyle verticillata, Cinna arundinacea*, and *Pilea pumila*. Substrates are mucky peats and mucks; nutrient regimes may be enhanced in some examples by rare, wind-tidal inputs. Because of higher nutrient status, this type is more diverse than non-tidal cypress-gum forests. Pronounced hummock/hollow microtopography is usually a prominent feature of this type, with the hollows filled with deep, soupy muck.
High-ranked species: No information

Alliance: NYSSA AQUATICA - (TAXODIUM DISTICHUM) SEMIPERMANENTLY FLOODED FOREST ALLIANCE (I.B.2.N.f.2)
Summary: This forest, dominated by *Nyssa aquatica* and *Nyssa biflora* in varying proportions, is found along shallow borders of alluvial swamps and flats near uplands. It is a Zone II community. The range has not been completely assessed; it is theoretically possible on the Atlantic Coastal Plain from southeastern Virginia to southern Georgia, the Gulf Coastal Plain from about Tallahassee west to southeastern Texas, and the Mississippi Alluvial Plain to southern Arkansas and western Tennessee. *Taxodium distichum* may occur in the canopy of this community, but is not a dominant (usually less than 25% cover). Other tree canopy/subcanopy species are *Fraxinus pennsylvanica, Salix nigra, Populus heterophylla*, and *Carpinus caroliniana*. Other shrub and herbaceous species are *Leucothoe racemosa, Cyrilla racemiflora, Planera aquatica*, and *Saururus cernuus*. *Decumaria barbara, Toxicodendron radicans, Ampelopsis arborea*, and *Bignonia capreolata* are commonly occurring vines, but have less than 10% cover.
High-ranked species: No information

Alliance: TAXODIUM DISTICHUM SEMIPERMANENTLY FLOODED FOREST ALLIANCE (I.B.2.N.f.3)

Summary: This bald-cypress swamp is found in the Atlantic and Gulf coastal plains of the United States in a variety of ecological settings. Examples may occur in oxbow lakes and ponds, and along the banks of rivers and lakes in saturated or flooded soils. This type is characterized by a monospecific canopy of straight, tall individuals of *Taxodium distichum* above shallow to deep water (depths ranging from soil saturation to approximately 6 m) during all or most of the year. Flooding is seasonal, occurring during winter and spring. Stands have a sparse to moderate subcanopy and depauperate shrub and herb layers. The trunks of the canopy trees typically form swelled buttresses. Canopy cover is variable, from at or near 100% to less than 60% in some examples. More open examples of this type tend to occur in deeper water. In the deepest water situations scattered trees grow over an open water surface covered by floating and submersed aquatic plants. *Taxodium distichum* regeneration is absent in areas of permanent inundation, as seed germination does not occur in standing water. The subcanopy and herbaceous layers are dependent upon timing, duration, and depth of flooding. *Cephalanthus occidentalis* and *Rosa palustris* may be common shrubs in some examples of this community, while *Fraxinus caroliniana* (in its range) and *Acer rubrum var. drummondii* are common in the subcanopy. Shallow water emergents, floating-leaved aquatics, such as *Azolla caroliniana, Brasenia schreberi, Cabomba caroliniana, Hydrocotyle ranunculoides, Limnobium spongia, Spirodela punctata, Wolffia columbiana, Lemna* spp. *Nymphaea* spp., and submerged hydrophytes, such as *Ceratophyllum demersum, Egeria densa, Myriophyllum aquaticum*, and *Potamogeton nodosus*, are common in permanent water zones throughout the range of *Taxodium distichum* swamps. This community is differentiated from other swamp forests by lacking *Nyssa* spp. as other than occasional individuals. This is the only community type currently defined outside Florida with *Taxodium distichum* as the sole dominant.
High-ranked species: CAREX DECOMPOSITA (G3)

Alliance: LIQUIDAMBAR STYRACIFLUA - (ACER RUBRUM) SEASONALLY FLOODED FOREST ALLIANCE (I.B.2.N.e.6)
Summary: This community occurs as small (less than one acre) depressions scattered in low oak flats in the Outer Coastal Plain of southeastern South Carolina and possibly adjacent Georgia. *Liquidambar styraciflua* and *Acer rubrum* are the constant dominants, sometimes with an admixture of *Nyssa biflora*. Scattered shrubs may occur, usually on logs, including *Itea virginica, Vaccinium formosum*, and *Leucothoe racemosa*. *Woodwardia areolata* dominates the herb layer, at least in the marginal portions of the pond where water is ponded more shallowly and for shorter periods of time; deeper ponds have a ring of *Woodwardia*, while shallower ponds are *Woodwardia*-dominated all the way across.
High-ranked species: No information

Alliance: QUERCUS (PHELLOS, NIGRA, LAURIFOLIA) TEMPORARILY FLOODED FOREST ALLIANCE (I.B.2.N.d.17)
Summary: These forests occur in small stream floodplains in the Coastal Plain and lower Piedmont with forest vegetation of mixed hydrological tolerances, due to fluvial landforms too small and hydrologic regime too variable to differentiate separate associated communities. The canopy of stands always includes substantial *Nyssa biflora* or *Taxodium distichum* along with substantial bottomland oaks (e.g., *Quercus nigra, Quercus laurifolia*) and other bottomland hardwoods, along with *Pinus taeda*. Typical subcanopy components include *Ilex opaca* and *Carpinus caroliniana*. The shrub stratum typically includes *Leucothoe axillaris* and *Cyrilla racemiflora*.
High-ranked species: No information

Alliance: QUERCUS LYRATA - (CARYA AQUATICA) SEASONALLY FLOODED FOREST ALLIANCE (I.B.2.N.e.13)
Summary: This vegetation of sloughs and edges of backswamps in the Atlantic Coastal Plain has a mixture of cypress - gum swamp and bottomland hardwoods species, generally *Quercus lyrata, Quercus laurifolia, Taxodium distichum, Populus heterophylla, Fraxinus profunda, Quercus phellos, Ulmus americana, Acer rubrum, Liquidambar styraciflua, Carya aquatica, Planera aquatica*, and *Fraxinus pennsylvanica*. Along with the canopy species, other species that may be present in the subcanopy are *Ulmus alata, Ilex decidua, Carpinus caroliniana*, and *Diospyros virginiana*. The shrub layer ranges from sparse to a moderate coverage by species of the canopy and subcanopy layers with *Sabal minor* and *Arundinaria gigantea*. Herbaceous coverage usually is well-developed, and dominant species include *Carex joorii, Carex intumescens, Carex lupulina, Boehmeria cylindrica, Justicia ovata, Saururus cernuus*,

and *Leersia lenticularis*. Other herbaceous species that occur include *Commelina virginica, Lobelia cardinalis, Ludwigia palustris, Diodia virginiana, Gratiola virginiana*, and others. The undergrowth (especially the prevalence of *Saururus cernuus*) is typical of cypress - gum swamps. This forest has well-developed canopy, subcanopy, and herbaceous strata.
High-ranked species: No information

Alliance: PINUS TAEDA - LIQUIDAMBAR STYRACIFLUA - NYSSA BIFLORA TEMPORARILY FLOODED FOREST ALLIANCE (I.C.3.N.b.4)
Summary: This association includes forests dominated by the nominal species on slightly elevated ridges of floodplains primarily in the Atlantic Coastal Plain. The canopy is typically dominated by some combination of *Pinus taeda, Liquidambar styraciflua*, and *Nyssa biflora*. A mixture of other bottomland hardwood species may be present which includes *Diospyros virginiana, Quercus nigra, Acer rubrum, Quercus michauxii, Quercus laurifolia, Ulmus alata, Carya cordiformis, Ulmus americana, Quercus pagoda, Celtis laevigata, Quercus phellos, Fagus grandifolia, Carya alba*, and others. *Asimina triloba* may be prominent in the understory with *Ilex decidua, Carpinus caroliniana, Crataegus viridis, Crataegus spathulata, Ilex opaca*, and other species. These forests develop following disturbance and may persist.
High-ranked species: No information

Alliance: PINUS TAEDA - QUERCUS (PHELLOS, NIGRA, LAURIFOLIA) TEMPORARILY FLOODED FOREST ALLIANCE (I.C.3.N.b.8)
Summary: *Pinus taeda* stands with few to no hardwoods that occur on higher ridges in floodplains; they develop following natural disturbance. Stands are dominated by *Pinus taeda*. Associated species vary with geography and floodplain position, but include *Quercus lyrata, Quercus laurifolia, Quercus nigra, Quercus phellos, Quercus michauxii, Celtis laevigata, Fraxinus pennsylvanica, Liquidambar styraciflua*, and *Nyssa biflora*. In Oklahoma, associates include *Fraxinus pennsylvanica, Quercus falcata, Quercus shumardii, Ulmus americana, Carpinus caroliniana, Crataegus marshallii, Ilex opaca, Morus rubra, Nyssa biflora, Arundinaria gigantea, Berchemia scandens, Carex lupulina*, and *Chasmanthium sessiliflorum*.
High-ranked species: No information

Alliance: VITIS ROTUNDIFOLIA - AMPELOPSIS ARBOREA - CAMPSIS RADICANS SEASONALLY FLOODED VINE-SHRUBLAND ALLIANCE (III.B.2.N.e.8)
Summary: This association includes vine-dominated vegetation that develops following clearcut logging, blowdowns, and possibly other disturbance in wetlands. *Vitis rotundifolia - Ampelopsis arborea - Campsis radicans* Vine-Shrubland is dominated by the nominal species. Other species that are present in the vine/liana stratum include *Parthenocissus quinquefolia, Toxicodendron radicans ssp. radicans, Bignonia capreolata, Smilax rotundifolia, Berchemia scandens*, and likely others. There may exist a limited canopy of *Liquidambar styraciflua, Ulmus americana, Quercus* spp., *Celtis laevigata, Salix* spp., and likely other species. Often the weight of the vine coverage will break the stems of woody species before they attain 5 m in height. A limited shrub stratum that contains canopy species as well as *Arundinaria gigantea, Ilex decidua, Lindera benzoin, Morella cerifera (= Myrica cerifera)*, and others may be present. *Carex abscondita, Arisaema dracontium, Eupatorium capillifolium, Boehmeria cylindrica, Cryptotaenia canadensis, Carex retroflexa, Carex lupulina, Polygonum* spp., *Cyperus* spp., and other species are present in the sparse herbaceous layer.
High-ranked species: No information

Alliance: ZENOBIA PULVERULENTA - LYONIA LUCIDA - ILEX (CORIACEA, GLABRA) SATURATED SHRUBLAND ALLIANCE (III.C.2.N.e.1)
Summary: Mixed evergreen-deciduous low pocosins of peat domes (ombrotrophic blanket bogs) of the outer Coastal Plain of North Carolina. The shrub height (0.5-2 m) is maintained by extremely poor nutrient status and (secondarily) by occasional fire. This shrubland has very scattered, stunted (less than 5 m tall) *Pinus serotina* (less than 10% cover). This association includes low pocosins of the Green Swamp TNC Preserve, Holly Shelter, Croatan National Forest, etc. Other characteristic species include *Ilex coriacea* and *Lyonia lucida*.
High-ranked species: No information

Alliance: LYONIA LUCIDA - ILEX GLABRA SATURATED WOODED SHRUBLAND ALLIANCE (III.A.2.N.j.2)
Summary: This is the typical high pocosin or tall pocosin of peatlands and wet mineral soils of the southeastern Coastal Plain, ranging from southeastern Virginia south to Georgia and apparently to Florida. *Pinus serotina* individuals are scattered and more-or-less stunted. Typical shrubs, forming a dense tangle with abundant *Smilax laurifolia*, are *Cyrilla racemiflora* (absent in occurrences at the northern limit of the range in southeastern Virginia), *Lyonia lucida, Ilex glabra, Ilex coriacea, Persea palustris*, and sometimes *Kalmia carolina*. Other component shrubs can include *Clethra alnifolia, Vaccinium formosum, Gaylussacia frondosa (= var. frondosa), Kalmia cuneata, Photinia pyrifolia (= Aronia arbutifolia), Chamaecyparis thyoides, Acer rubrum var. trilobum, Morella cerifera (= Myrica cerifera var. cerifera), Lyonia ligustrina var. foliosiflora, Magnolia virginiana, Rhododendron viscosum*, and *Toxicodendron radicans*. Compare III.C.2.N.f.
High-ranked species: KALMIA CUNEATA (G3), PELTANDRA SAGITTIFOLIA (G3G4)

Alliance: PINUS PALUSTRIS - PINUS (ELLIOTTII, SEROTINA) SATURATED WOODLAND ALLIANCE (II.A.4.N.f.6)
Summary: This community occurs in narrow bands between various sandhill communities and streamhead pocosins, in the Fall-line Sandhills of North Carolina and South Carolina. In floristic composition it typically resembles Outer Coastal Plain savannas and flatwoods, but lacks some of the Outer Coastal Plain species, and has some species (often from the adjacent sandhill and streamhead pocosins) not present in Outer Coastal Plain savannas and flatwoods. The fire dynamics of this community are also different, since it occurs in narrow bands between peaty wetlands and xeric sandhills, rather than in large, flat expanses. Many of the plant species in this community occur in no other community in the landscape. Species found in this association which are more prevalent in this community than in Outer Coastal Plain savannas and flatwoods include *Oxydendrum arboreum, Calamovilfa brevipilis, Chasmanthium laxum, Doellingeria sericocarpoides (= Aster sericocarpoides), Glyceria obtusa*, and *Hexastylis minor*. Species more prevalent in Outer Coastal Plain savannas and flatwoods longleaf pine communities than in this one include *Lysimachia loomisii, Pinguicula caerulea, Pinguicula caerulea, Pinguicula pumila, Dionaea muscipula, Pyxidanthera barbulata, Arnoglossum ovatum, Cirsium horridulum, Carphephorus odoratissimus, Pterocaulon pycnostachyum, Bigelowia nudata ssp. nudata, Helianthus heterophyllus, Balduina uniflora, Coreopsis falcata, Helenium pinnatifidum, Helenium vernale, Amphicarpum purshii, Paspalum praecox, Anthaenantia rufa, Andropogon glaucopsis, Rhynchospora chapmanii, Rhynchospora latifolia, Pleea tenuifolia, Lilium catesbaei ssp. catesbaei, Platanthera nivea, Platanthera integra, Sarracenia minor, Drosera brevifolia, Polygala brevifolia*, and *Polygala hookeri*.
High-ranked species: DIONAEA MUSCIPULA (G3), LYSIMACHIA LOOMISII (G3), POLYGALA HOOKERI (G3)

Alliance: WOODWARDIA VIRGINICA SEASONALLY FLOODED HERBACEOUS ALLIANCE (V.B.2.N.h.3)
Summary: This generally defined association covers seasonally flooded wetland depressions, often strongly dominated by *Woodwardia virginica*, which occur in acid sands of the Coastal Plain. More information is needed on this vegetation type. It is attributed to various states in the Atlantic Coastal Plain from Delaware to Florida.
High-ranked species: No information

Alliance: NYMPHAEA ODORATA - NUPHAR SPP. PERMANENTLY FLOODED TEMPERATE HERBACEOUS ALLIANCE (V.C.2.N.a.102)
Summary: This association consists of beds of the floating-leaf or submersed aquatic *Nuphar lutea ssp. sagittifolia*. This vegetation is found in 30-150 cm deep waters of blackwater rivers, streams, and lakes, sometimes extending downstream into slightly tidal reaches of blackwater rivers. In rivers and streams, *Nuphar lutea ssp. sagittifolia* is usually monospecific. In the only known lake occurrence (Lake Waccamaw, Columbus County, North Carolina), *Nuphar lutea ssp. sagittifolia* is the dominant species, but other floating and submersed aquatics are present. This vegetation is associated with the acidic and tea-colored waters of blackwater systems.
High-ranked species: NUPHAR LUTEA SSP SAGITTIFOLIA (G5T2)

Alliance: ERAGROSTIS HYPNOIDES - LIPOCARPHA MICRANTHA - MICRANTHEMUM UMBROSUM SEASONALLY FLOODED HERBACEOUS ALLIANCE (V.D.2.N.g.1)
Summary: Annual-dominated drawdown banks of blackwater rivers and other seasonally flooded muddy to silty banks. Annuals dominate this community, and can include *Eragrostis hypnoides, Lipocarpha micrantha (= Hemicarpha micrantha), Fimbristylis autumnalis, Micranthemum umbrosum, Lindernia dubia var. dubia, Lindernia dubia var. anagallidea, Fimbristylis perpusilla*. Perennials are also present, including *Juncus repens, Helenium flexuosum, Gratiola aurea, Sabatia kennedyana*, but the community is generally dominated by a sparse to dense turf of annuals, most of the cover 2-10 cm tall. Seedlings and scattered larger individuals of trees, such as *Betula nigra* and *Acer rubrum* may occur. Other species present may include *Bidens frondosa, Boehmeria cylindrica, Commelina diffusa, Cyperus erythrorhizos, Cyperus polystachyos, Diodia virginiana, Digitaria sanguinalis, Echinochloa muricata, Echinodorus cordifolius, Eleocharis obtusa, Erechtites hieraciifolia, Hydrocotyle verticillata var. verticillata, Hypericum mutilum, Hypoxis curtissii (= Hypoxis leptocarpa), Justicia ovata, Ludwigia decurrens, Ludwigia palustris, Mitreola petiolata, Oldenlandia boscii, Panicum dichotomiflorum, Panicum rigidulum var. elongatum, Panicum verrucosum, Paspalum fluitans, Pluchea camphorata, Polygonum hydropiperoides, Polygonum pensylvanicum, Rhynchospora corniculata, Rotala ramosior, Sabatia calycina, Scirpus cyperinus*, and *Triadenum walteri*. A wide range of other species may occur, including aliens, since seeds wash into this community from a variety of sources. This community often provides habitat for globally or regionally rare plant species, many of them adapted for this unusual environment.
High-ranked species: FIMBRISTYLIS PERPUSILLA (G2), SABATIA KENNEDYANA (G3)

Alliance: PHRAGMITES AUSTRALIS SEMIPERMANENTLY FLOODED HERBACEOUS ALLIANCE (V.A.5.N.l.4)
Summary: This reed marsh type is found across the east-temperate regions of the United States and Canada. Stands occur in semipermanently flooded marshes, ditches, impoundments, etc., that have often been disturbed by human activity. The vegetation is variable, as *Phragmites australis* will often invade into existing natural or semi-natural communities present on the site. Once firmly established, this community is usually strongly dominated by *Phragmites australis*, with few or no other vascular plants present.
High-ranked species: No information

Alliance: POLYGONUM SPP. (SECTION PERSICARIA) SEASONALLY FLOODED HERBACEOUS ALLIANCE (V.B.2.N.h.100)
Summary: This association is documented from an herbaceous slough of the Alabama River at Haines Island in Monroe County, Alabama. It is a seasonally or perhaps semipermanently flooded herbaceous marsh with some beaver activity. There are very sparse widely scattered trees of *Taxodium distichum* and *Salix nigra*, and shrubs of *Cephalanthus occidentalis, Salix nigra, Acer saccharinum*, and *Populus deltoides*. The dominant plants are all herbaceous, most dominant are *Polygonum* spp. and *Phanopyrum gymnocarpon*; near dominant taxa (in decreasing order) include *Sagittaria latifolia, Glottidium vesicarium, Lycopus* spp., *Alternanthera philoxeroides, Mimulus* sp., *Saururus cernuus, Cyperus* sp., *Bidens* sp., *Boehmeria cylindrica, Triadenum walteri, Polygonum punctatum, Strophostyles helvula, Ludwigia decurrens*, and *Ludwigia* sp. This association is expected to occur elsewhere in open bottomland sloughs in the Coastal Plain within the range of *Phanopyrum gymnocarpon*, from Nother Carolina to northern Florida, Arkansas, and southeastern Texas. This association is distinguished from others in the same alliance by the codominance of *Phanopyrum gymnocarpon* with *Polygonum* spp.
High-ranked species: No information

Alliance: POTAMOGETON SPP. - CERATOPHYLLUM SPP. - ELODEA SPP. PERMANENTLY FLOODED HERBACEOUS ALLIANCE (V.C.2.N.a.14)
Summary: This broadly defined type represents vegetation dominated by various floating-leaved and submerged aquatic species (including *Potamogeton* spp., *Ceratophyllum* spp., and *Elodea* spp.) for the states and ecoregions given. Individual stands may be dominated by a single species, this leading to any number of apparent dominance types. Until the patterns are better understood, these are all grouped together. Additional types may be developed as more information becomes available.
High-ranked species: No information

Species Under Federal Protection in Robeson County

Vertebrates

Picoides borealis (Red-cockaded woodpecker) **Endangered**
Family: Picidae
Federally Listed: 1970

The red-cockaded woodpecker is a small to medium sized bird 7.4 to 8.5 inches (18 to 20 cm) long with a wingspan of 14 to 15 inches (35 to 38 cm). The back and top of the head are black. The cheek is white. Numerous small white spots arranged in horizontal rows give a ladder-back appearance. The chest is dull white with small black spots on the side. Males and females look alike except males have a small red streak above the cheek.

Among woodpeckers, the red-cockaded has an advanced social system. They live in a group termed a clan. The clan may have from two to nine birds, but never more than one breeding pair. The other adults are usually males and are called helpers. The helpers are usually the sons of the breeding male and can be from 1 to 3 years old. The helpers assist in incubating eggs, feeding young, making new cavities, and defending the clan's area from other red-cockaded woodpeckers.

Roosting cavities are excavated in living pines, and usually in those that are infected with a fungus producing red-heart disease. A clan nests and roosts in a group of cavity trees called a colony. The colony may have one or two cavity trees to more than 12, but only one clan uses it. In most colonies, all the cavity trees are within a circle about 450 m (1,500 ft) wide. Open stands of pines with a minimum age of 80 to 120 years provide suitable nesting habitat. Longleaf pines are the most commonly used, but other species of southern pine are also acceptable. Dense stands of pines, or stands that have a dense hardwood understory are avoided. Foraging habitat is provided in pine and pine hardwood stands 30 years or older with foraging preference for pine trees 10 inches (25 cm) or larger in diameter. The woodpeckers diet consists mainly of insects including ants, beetles, wood-boring insects, and caterpillars.

Alligator mississippiensis (American alligator) **Threatened**
Family: Alligatoridae
Federally Listed**:** 1967

The American alligator is a conservation success story. This species was nearly extirpated from their range as a result of market hunting and loss of habitat by the 1960's. It was listed as Endangered in 1967. Alligators responded well to management practices and were delisted in 1987. Although this species is secure some related crocodiles and caimans are still in trouble. For this reason alone, the USFWS still regulates the trade of alligator skins or any products made from them. Hopefully this will protect those

endangered animals whose skin has a similar appearance, but that is illegal on the commercial market.

Male alligators may reach lengths of 15 feet (4.5 m) while females tend to only reach 6 feet (1.8 m). These animals have a large, slightly rounded body with thick limbs, a broad head, and a very powerful tail used for propulsion in the water as well as for defense.

These reptiles frequent wetland areas and are the top predator of the food chain. Alligators will eat just about anything but prefer fish, turtles, and snails. Small mammals that venture to the water's edge may also be eaten. Young alligators mostly feed on insects, crustaceans, snails, and fish.

The alligator's greatest value to the wetland is the "gator holes" created by adults as a resting area. After removing vegetation with it's mouth an adult gator will thrash about in the depression to create a hole that will trap water during the rains and retain it during the dry season. These holes serve as refugia and watering areas for fish, birds, turtles, snakes and many other animals. Alligators may expand their holes by digging underneath an overhanging bank up to 20 feet away from the water body. These areas are then expanded and used by the animals to survive dry seasons and winters.

Vascular Plants

Rhus michauxii (Michaux's sumac) **Endangered**
Family: Anacardiaceae
Federally Listed: 1989

Michaux's sumac or false poison sumac is a densely hairy colonial shrub with erect stems, which are 1 to 3 feet (0.3-0.9 m) in height. The shrub's compound leaves are narrowly winged at the base, dull on the tops, and veiny and slightly hairy on the bottom. Each leaf is finely toothed on its edges. Flowers are greenish-yellow to white and are 4 to 5 parted. Each plant is unisexual. With a male plant the flowers and fruits are solitary, with a female plant all flowers are grouped in 3 to 5 stalked clusters. The plant flowers from April to June; its fruit, a dull red drupe, is produced in October and November.

Michaux's sumac grows in sandy or rocky open woods in association with basic soils. Apparently, this plant survives best in areas where some form of disturbance has provided an open area. Most of the plant's remaining populations are on highway rights-of way, roadsides, or on the edges of artificially maintained clearings. Other populations are in areas with periodic fires, or on sites undergoing natural succession. One population is situated in a natural opening on the rim of a Carolina bay. Currently, the plant survives in the following North Carolina Counties: Richmond, Hoke, Scotland, Franklin, Davie, Robeson, and Wake.

Species on State List of Threatened and Endangered Species

Common Name	Scientific Name	Status
Vertebrates		-
Star-nosed Mole	*Condylura cristata*	SC
Eastern Fox Squirrel	*Sciurus niger*	SR
Anhinga	*Anhinga anhinga*	SR
Little Blue Herron	*Egretta caerulea*	SC
Snowy Egret	*Egretta thula*	SC
Loggerhead Shrike	*Lanius ludovicianus ludovicianus*	SC
Purple Gallinule	*Porphyrula martinica*	SR
Easter Diamondback Rattlesnake	*Crotalus adamanteus*	E
Timber Rattlesnake	*Croatalus horridus*	SC
Chicken Turtle	*Deirochelys reticularia*	SR
Glossy Crayfish Snake	*Regina rigida*	SR
Mabee's Salamander	*Ambystoma mabeii*	SR
Eastern Tiger Salamander	*Ambystoma tigrinum*	T
Dwarf Salamander-Silver Morph	*Eurycea quadridigitata pop1*	SC
Ornate Chorus Frog	*Pseudacris ornata*	SR
River Frog	*Rana heckscheri*	SC
Santee Chub-Coastal Plain Population	*Cyprinella zanema pop2*	SC
Broadtail Madtom	*Noturus sp.*	SC
Invertebrates		-
Cape Fear Spike	*Elliptio marsupiobesa*	SC
Rotund Mysterysnail	*Viviparus intertextus*	SR
Reversed Roadside-Skipper	*Amblyscirtes reversa*	SR
Argo Ephemerellan Mayfly	*Ephemerella argo*	SR
a triaenode caddisfly	*Triaenodes marginata*	SR
Vascular Plants		-
Florida Goober Grass	*Amphicarpum muehlenbergianum*	SR-P
Bog Bluestem	*Andropogon mohrii*	SR-P
Georgia Calamint	*Calamintha Georgiana*	SR-P
Woody goldenrod	*Chrysoma pauciflosculosa*	E

Dissected Sneezeweed	*Helenium pinnatifidum*	SR-P
Comfortroot	*Hibiscus aculeatus*	SR-P
Sarvis Holly	*Ilex amelanchier*	SR-P
Small-headed Marsh Elder	*Iva microcephala*	SR-P
Earle's Blazing Star	*Liatris squarrulosa*	SR-P
Pinebarren Smokegrass	*Muhlenbergia torreyana*	E
Yellow Fringeless Orchard	*Platanthera integra*	T
Snowy Orchard	*Platanthera nivea*	T
Georgia Nutrush	*Scleria Georgiana*	SR-P
Leavenworth's Goldenrod	*Solodago leavenworthii*	SR-P
Twisted-leaf Goldenrod	*Solidago tortifolia*	SR-P
Water Dawnflower	*Stylisma aquatica*	SR-P
Spike Triodia	*Tridens strictus*	SR-P
Florida Yellow-eyed-grass	*Xyris difformis var floridana*	SR-P

E-Endangered
T-Threatened
SC- Special Concern
SR Significantly Rare
SR-P Significantly Rare Proposed

North Carolina Division of Water Quality
Water Quality Section
Updated January 5, 2004

Summary of Existing Water Quality Data
Bear Swamp and the Adjacent Portion of the Lumber River, Robeson County

Lumber River Basin
Subbasin 03-04-51
Catalog Unit # 03040203
HU's # 030010, # 050010

This document provides a summary of the existing water quality data for the Bear Swamp / Lumber River watershed. The intent of this summary is to provide a synopsis of existing information to support the watershed characterization (Phase 1) portion of the Local Watershed Planning process initiated in this area by the North Carolina Wetlands Restoration Program.

I. Background

A. Location

- Bear Swamp is a tributary of the Lumber River. Multiple tributaries drain into Bear Swamp including Little Bear Swamp, Watering Hole Swamp, Moss Neck Swamp and Kersey Branch.
- The study watershed includes the Lumber River from approximately the Gum Swamp confluence to the municipal boundary of Lumberton. Mill Branch and Jacks Branch are small tributaries that drain directly into the Lumber River. The entire area is located in Robeson County.
- The Town of Pembroke lies entirely within the watershed and straddles the border of the two hydrologic units.

B. Stream Classifications

Stream Classification is variable within the watershed as shown in Table 1.

Table 1. Stream Classifications for Bear Swamp and the Adjacent Portion of the Lumber River.

STREAM	DESCRIPTION	CLASSIFICATIONS
Lumber River	Gum Swamp confluence to RR Bridge near Pembroke	B; Sw, HQW
Lumber River	RR Bridge near Pembroke to Lumberton	WS-IV, B; Sw, HQW
Mill Branch	Source to Lumber River	C
Jacks Branch	Source to Lumber River	WS-IV; Sw
Bear Swamp	Source to SR 1515	C; Sw
Little Bear Swamp	Source to Bear Swamp	C; Sw
Bear Swamp	SR 1515 to Lumber River	WS-IV; Sw
Watering Hole Swamp	Source to Bear Swamp	WS-IV; Sw
Moss Neck Swamp	Source to SR 1576	C; Sw
Moss Neck Swamp	SR 1576 to Bear Swamp	WS-IV; Sw
Kersey Branch	Source to Bear Swamp	WS-IV; Sw

(WS-IV = Water supply watershed; B = Primary recreation, freshwater; C = Aquatic life & secondary recreation, freshwater; Sw = Swamp waters; HQW = High quality waters)

C. Overview of Data Availability

Data sources for the Lumber River and Bear Swamp hydrologic units include:

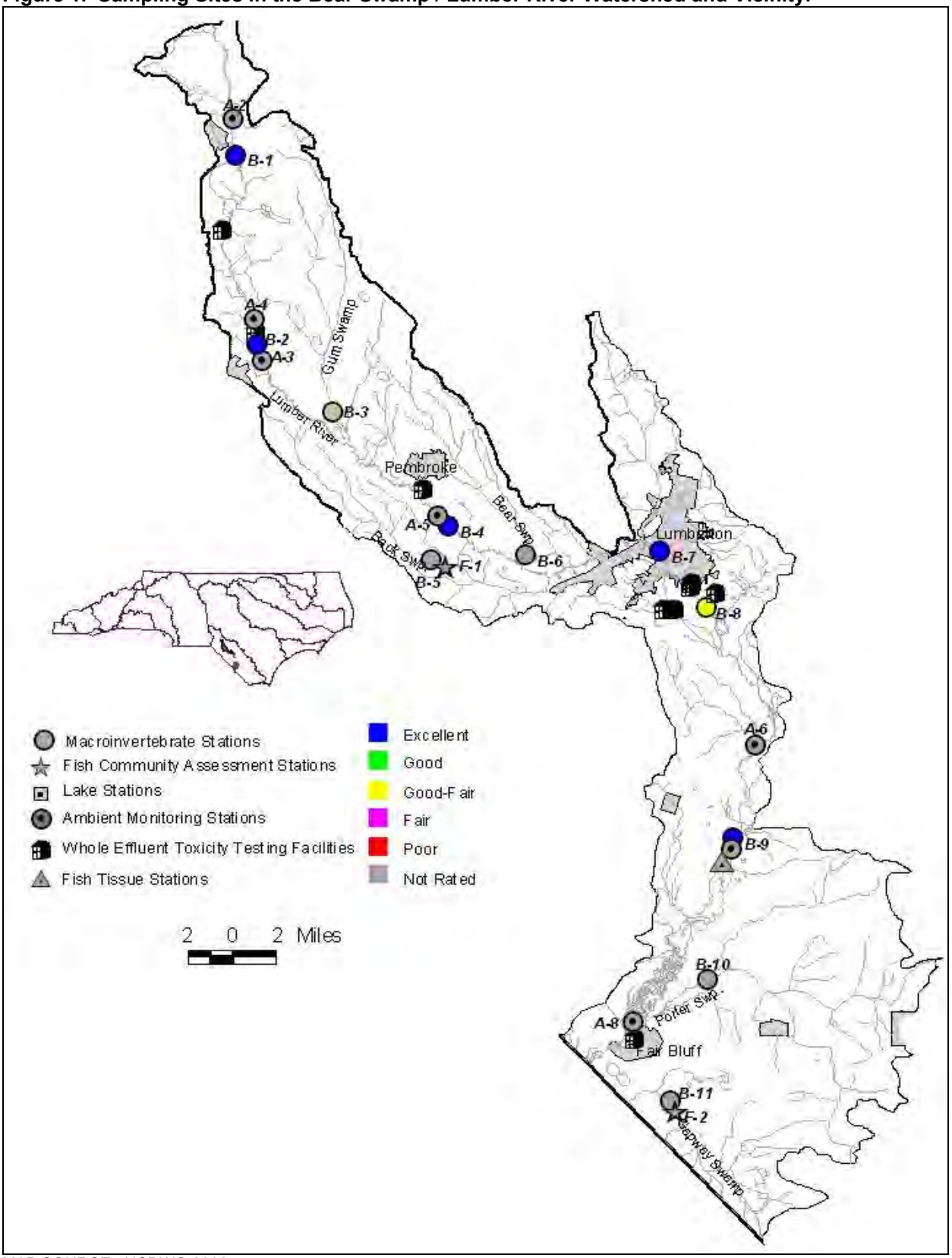
- Benthic macroinvertebrate community monitoring by the Division of Water Quality (DWQ) at one site each on the Lumber River (10 samples since 1983) and in Bear Swamp (three samples since 1996);
- Habitat and basic ambient field data collected by DWQ during benthic community sampling multiple times since 1983;
- Approximately monthly ambient data from one site on the Lumber River between 1992 and 2000; and
- Monthly effluent chemistry and instream (upstream / downstream) data from the Pembroke WWTP since 1982 and recent toxicity test data since 1996.

Additional ambient water quality, fish community and fish tissue samples have been collected by DWQ nearby but outside the study area. These data will not be discussed here. See NCDWQ (1999 and 2002) for a description of additional available data. See Figure 1 for a map of the sampling sites, including nearby sampling stations.

D. Impaired Waterbodies

The 303(d) list (NCDWQ 2003a) classifies all of the Lumber River in this watershed as impaired due to mercury levels in fish tissue samples and the resulting fish consumption advisory. None of the tributaries in the study area are specifically listed though *there is no reason to believe that migration of fish with high mercury levels from the mainstem into the tributaries is limited*. No other causes of impairment leading to 303(d) listing are evident in this watershed.

Figure 1. Sampling Sites in the Bear Swamp / Lumber River Watershed and Vicinity.



MAP SOURCE: NCDWQ 2002.

II. Summary of Existing Data

A. Benthic Macroinvertebrate Data.

DWQ has collected benthic macroinvertebrate samples from one site on the Lumber River at SR 1003 10 times since 1982. The instream habitat has been consistently diverse and water quality has been good. The site has maintained an "Excellent" bioclassification for the duration of sampling. Another site has been sampled three times since 1996 in Bear Swamp at SR 1339. This sampling was conducted by the Biological Assessment Unit as part of its regular basinwide assessments. Benthic macroinvertebrate community samples were collected using full scale methods as described in the *Standard Operating Procedures for Benthic Macroinvertebrates* (NCDWQ, 2003b). Additionally two of the Bear Swamp samples were used to help establish criteria for rating swamp waters (Lenat, 2003). Historical and recent bioclassifications for these locations are shown in Table 2.

Table 2. Bioclassification Data for the Bear Swamp / Lumber River Watershed.

WATER BODY	DATE	EPT	BI	EPTBI	BIOCLASSIFICATION
Lumber River at SR 1003	7/18/01	32	5.1	4.03	Excellent
	7/9/96	31	4.79	3.79	Excellent
	9/11/91	30	5.79	3.89	Excellent
	8/7/90	28	5.37	4.18	Excellent
	7/13/88	28	5.2	4.25	Excellent
	10/23/86	31	5.21	3.56	Excellent
	7/15/86	32	5.27	4.06	Excellent
	7/17/85	30	5.31	4.25	Excellent
	7/27/83	30	5.43	3.9	Excellent
	7/27/83	24	5.29	4.41	Excellent
Bear Swamp at SR 1339	7/18/01	11	---	6.31	Not Rated
	2/8/01	17	6.22	4.89	Natural
	3/14/96	20	6.13	5.31	Natural

EPT = Number of mayfly, stonefly & caddisfly species; BI = Biotic Index; EPTBI = Biotic Index for EPT species.

Adapted from NCDWQ 2002.

Synopsis of benthic data. Since 1982, Lumber River water quality in this watershed has not changed significantly with respect to its ability to support a diverse benthic community. It is currently rated "Excellent" and has been consistently so since sampling began. Bear Swamp at SR 1339 received the official rating of "Natural" for winter samples. Although it was not rated in July 2001, community composition "does not suggest major degradation" (NCDWQ 2002). Biologists reported that low dissolved oxygen concentration at this site may have been responsible for the absence of some species. Despite the low dissolved oxygen, the community was still diverse and suggests good water quality.

B. Aquatic Habitat and Instream Field Data.

During the basinwide assessments of benthic communities, stream habitat and riparian area conditions were evaluated for each sampling site using DWQ's standard habitat assessment protocol for coastal streams (NCDWQ, 2003b). This protocol rates the aquatic habitat of the sampled reach by adding the scores of a suite of local (reach scale) habitat factors relevant to macroinvertebrates. Total scores range from zero (worst) to 100 (best). Individual factors include (maximum factor score in parentheses):

- channel modification (15);
- in-stream habitat variety and area available for colonization (20);
- bottom substrate type and embeddedness (15);
- pool variety and frequency (10);

- bank stability and vegetation (20);
- light penetration/canopy coverage (10); and
- riparian zone width and integrity (10).

These maximum values differ from piedmont streams in that riffle habitats are not considered due to their scarcity in coastal plain streams. Channel modification and bank stability are given additional weight.

The Lumber River at SR 1003 received a habitat score of 83 and 81 and Bear Swamp at SR 1339 received a score of 96 and 83 for the 1996 and 2001 sampling periods, respectively. The Bear Swamp site had suffered from hurricane damage and some land clearing in the recent past. During a July 2001 benthic sample collection in Bear Swamp, dissolved oxygen concentration under low flow conditions was 3.5 mg/L, slightly below the state standard. Historical habitat scores and associated instream water quality data (dissolved oxygen, temperature, pH, and specific conductance) are available from the NCDWQ Biological Assessment Unit.

C. Ambient Station Data.

An ambient monitoring station has been operated at SR 1003 on the Lumber River since 1992. Data are summarized in Table 3 for September 1996 through August 2000.

Table 3. Ambient Data Summary for the Lumber River, Station # I305000, Sept. 1996 to Aug. 2000.

PARAMETER	STATISTICS					Evaluation Level	< or > Eval. Level	
	Number	Number BQL	Minimum	Median	Maximum		number	%
FIELD								
Dissolved Oxygen (mg/L)	44	NA	4	7.6	11.3	<5	1	2.3
Conductivity (µS/cm)	43	NA	33	106	254	--	--	--
Temperature (C)	44	NA	7	14	28	--	--	--
pH (SU)	44	NA	3.8	6.5	7.5	<6	5	11.4
OTHER (mg/L)								
Total Residue	23	0	42	82	180	--	--	--
TSS	44	8	1	2	17	>10	1	2.3
Chloride	24	0	5	18	45	--	--	--
Turbidity (NTU)	44	1	1	2	6	>50	0	0
NUTRIENTS (mg/L)								
NH3 as N	44	16	0.01	0.03	1.6	--	--	--
TKN as N	44	0	0.1	0.3	10.3	--	--	--
NO2+NO3 as N	44	1	0.01	0.31	1.4	>10	0	0
Total Phosphorus	44	2	0.01	0.05	0.24	>0.05	21	47.7
METALS (µg/L)								
Aluminum (Al)	44	0	150	255	470	--	--	--
Copper (Cu)	44	26	2	2	41	>7	3	6.8
Iron (Fe)	44	0	150	480	1100	>1000	1	2.3
Manganese (Mn)	23	9	10	11	23	>200	0	0
Zinc (Zn)	44	3	10	19	440	>50	7	15.9
Arsenic (As)	44	44	BQL	BQL	BQL	>50	--	--
Cadmium (Cd)	44	44	BQL	BQL	BQL	>2	--	--
Chromium (Cr)	44	44	BQL	BQL	BQL	>50	--	--
Lead (Pb)	44	44	BQL	BQL	BQL	>25	--	--
Mercury (Hg)	44	44	BQL	BQL	BQL	>0.012	--	--
Nickel (Ni)	43	43	BQL	BQL	BQL	>88	--	--

Abbreviations: BQL = below quantitation limit; TSS = Total Suspended Solids. Evaluation Levels (EL) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the EL.

Adapted from NCDWQ 2002.

D. Discharge Compliance Data.

A single discharger is situated in the watershed. The Pembroke WWTP (Permit number NC0027103) has discharged effluent into the Lumber river upstream of SR 1339 since 1981. The discharge is upstream of the DWQ ambient monitoring station at SR 1003 approximately 1.5 miles. As a part of its permit requirements, the plant conducts chemical monitoring on its effluent and monitors BOD upstream and downstream of the discharge. In recent years the plant has conducted toxicity testing using *Ceriodaphnia dubia* to assess the water quality of its effluent. The plant has a reasonably good record of compliance with no major recurring violations. Data for this plant is available via the Basinwide Information Management System of DWQ.

III. Conclusions

The benthic macroinvertebrate community in the Lumber River has been consistently diverse and healthy since monitoring began in the early 1980's. Bear Swamp appears to have a good benthic community despite recent damage to the riparian zone. The 303(d) classification of this portion of the Lumber River is due to mercury contamination in fish and it is unlikely that wetland or stream restoration can effectively address this issue. Little is known about the tributaries.

IV. References Cited

Lenat, D.R. 2003. *Macroinvertebrate Criteria for North Carolina Swamp Streams*. Division of Water Quality. Internal Memorandum. March.

NCDWQ. 1999. *Lumber River Basinwide Water Quality Plan*. Planning Branch. May. (http://h2o.enr.state.nc.us/basinwide/lumber_river_basinwide_plan_index.htm)

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NCDWQ. 2003b. *Standard Operating Procedures for Benthic Macroinvertebrates*. Biological Assessment Unit. July. (http://www.esb.enr.state.nc.us/BAUwww/benthossop.pdf)

EXISTING WATERSHED IMPROVEMENT PROGRAMS

FEDERAL

Clean Water Act – Section 319 Program

Section 319 of the Clean Water Act provides grant money for nonpoint source demonstration projects. Approximately $3.46 million is available annually for demonstration and education projects across the state. Grant money awarded for work in the Lumber River basin totaled $227,667 for two projects through the Section 319 program between 1999 and 2003. This money has primarily been used for basinwide education programs that disseminate information to the public. One such program is the Friends of Lake Waccamaw State Park, which has been responsible for hosting education workshops and demonstration of nonpoint source pollution solution. They also produce and distribute a bimonthly newsletter to all landowners in Lake Waccamaw area (DENR 2003).

STATE

NC Agriculture Cost Share Program

The North Carolina Agriculture Cost Share Program was established in 1984 to help reduce the sources of agricultural nonpoint source pollution to the state's waters. The program helps owners and renters of established agricultural operations improve their on-farm management by using Best Management Practices (BMPs). These BMPs include vegetative, structural or management systems that can improve the efficiency of farming operations while reducing the potential for surface and groundwater pollution. The Agriculture Cost Share Program is a voluntary program that reimburses farmers up to 75 percent of the cost of installing an approved BMP. The program is implemented by the Division of Soil and Water Conservation (DSWC). The cost share funds are paid to the farmer once the planned control measures and technical specifications are completed. The annual statewide budget for BMP cost sharing is approximately 6.9 million. From 1998 to 2002, $3,005,169 was provided for projects in counties wholly or partially in the Lumber River basin. The projects affected over 52,633 acres and saved almost 269,151 tons of soil from erosion. Also, 2,614,440 pounds of nitrogen and 342,223 pounds of phosphorus were saved (NCDENR-DSWC, 2003, ACSP Report: BMP Summary). For more information, the Soil and Water Conservation District website may be visited at http://www.enr.state.nc.us/DSWC/files/acs.htm (DENR 2003).

Clean Water Management Trust Fund

North Carolina's Clean Water Management Trust Fund (CWMTF) was established by the General Assembly in 1996 (Article 13A; Chapter 113 of the North Carolina General Statutes). At the end of each fiscal year, 6.5 percent of the unreserved credit balance in North Carolina's General Fund (or a minimum of $30 million) goes into the CWMTF. Revenues from the CWMTF are then allocated in the form of grants to local governments, state agencies and conservation nonprofit organizations to help finance projects that specifically address water pollution problems. The 18-member, independent, CWMTF Board of Trustees has full responsibility over the allocation of moneys from the fund. The CWMTF funds projects that: 1) enhance or restore degraded waters; 2) protect unpolluted waters; and/or 3) contribute toward a

network of riparian buffers and greenways for environmental, educational and recreational benefits. In the Lumber River basin, 30 projects have been funded for over 20 million dollars ($20,232,900). For more information on the CWMTF or these grants, call (252) 830-3222 or visit the website at www.cwmtf.net.

NC Construction Grants and Loans Program

The NC Construction Grants and Loans Section provides grants and loans to local government agencies for the construction, upgrade and expansion of wastewater collection and treatment systems. As a financial resource, the section administers two major programs that assist local governments, the federally funded Clean Water State Revolving Fund (SRF) Program and the NC Clean Water Revolving Loan and Grant Program. These programs can provide both low interest loan and grant funds for wastewater treatment projects. In the Lumber River basin, seven applicants have been offered a total of $13,032,255 in SRG projects, and two applicants have been offered a total of $2,154,350 in SRL projects. As a technical resource, the Construction Grants and Loans Section, in conjunction with the Environmental Protection Agency, has initiated the Municipal Compliance Initiatives Program. It is a free technical assistance program to identify wastewater treatment facilities that are declining but not yet out of compliance. A team of engineers, operations experts and managers from the section work with local officials to analyze the facility's design and operation (DENR 2003).

North Carolina Stream Watch

The realization that local residents are best suited to keep an eye on their nearby waterways is what prompted North Carolina to begin project Stream Watch. With Stream Watch, citizens groups "adopt" a waterway, or a portion of one, and act on its behalf. Stream Watchers become the adoptive parents of a stream and, as such, become its primary caretakers. With the help of the Department of Environment and Natural Resources' Division of Water Resources, Stream Watchers become informed stewards, learning how to react to the changing stream conditions. Local efforts combined with state support allow North Carolina's 37,000 miles of waterways to be monitored by those with the best view--local residents. In the Lumber River basin, there are four different groups monitoring different stream segments (DENR 2003). Call (919) 715-5433 or visit http://www.ncwater.org/Education_and_Technical_Assistance/Stream_Watch/ for more information on Stream Watch,.

Regional Initiatives

Conservation Trust for North Carolina

The Conservation Trust for North Carolina and CWMTF have funded two riparian corridor conservation plans in the Lumber River basin. Plans were prepared for the Drowning Creek watershed (subbasin 03-07-50) and the Waccamaw River (subbasin 03-07-56 and 03-07-57) (DENR 2003).

Lumber River Council of Government

Surface Water Initiatives of the Lumber River COG

In 1998, the Lumber River Council of Governments (LRCOG) published a report on the potential regionalization of wastewater discharge points within a large portion of the Lumber River basin. A section on this report contained a recommendation to begin organizing a

basinwide planning organization comprised of the region's stakeholders. Since 1998, the LRCOG has taken the initiative in addressing water resource concerns within the southeastern region of North Carolina, particularly within the Lumber River basin. In 2000, the LRCOG established the ***Lumber River Basin Consortium***. The consortium is a multi-stakeholder membership which includes business and industry; environmental groups; federal, state and local agencies such as Cooperative Extension and Soil and Water Conservation Service; the agricultural community; and educational/research institutions. The consortium's goal is to provide direction and recommendations for implementation on surface water issues and extend its reach to: 1) provide water quality research; 2) assist in water conservation education; and 3) promote wise stewardship of surface water resources. The consortium hopes to serve as a forum to provide coordinated management, communication among stakeholders, and assist in resolving water resource issues and concerns within the basin. In December of 2002, the LRCOG completed the **Lumber River Basin Strategic Plan**. This document lists strategies to help the consortium establish its leadership role in the Lumber River basin (DENR 2003). Components of the plan will include descriptions of the current status and future needs related to:

1. River Monitoring
2. Education
3. Advocacy
4. Intra-State Agreements
5. Inter-State Agreements with South Carolina
6. Riparian Buffers
7. River-Cleanup/Restoration
8. Public Awareness

Table G-1. Raw Indicator Data

Indicator		Total SW Area (Acres)	Total Stream Length (feet)	Ditches (feet)	Stream Buffered 50 (feet)	Stream Buffered 300 (feet)	Impervious Area (acres)	Forested (acres)	Wetlands (acres)	Interior Patches (acres)	Number of Interior Patches	Number of Corridors
HU	**SW**											
L	1	5193.6	126110.7	24302.0	57973.1	26067.3	171.6	1752.5	920.3	783.6	7	3
L	2	4621.7	119231.1	47174.6	52119.3	33486.0	358.0	1346.7	652.4	759.8	6	1
L	3	2557.4	82063.9	14177.6	50803.3	40536.1	51.8	1242.1	1011.8	996.7	5	2
BS	4	2763.6	59901.8	26142.2	14407.1	925.8	66.2	470.5	198.8	0.0	8	1
BS	5	1620.9	20648.4	5624.9	2011.4	0.0	49.5	413.4	105.4	95.5	7	1
BS	6	3355.1	70066.2	28815.0	27378.6	4167.0	332.0	747.4	274.4	124.9	2	0
BS	7	3108.6	82861.2	11681.8	28649.0	11901.7	127.0	751.5	336.9	199.4	2	1
BS	8	2257.5	58164.0	10804.7	22041.9	13606.8	49.8	632.8	405.2	316.3	5	0
BS	9	2742.0	69460.4	19171.0	19812.3	3263.3	123.6	622.1	320.5	37.3	1	0
BS	10	2911.4	61036.6	5256.5	45863.3	33026.5	54.0	1417.3	1129.1	991.8	0	0
BS	11	2214.4	64283.6	0.0	22465.4	11478.2	104.1	690.4	314.4	266.7	2	0

Table G-2. Relativized Indicator Data, Indicator Ratings, and Cumulative Function Ratings

Indicator		% Ditches	Rating	% Stream Buffered 50 ft	Rating	% Stream Buffered 300 ft	Rating	% Impervious Area	Rating	% Forested	Rating	% Wetlands	Rating	% Interior Area	Rating	No. of Interior Patches	Rating	No. of Corridors	Rating	Cumulative Score Water Quality	Rating	Cumulative Score Hydrology	Rating	Cumulative Score Habitat	Rating	Cumulative Score Overall	Rating
Water					x		x		x		x		x														
Hydrology			x		x		x		x		x		x														
Habitat											x		x		x		x		x								
HU	**SW**																										
BS	10	9%	1	75%	1	54%	1	2%	1	49%	1	39%	1	70%	1	7	1	3	1	5	1	6	1	5	1	9	1
L	3	17%	2	62%	1	49%	1	2%	1	49%	1	40%	1	80%	1	6	2	1	2	5	1	7	1	7	1	12	1
BS	8	19%	2	38%	2	23%	2	2%	1	28%	2	18%	2	50%	1	5	2	2	1	9	1	11	2	8	1	15	2
L	1	19%	2	46%	2	21%	2	3%	2	34%	1	18%	2	45%	2	8	1	1	2	9	1	11	2	8	1	16	2
L	2	40%	3	44%	2	28%	2	8%	3	29%	2	14%	2	56%	1	7	1	1	2	11	2	14	3	8	1	18	2
BS	11	0%	1	35%	2	18%	2	5%	2	31%	2	14%	2	39%	2	2	3	0	3	10	2	11	2	12	2	19	2
BS	7	14%	1	35%	2	14%	2	4%	2	24%	3	11%	2	27%	3	2	3	1	2	11	2	12	2	13	2	20	3
BS	9	28%	2	29%	3	5%	3	5%	2	23%	3	12%	2	6%	3	5	2	0	3	13	3	15	3	13	2	23	3
BS	5	27%	2	10%	3	0%	3	3%	2	26%	2	7%	3	23%	3	1	3	0	3	13	3	15	3	14	3	24	3
BS	4	44%	3	24%	3	2%	3	2%	1	17%	3	7%	3	0%	3	0	3	0	3	13	3	16	3	15	3	25	3
BS	6	41%	3	39%	2	6%	3	10%	3	22%	3	8%	3	17%	3	2	3	0	3	14	3	17	3	15	3	26	3

MONITORING RECOMMENDATIONS FOR PHASE II OF THE LUMBER RIVER LOCAL WATERSHED PLAN

January 23, 2004

Information compiled about this watershed and field reconnaissance suggest multiple monitoring approaches will improve our understanding of the water quality here. Benthic sampling (using swamp stream methodology), fish sampling and chemical and physical parameter monitoring in a handful of key locations should be sufficient to determine whether the water quality in the various tributaries differ significantly from the consistently excellent water quality of the Lumber River in these hydrologic units. Below are each of the tributaries (and main stem) in the study area which are classified by the NC Division of Water Quality. Table 1 outlines the proposed monitoring plan. Narrative explanation for proposed sampling follows for each subwatershed. Lower priority sampling may be eliminated dependent upon time and effort constraints.

Table 1. Monitoring Recommendations for the Lumber River Local Watershed Plan, Phase II.

Stream	Parameters	Flow	Minimum N	Frequency	Priority
Lumber River at SR 1003	nutrients, field [1]	base	4	bimonthly	1
Mill Branch at SR 1339	benthos	base	1	- [2]	1
	fish	base	1	-	1
	nutrients, metals, field	base	4	bimonthly	1
Jacks Branch at NC 711	benthos	base	1	-	1
	nutrients, metals, field	base	8	monthly	1
	nutrients, metals, residue, field	storm	4	- [3]	1
	toxicity	storm	4	-	1
Jacks Branch upstream of Golf Club	nutrients, metals, residue, field	storm	4	-	1
	toxicity	storm	4	-	1
Bear Swamp at SR 1339	benthos	base	1	-	1
	fish	base	1	-	1
	nutrients, metals, field	base	8	monthly	1
	nutrients, metals, residue, field	storm	4	-	1
	toxicity	storm	4	-	1
Bear Swamp at Saint Anna Road	nutrients, metals, field	base	8	monthly	2
	nutrients, metals, residue, field	storm	4	-	2
	toxicity	storm	4	-	1
Little Bear Swamp	none	-	-	-	-
Watering Hole Swamp at Jones Road	benthos	base	1	-	1
	fish	base	1	-	1
	nutrients, metals, field	base	8	monthly	1
	nutrients, metals, residue, field	storm	4	-	1
	toxicity	storm	4	-	1
Moss Neck Swamp at Holly Swamp Church Road	benthos	base	1	-	1
	fish	base	1	-	1
	nutrients, metals, field	base	8	monthly	2
	nutrients, metals, residue, field	storm	4	-	2
Kersey Branch	none	-	-	-	-

[1] Field parameters include dissolved oxygen, water temperature, turbidity, specific conductance, and pH.

[2] Benthic sampling will only occur once per site during the study period.

[3] Storm sampling is contingent upon the weather and cannot be regularly scheduled.

LUMBER RIVER – An abbreviated chemical and physical parameter sampling regime (bimonthly nutrient sampling and field parameters at baseflow only) is recommended for the main stem of the river at SR 1003 to document current conditions, especially with respect to phosphorus levels. Because ambient sampling was discontinued in 2000, this relatively small amount of sampling will verify if water quality conditions are relatively unchanged. The recent benthic community composition data suggest additional sampling would only confirm continued excellent water quality.

MILL BRANCH – This tributary drains a significant mostly rural area directly into the Lumber River. Its designated uses are for aquatic life and secondary recreation. No data currently exists for this tributary.

Benthic community sampling in the lower part of the subwatershed is recommended to assess recent water quality conditions here. Fish sampling may also be necessary to augment our understanding of the biological conditions here. The site upstream of SR 1339 is accessible and is less impacted by roads than nearby bridges. However, if flow is not adequate at this site, the site at NC 711 may be more suitable. Also, an abbreviated chemical and physical monitoring regime (bimonthly nutrient sampling and field parameters at baseflow only) would be useful to characterize conditions in the tributary and verify whether or not nutrient contributions are proportional to concentrations in the main stem.

JACKS BRANCH – This tributary drains a significant rural area between Bear and Gum swamps into the Lumber River. No data exists for this branch. A large golf course exists just north of NC 711 near the confluence with the river and may contribute an array of chemicals not in common use elsewhere in the watershed.

Assuming adequate winter flow, benthic sampling is recommended here in the lowermost portion of the subwatershed at NC 711 to assess water quality. The altered nature of the channel through the golf course above NC 711 would make fish community data difficult to directly compare with the other streams and is therefore not recommended at this site. Toxicity testing may be useful to determine if golf course chemicals are impacting stream biota and is recommended for storm flow. Chemical and physical parameter sampling should also be performed to characterize water quality (monthly nutrients, metals, and field parameters during base flow; these plus residue for storm flow). An abbreviated sampling regime should be undertaken upstream of the golf course for comparative purposes, paying particular attention to conductivity and nutrients (bimonthly nutrients, metals, field parameters and residue during storm flow). This would possibly require special access.

BEAR SWAMP – This is the largest tributary in the study area. It contains primarily rural agricultural areas but also much of the town of Pembroke. Several other tributaries flow into Bear Swamp before it drains into the Lumber River including Little Bear Swamp, Moss Neck Swamp, Watering Hole Swamp, and Kersey Branch. Benthic community data exists for this tributary at SR 1339. These data suggest water quality is representative of natural swamp conditions.

Benthic and fish sampling at SR 1339 would be useful to verify current conditions have not declined since 2001. Chemical and physical parameter monitoring should include base flow and storm flow samples at SR 1339 and upstream at Saint Anna Road above Pembroke. Particular attention should be given to nutrients and conductivity to determine if levels are significantly above background levels. Limited toxicity testing is recommended to document whether or not runoff from Pembroke is impacting the stream.

LITTLE BEAR SWAMP – This tributary drains a relatively small agricultural area. Although there is no data available on this tributary, no monitoring is recommended at this time. Should an undetected source of degradation be discovered or a potential restoration opportunity be identified on this branch, appropriate monitoring may be subsequently initiated.

WATERING HOLE SWAMP – This relatively small tributary drains much of the town of Pembroke into Bear Swamp. No ambient or benthic data is available for this tributary.

Providing adequate winter base flow, benthic sampling is recommended at Jones Road. Fish sampling may be recommended later in the spring, especially if benthic data are difficult to interpret when compared to the other larger streams. Nutrients, metals and physical parameter sampling are recommended for storm and base flow. Residue samples should also be collected during storm flow. Limited toxicity testing (bimonthly) would help to verify whether Pembroke is contributing significantly to any water quality degradation that may be present.

MOSS NECK SWAMP – This tributary is relatively large and drains much of the northern part of the watershed into Bear Swamp. It is primarily agricultural with scattered housing. Much of the stream is channelized and is maintained by a drainage district. No data specific to this tributary is available.

Benthic and fish monitoring is recommended for the downstream site at Holly Swamp Church Road where access and habitat issues are minimized. Regular chemical and physical parameter monitoring during both base (nutrients, metals and field parameters) and storm flows (these plus residue) are recommended to characterize water quality on this branch.

KERSEY BRANCH – This tributary drains a relatively small area into Bear Swamp just above its confluence with the Lumber River. No benthic or chemical data is available. Due to its small size and lack of obvious sources of degradation, no monitoring is recommended at this time.

METHODS OF ANALYSES. Benthic macroinvertebrate and fish community monitoring will be conducted according to the standard procedures used by the DWQ Biological Assessment Unit (NCDWQ 2003a for benthos; NCDWQ 2001 for fish).

Water temperature, dissolved oxygen, pH, turbidity and specific conductance will be measured in situ using appropriate field instrumentation. Samples for other parameters will be submitted to the DWQ Laboratory Section for analysis. Chemical-physical monitoring will be conducted according to the procedures described in the Intensive Survey Unit's Standard Operating Procedures (SOP) manual (NCDWQ 2003b) and the DWQ Laboratory Section's sample

submission guidance (NCDWQ, 2002). Current sample preservation requirements are available on-line at http://www.esb.enr.state.nc.us/lab/qa/collpreswq.htm. Analytical methods used by the DWQ Laboratory Section for the parameters covered by this monitoring plan (plus discretionary analyses that may be employed if needed) are listed in Table 2. Unanticipated sources of water quality degradation (ie-those suggested by toxicity testing) may require additional chemical testing not accounted for in the basic monitoring plan as outlined in Table 1.

Table 2. Laboratory Methods for Chemical Analyses.

Parameter	EPA Method	APHA Method	Other Method	Practical Quantitation Limit (PQL)	Revision Date
Suspended residue	160.2	2540D		2 mg/L	3/13/2001
Suspended volatile residue	160.4			2 mg/L	3/13/2001
Suspended fixed residue	160.4			2 mg/L	3/13/2001
Turbidity	180.1	2130B		1NTU	3/13/2001
NH3 as N	350.1 and 350.2		QUIK CHEM 10-107-06-1-J	0.01 mg/L	7/24/2001
TKN as N	350.1 and 351.2		QUIK CHEM 10-107-06-2-H	0.20 mg/L	7/24/2001
NO2+ NO3 as N	353.2		QUIK CHEM 10-107-04-1-C	0.01 mg/L	7/24/2001
P total as P	365.1		QUIK CHEM 10-115-01-1-EF	0.02 mg/L	7/24/2001
Cadmium (Cd)	200.8/213.2			2.0µg/L	3/13/2001
Chromium (Cr)	200.8/200.7			25µg/L	3/13/2001
Copper (Cu)	200.8/220.2			2.0µg/L	3/13/2001
Nickel (Ni)	200.8/200.7			10µg/L	3/13/2001
Lead (Pb)	200.8/239.2			10µg/L	3/13/2001
Zinc (Zn)	200.8/200.7			10µg/L	3/13/2001
Silver (Ag)	200.8/272.2			5µg/L	3/13/2001
Aluminum (Al)	200.7			50µg/L	3/13/2001
Calcium (Ca)	200.7			0.10 mg/L	3/13/2001
Iron (Fe)	200.7			50µg/L	3/13/2001
Magnesium (Mg)	200.7			0.10 mg/L	3/13/2001
Manganese (Mn)	200.8/200.7			10µg/L	3/13/2001
Arsenic (As)	200.8/206.2			10µg/L	3/13/2001
Mercury (Hg)	245.1			0.2µg/L	3/13/2001

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