Middle Cape Fear
Local Watershed Plan

Technical Memorandum 1:
Watershed Characterization

North Carolina Department of Environment and Natural Resources
Wetlands Restoration Program

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Appendix 1 – SPOT Aerial Photography by Subwatershed

1 Background

The North Carolina Wetlands Restoration Program (NCWRP) contracted with Buck Engineering to perform a technical assessment of three 14-digit hydrologic units (HUs) in the Middle Cape Fear River Basin. This work is being completed as part of their Local Watershed Planning (LWP) initiative. This Technical Memorandum presents a watershed characterization for the study area and is accompanied by a GIS-based data compendium which was used to produce the statistics for each watershed (populations, percent impervious surface, land use by area, etc).

The three HUs are parallel drainages to the Cape Fear River and are located within portions of Chatham, Wake, and Harnett Counties (Figure 1.1). Table 1.1 shows the land area of the watersheds within each of the counties. The watersheds include parts of the towns of Apex, Holly Springs, and Fuquay-Varina and the portion of Raven Rock State Park north and east of the Cape Fear River. Major streams in the watersheds include: tributaries to Harris Lake (White Oak Creek, Little White Oak Creek, Buckhorn Creek, Utley Creek, and Cary Branch), Parkers Creek, Mill Creek, Avents Creek, Hector Creek, Kenneth Creek, Neills Creek, and Dry Creek.

Table 1.1. County Land Area within Study Watersheds

County	Land Area within Study Watersheds (mi^2)	Total County Land Area (mi^2)
Chatham	15.4	709
Harnett	88.3	601
Wake	76.4	856

Three streams have a High Quality Waters (HQW) designation according to the North Carolina Division of Water Quality (DWQ). These are Parkers Creek, Avents Creek, and Hector Creek. HQW is a supplemental classification intended to protect waters with quality higher than state water quality standards.

A portion of Kenneth Creek was listed with a high priority on North Carolina's 2000 Clean Water Act Section 303(d) list of impaired waters and is within a water supply watershed. Other creeks in the watershed are potentially degraded and/or threatened by development and existing uses, including agriculture and silviculture.

This report presents a summary of existing watershed and land use information collected within the study area. Tasks performed include the following:

- Collect and review existing planning information
- Collect and review existing GIS data
- Identify and obtain critical missing GIS data
- Develop enhanced agricultural land use and practice data layer
- Develop enhanced stormwater data layer for Holly Springs and Fuquay-Varina
- Collect and review existing monitoring data
- Identify potential types of restoration projects.

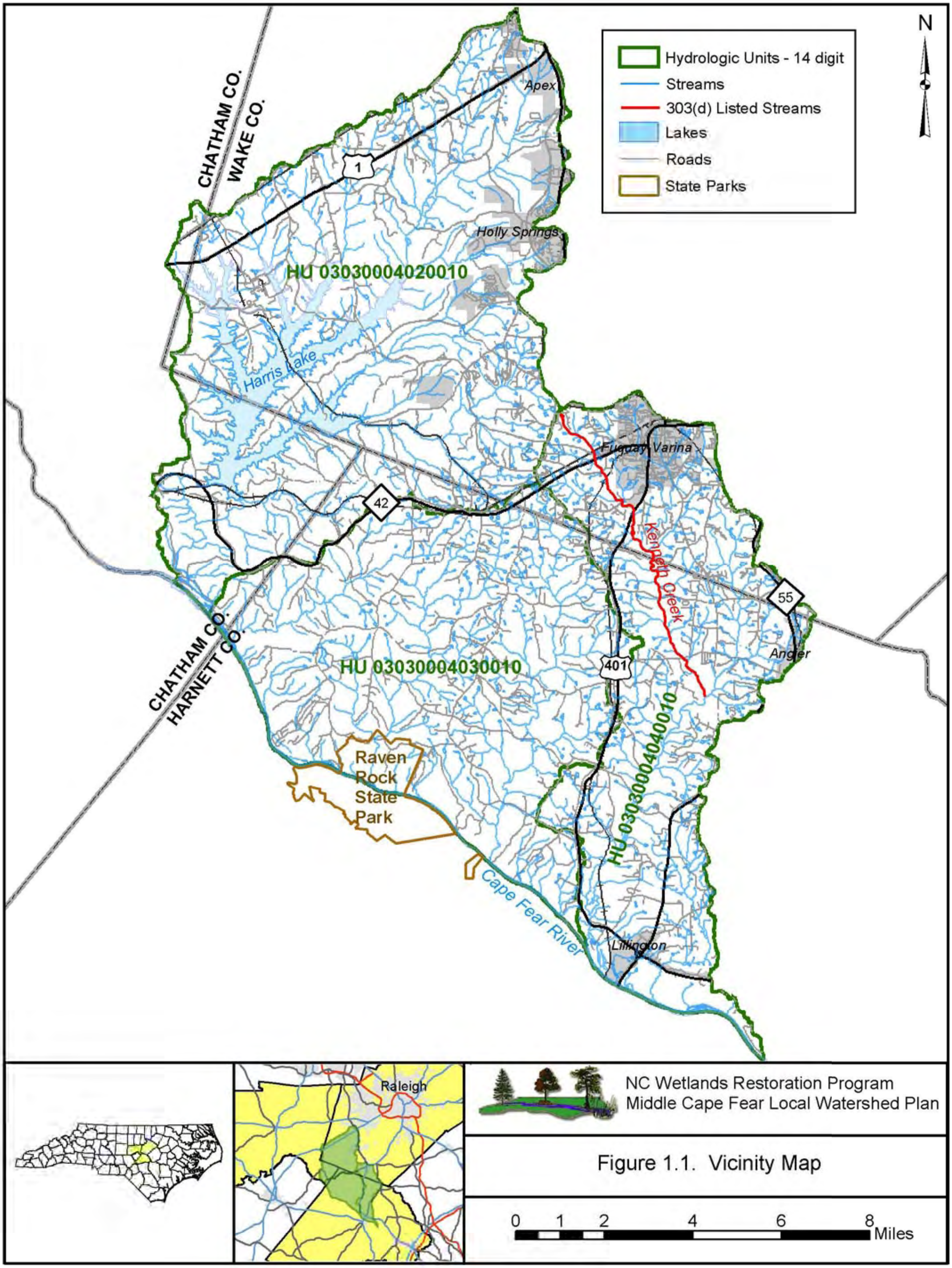

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Figure 1.1. Vicinity Map

The characterization presented in this memorandum will be supplemented with field data collected within the watersheds (Figure 1.2). Together this information will allow the NCWRP to draw general conclusions about the more than 700 stream miles within the watershed as well as similar streams in adjacent watersheds. Following the field work phase of the project, modeling will be implemented to estimate watershed response to land use changes. The final product of this effort will be an assessment of watershed functions, determination of sources of degradation, and identification and prioritization of watershed management strategies to address functional deficits.

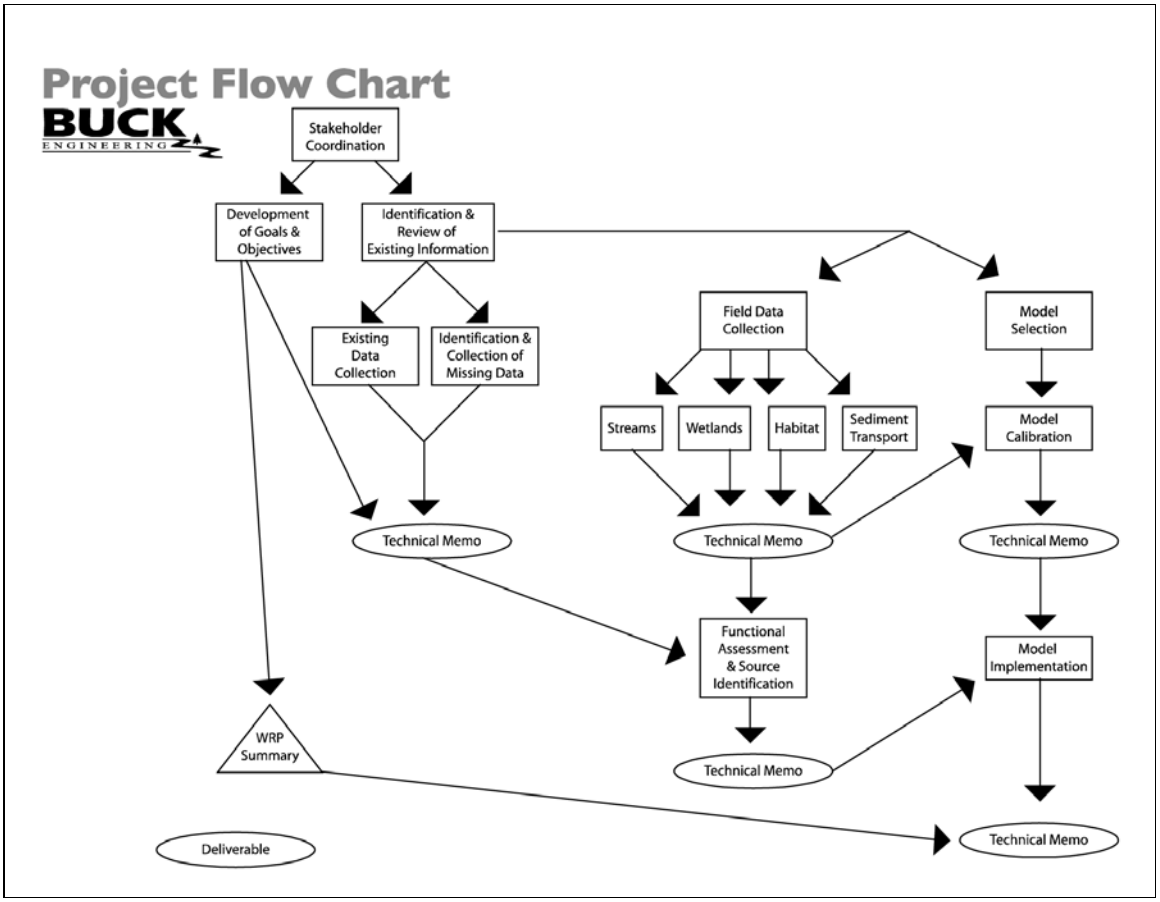

Figure 1.2 Local Watershed Plan Project Flow Chart

2 Watershed Overview

2.1 Harris Lake & Tributaries (HU 03030004020010)

This watershed is approximately 80 square miles in size, extending south from the Town of Apex to the Cape Fear River and east from the Chatham/Wake County line to the Town of Holly Springs (Figure 2.1). Both Apex and Holly Springs span the ridgeline that separates the Neuse and Cape Fear River basins. The watershed contains Harris Lake, an impoundment of Buckhorn Creek, which is used by Progress Energy's 900-megawatt Shearon Harris Nuclear Plant for cooling. The watershed also contains six named tributaries to Harris Lake - White Oak Creek, Little White Oak Creek, Utley Creek, Cary Branch, Thomas Creek, and Tom Jack Creek.

Progress Energy is a major landowner within the watershed. The Shearon Harris plant is located on a 10,700-acre site near the town of New Hill. Progress Energy also owns land outside the power plant and has enrolled more than 13,000 acres within the watershed into the North Carolina Wildlife Resources Commission's Game Lands Program.

Major point source dischargers in the watershed are the Town of Holly Springs and Shearon Harris Nuclear Plant. (See Section 6.1 for a list of all point source dischargers.) There are two hazardous materials areas, the Harris plant and a Wake County (Feltonsville) landfill near Apex. The landfill has a non-discharge permit from DWQ for use of land application as waste disposal.

2.2 Parkers, Avents, & Hector Creeks (HU 03030004030010)

This watershed is approximately 54 square miles in size, and is located almost entirely within Harnett County (Figure 2.2). Raven Rock State Park is located along the Cape Fear River on the southern boundary of the watershed. There are no municipalities within the watershed. Most of the land area is part of the water supply watershed for the Town of Lillington, located farther downstream along the Cape Fear River.

The three mainstem streams in this watershed, Parkers Creek, Avents Creek, and Hector Creek, all have High Quality Waters designations because of the "Excellent" water quality ratings they received from DWQ. There are no point source discharges or hazardous materials sites within the watershed.

2.3 Kenneth & Neills Creeks (HU 03030004040010)

This watershed is approximately 46 square miles in size, extending south from the Town of Fuquay-Varina to Lillington, and east from US 401 to the Town of Angier (Figure 2.3). Kenneth Creek is a tributary to Neills Creek, which flows to the Cape Fear River near Lillington. A portion of Kenneth Creek was listed on North Carolina's 2000 Clean Water Act Section 303(d) list for receiving a poor water quality rating.

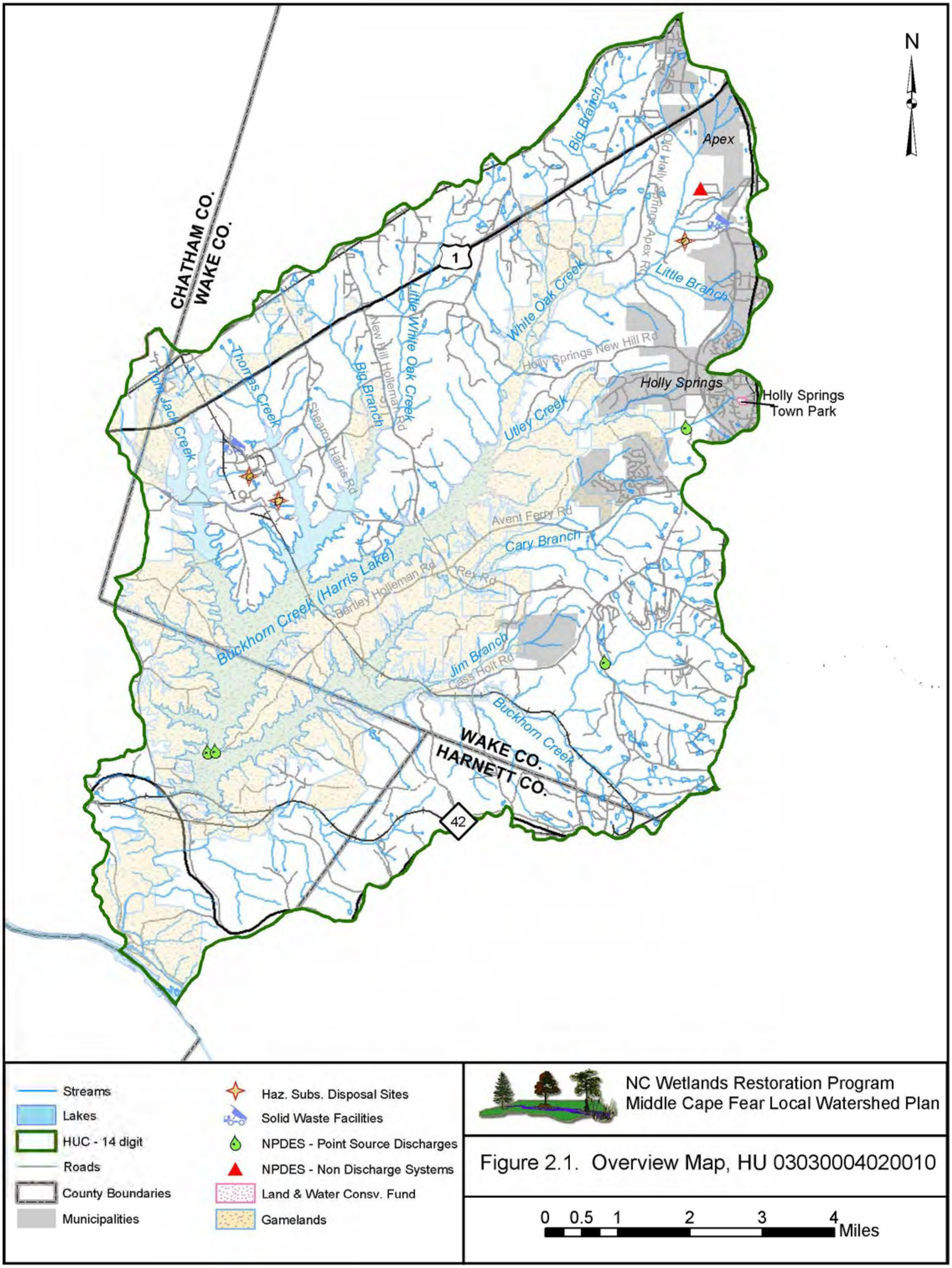

Figure 2.1. Overview Map, HU 03030004020010

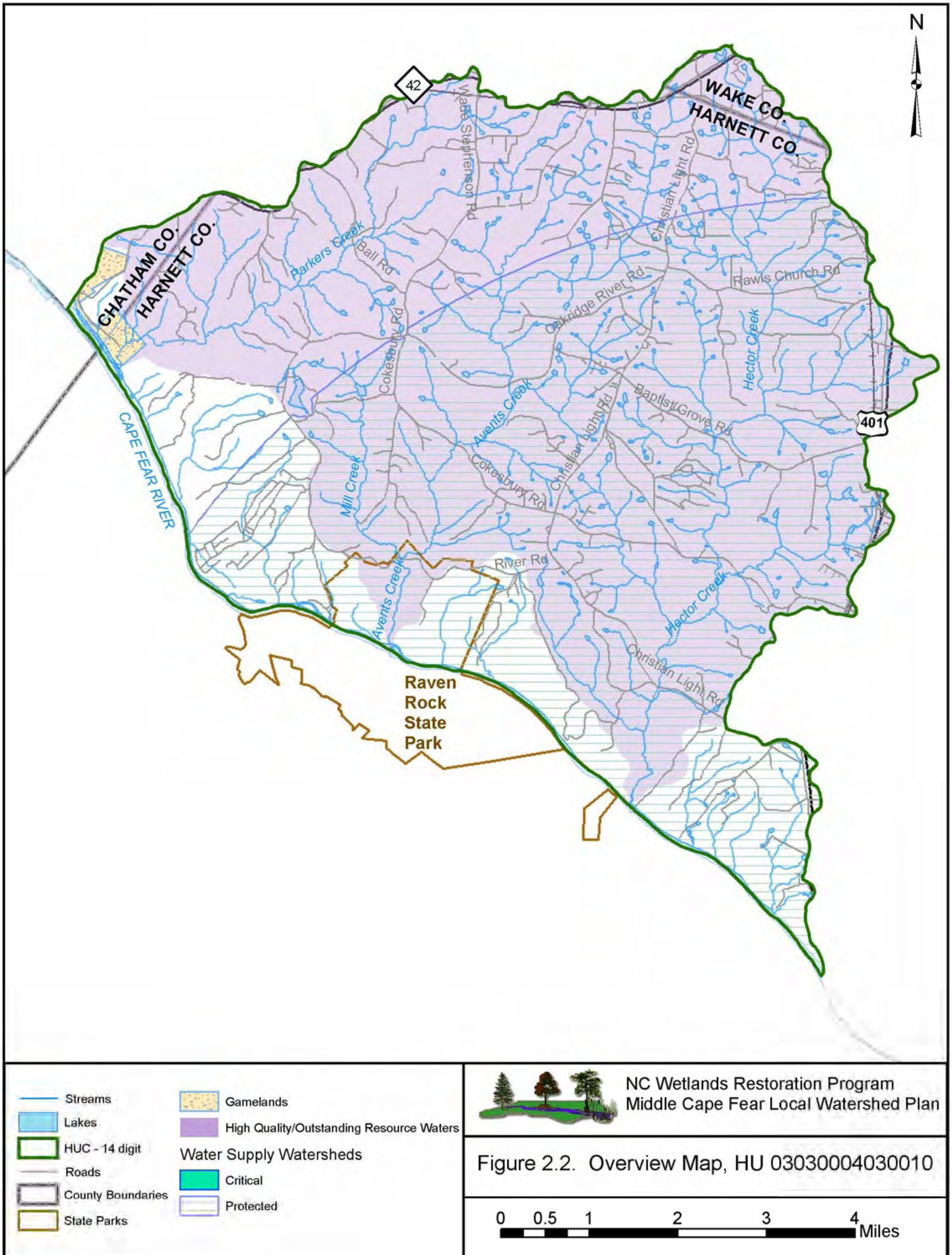

Figure 2.2. Overview Map, HU 03030004030010

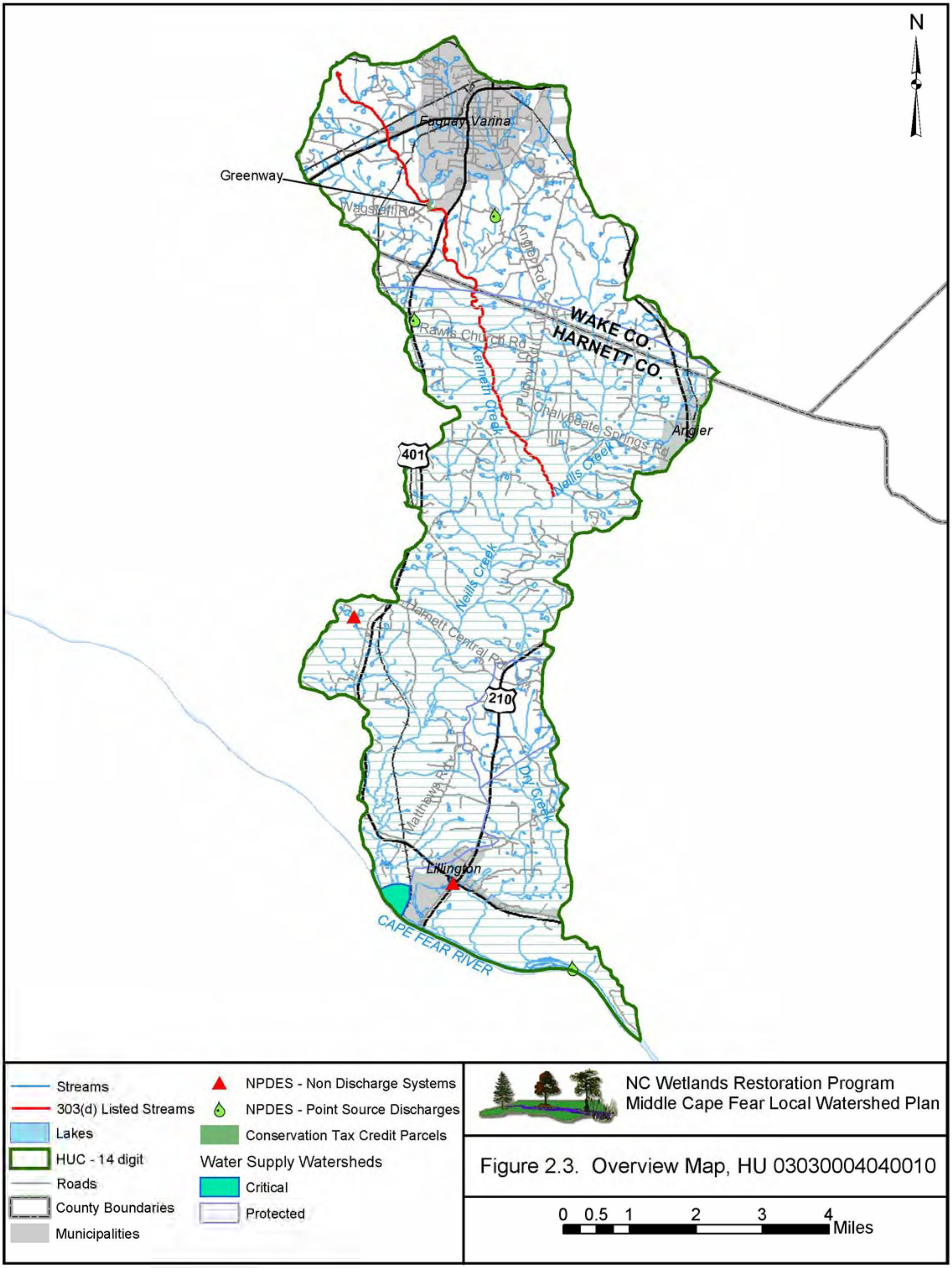

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Figure 2.3. Overview Map, HU 03030004040010

Much of the land area is part of the water supply watershed for the Town of Lillington. The only major point source discharge is the Town of Fuquay-Varina waste water treatment plant (WWTP), which is permitted at 1.2 million gallons per day. This plant is scheduled to be taken off-line in 2005 when the Harnett County regional WWTP will be operational. There are no known hazardous materials sites within the watershed.

2.4 Subwatersheds

For the purposes of this study, the three hydrologic units were further sub-divided based on their drainage system in order to develop more manageable units for analysis and management (Figure 2.4). Using GIS, the three watersheds were divided into 19 subwatersheds, ranging in size from 3.6 to 16.5 square miles. The delineation was based on major named tributaries to the Cape Fear River. The three largest tributaries (Neills Creek, Avents Creek, and Hector Creek) were divided into multiple subwatersheds in order to create smaller assessment units with more homogeneous conditions (e.g., geology, soils, and land use).

Aerial photography of the subwatersheds is included in Appendix 1. Table 2.1 lists the subwatersheds and includes their drainage areas, stream length, and drainage density. Drainage density is the ratio between the total length of the streams in a drainage basin and the area drained by them.

Table 2.1. Subwatershed Statistics

Subwatershed	Drainage Area (mi^2)	Total Stream Length (mi)*	Drainage Density
White Oak Creek	15.1	55.5	3.7
Little White Oak Creek	8.3	24.2	2.9
Thomas Creek	4.6	14.2	3.1
Tom Jack Creek	9.2	31.9	3.5
Utley Creek	9.5	29.3	3.1
Cary Branch	6.7	27.9	4.1
Buckhorn Creek	13.9	57.1	4.1
Harris Lake Arm	3.6	14.6	4.0
Below Harris Lake	9.1	34.0	3.7
Total for HU 3030004020010	80.0	288.9	3.6
Parkers Creek	9.7	35.7	3.7
Upper Avents Creek	8.1	38.0	4.7
Lower Avents Creek	12.6	46.4	3.7
Upper Hector Creek	10.9	47.2	4.3
Lower Hector Creek	12.5	49.5	4.0
Total for HU 3030004030010	53.8	216.8	4.0
Kenneth Creek	16.5	82.1	5.0
Upper Neills Creek	8.0	37.8	4.7
Middle Neills Creek	8.2	38.6	4.7
Lower Neills Creek	7.3	35.4	4.9
Dry Creek	6.3	34.4	5.4
Total for HU 3030004040010	46.3	228.2	4.9

* Note: Estimates of stream length calculated using GIS data produced by the NC Center for Geographic Information and Analysis, based on streams as they appear on USGS 1:24,000-scale topo sheets. Ephemeral channels, ditches, and other waterways that do not appear on 1:24,000-scale maps are not included.

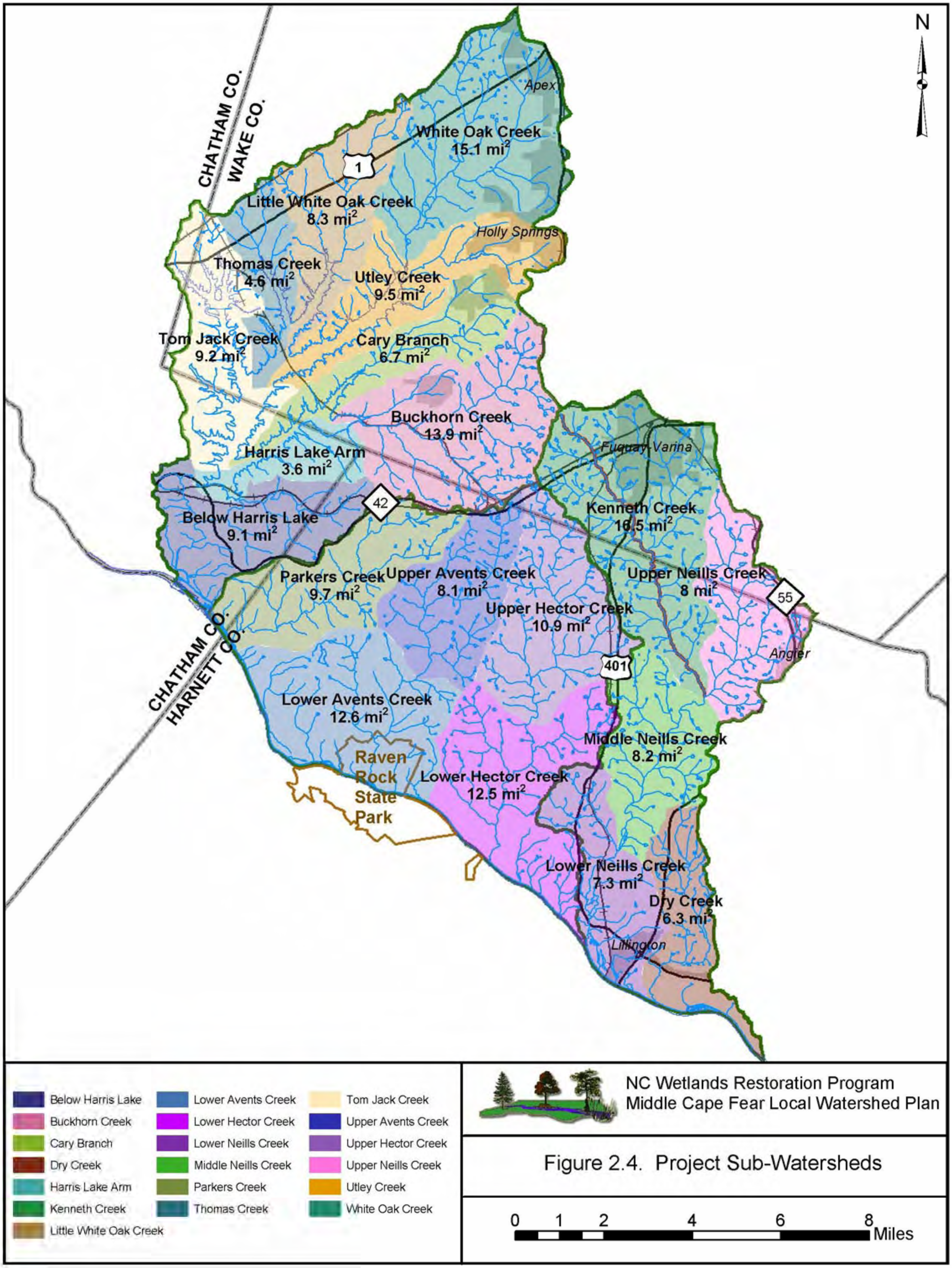


Figure 2.4. Project Sub-Watersheds

3 Natural Resources

3.1 Geology

The study watersheds lie predominantly in the Triassic Basins, Rolling Coastal Plain, and Northern Outer Piedmont ecoregions (Figure 3.1). Small areas within the watersheds are also classified as lying in the Sand Hills and Southeast Floodplains and Low Terraces ecoregions. The following sections describe the geology of the watersheds. Descriptions of the geological names are presented in Table 3.1.

Table 3.1. Geology Descriptions for the Study Watersheds

Abbr.	Name	Description
CZbg	Biotite Gneiss and Schist	Inequigranular and megacrystic; in places contains garnet; interlayered and gradational with mica schist and amphibolite; includes small masses of granitic rock
CZfg	Felsic Mica Gneiss	Interlayered with graphitic mica schist and mica-garnet schist, commonly with kyanite; minor hornblende gneiss
CZg	Metamorphosed Granitic Rock	Megacrystic, well foliated, locally contains hornblende; Vance County suite and Buckhorn granite
CZg	Metamorphose Granitic Rock	Megacrystic, well foliated, locally contains hornblende; Vance County suite and Buckhorn granite
CZph	Phyllite and Schist	Minor biotite and pyrite; includes phyllonite, sheared fine-grained metasediment, and metavolcanic rock
Km	Middendorf Formation	Sand, sandstone, and mudstone, gray to pale gray with an orange cast, mottled; clay balls and iron-cemented concretions common, beds laterally discontinous, cross-bedding common
TRc	Triassic Basin, Chatham Group	Conglomerate, fanglomerate, sandstone, and mudstone
Trcc	Cumnock Formation	Sandstone and mudstone, gray to black; coal beds and carbonaceous shale; grades into Pekin and Sanford Formations
Trcp	Pekin Formation	Conglomerate, sandstone, and mudstone
TRcs	Sanford Formation	Conglomerate, fanglomerate, sandstone, and mudstone
Tt	Terrace Deposits and Upland Sediment	Gravel, clayey sand, and sand, minor iron-oxide cemented sandstone

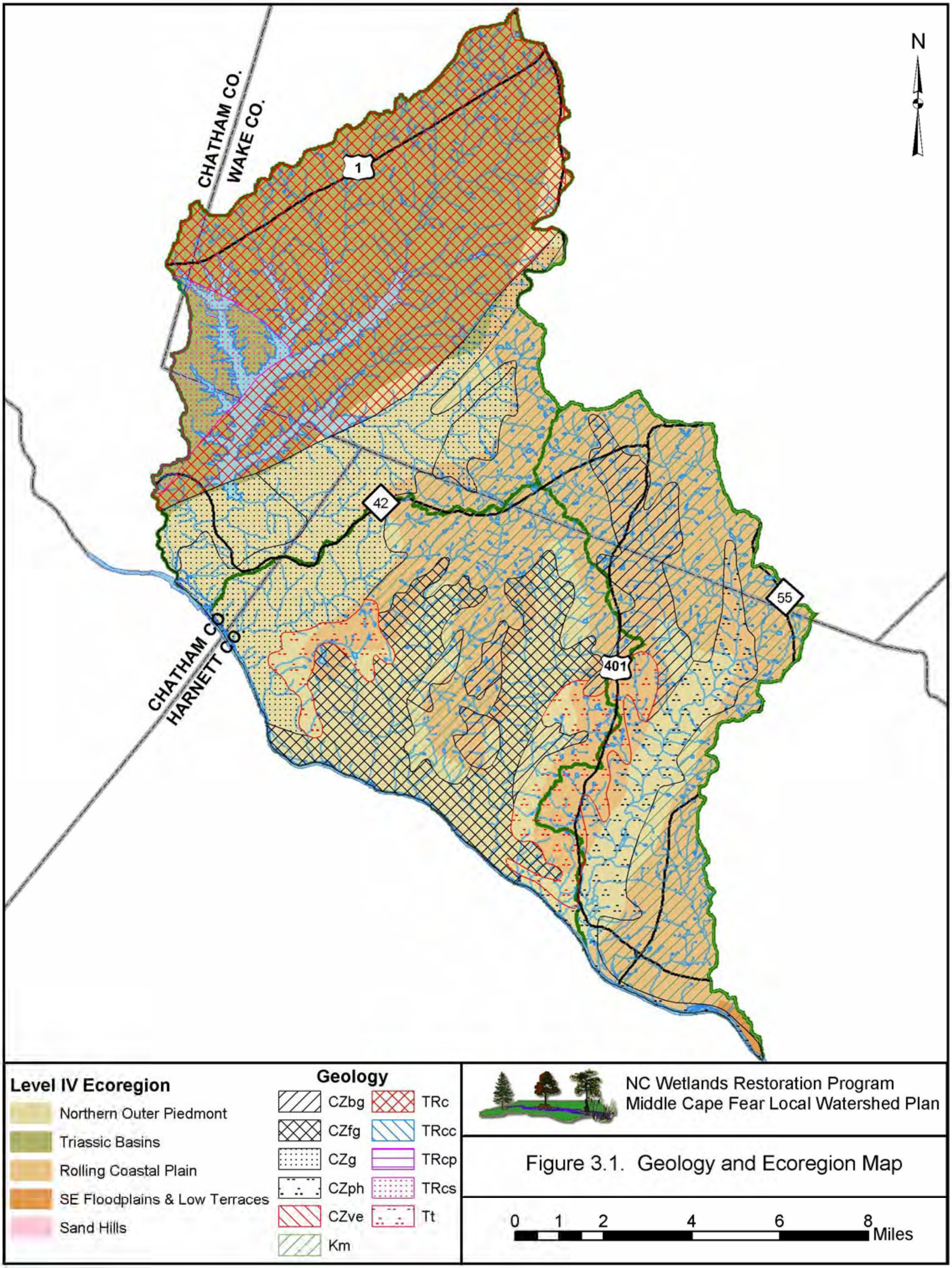


Figure 3.1. Geology and Ecoregion Map

3.1.1 Harris Lake & Tributaries (HU 03030004020010)

Most of the Harris Lake watershed lies in the Triassic Basin ecoregion, with land along the eastern edge of the watershed in the Northern Outer Piedmont and Rolling Coastal Plain ecoregions. Geology in the Triassic Basin ecoregion is predominantly the Chatham Group (TRc), with some Metamorphosed Granitic Rock (CZg) along the eastern edge of the watershed. A small area around the southwestern arm of Harris Lake is classified as the Sanford Formation (TRcs). A very small section of the watershed along the Chatham/Wake County line is classified as Cumnock Formation (Trcc) and Pekin Formation (Trcp). The northern tip of the watershed near Apex contains a small section of Terrace Deposits and Upland Sediment (Tt).

3.1.2 Parkers, Avents, & Hector Creeks (HU 03030004030010)

The watershed containing Parkers, Avents, and Hector Creeks is on the divide between the Northern Outer Piedmont and Rolling Coastal Plain ecoregions. Along the boundary with the Harris Lake watershed, the geology is Middendorf Formation (Km) and Metamorphose Granitic Rock (CZg). The predominant geology in the lower portion of the watershed is Felsic Mica Gneiss (CZfg). Small areas of Biotite Gneiss and Schist (CZbg) and Terrace Deposits and Upland Sediment (Tt) are scattered throughout the watershed.

3.1.3 Kenneth & Neills Creeks (HU 03030004040010)

The Kenneth and Neills Creek watershed is similar in ecoregion and geology to the adjacent watershed of Parkers, Avents, and Hector Creeks. It is predominantly in the Rolling Coastal Plain ecoregion with some areas in the Northern Outer Piedmont. The geology is predominantly Middendorf Formation (Km) along the western watershed boundary. The eastern part of the watershed is a mix of Phyllite and Schist (CZph), Biotite Gneiss and Schist (CZbg), and Terrace Deposits and Upland Sediment (Tt).

3.2 Habitat and Endangered Species

The project watersheds include unique habitat areas as well as endangered and threatened species. Information about these resources is important in the watershed planning process as a means of assessing habitat functions. Habitat and species occurrence data, along with gap analysis (Figure 3.2), address issues of habitat loss and fragmentation. Smaller and less connected habitat areas limit species survival and result in species isolation and loss of genetic diversity. Efforts should be made to locate watershed restoration projects in areas of unique and important habitat.

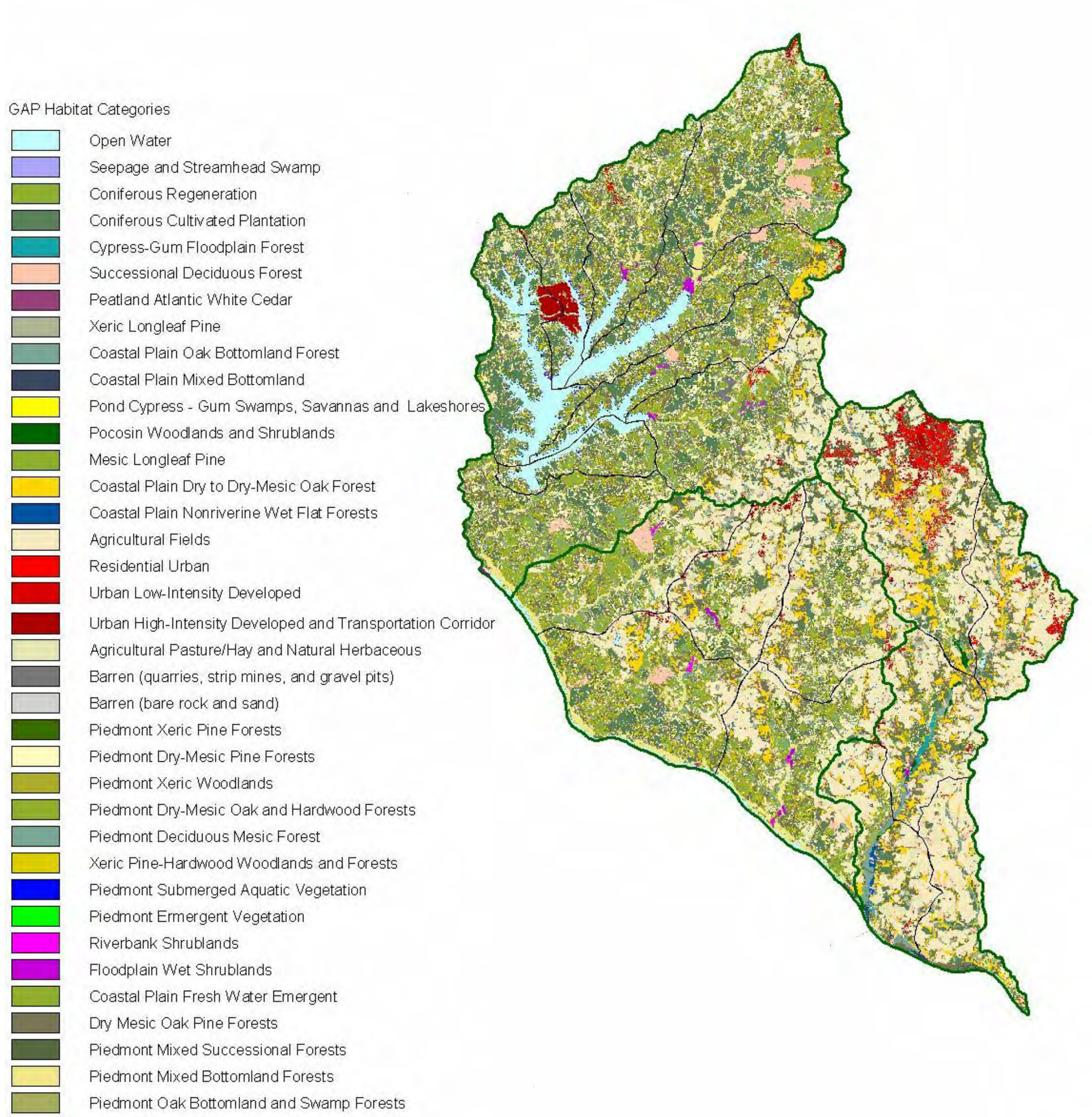


Figure 3.2 Gap Habitat Data for the Study Watersheds

Within North Carolina, gap analysis is being sponsored by the Biological Resources Division of the United States Geological Survey and North Carolina State University. Gap analysis is a scientific means for assessing the extent to which native animal and plant species are being protected. The goal of gap analysis is to assist conservation efforts by identifying those species and plant communities that are not adequately represented in existing conservation lands. Resources used in the development of gap data for North Carolina include state-level land use, national land cover, National Wetland Inventory, National Elevation Data Set, and detailed soils information. Ground truthing of data was performed. Gap analysis GIS data will be used in the identification of restoration and preservation opportunities within the study watersheds.

According to the state's database of Natural Heritage Element Occurrence Sites, the 22 threatened and endangered species in Table 3.2 are found in the project watersheds. In addition to these species, six natural communities appear in the database based on their Schafale and Weakley classification (1990). These communities are described in the following sections.

Table 3.2. Threatened and Endangered Species in the Study Watersheds

Common Name	**Scientific Name**	**Federal Status**	**State Status**
Atlantic Pigtoe	*Fusconaia masoni*	Federal Species of Concern	Endangered
Bachman's Sparrow	*Aimophila aestivalis*	Federal Species of Concern	Special Concern
Bald Eagle	*Haliaeetus leucocephalus*	Threatened (Proposed for Delisting)	Endangered (Proposed Threatened)
Buttercup Phacelia	*Phacelia covillei*	Federal Species of Concern	Significantly Rare
Cape Fear Shiner	*Notropis mekistocholas*	Endangered	Endangered
Carolina Ladle Crayfish	*Cambarus davidi*	----	Significantly Rare
Carolina Redhorse	*Moxostoma sp 2*	Federal Species of Concern	Significantly Rare (Proposed Endangered)
Eastern Fox Squirrel	*Sciurus niger*	----	Significantly Rare
Four-Toed Salamander	*Hemidactylium scutatum*	----	Special Concern
Lemmer's Pinion Moth	*Lithophane lemmeri*	----	Significantly Rare
Lewis' Heartleaf	*Hexastylis lewisii*	----	Significantly Rare
(a liverwort)	*Lejeunea glaucescens var acrogyna*	----	Significantly Rare (Limited)
Mississippi Kite	*Ictinia mississippiensis*	----	Significantly Rare
Notched Rainbow	*Villosa constricta*	----	Special Concern
Pod Lance	*Elliptio folliculata*	----	Special Concern
Red-Cockaded Woodpecker	*Picoides borealis*	Endangered	Endangered
Rigid Sedge	*Carex tetanica*	----	Significantly Rare
Roanoke Slabshell	*Elliptop roanokensis*	----	Threatened
Squawfoot	*Strophitus undulatus*	----	Threatened
Triangle Floater	*Alasmidonta undulata*	----	Threatened
Yellow Lampmussel	*Lampsilis cariosa*	Federal Species of Concern	Endangered
Virginia Spiderwort	*Tradescantia virginiana*	----	Significantly Rare (Peripheral)

3.2.1 Basic Mesic Forest (Piedmont Subtype)

This natural community occurs along lower slopes, north-facing slopes, ravines, and occasionally well-drained small stream bottoms, with basic or circumneutral soils. Canopy is dominated by mesophytic trees, primarily tulip poplar (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), southern sugar maple (*Acer floridanum*), and red oak (*Quercus rubra*). Other trees, typical of better-drained bottomland sites, such as Shumard oak (*Quercus shumardii*), black walnut (*Juglans nigra*), and sugarberry (*Celtis laevigata*) may be present. Understory and shrub species may include redbud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), hop hornbeam (*Ostrya virginiana*), ironwood (*Carpinus caroliniana*), pawpaw (*Asimina triloba*), slippery elm (*Ulmus rubra*), arrowwoods (*Viburnum* spp.), spicebush (*Lindera benzoin*), bigleaf snowbell (*Styrax grandifolia*), wild hydrangea (*Hydrangea arborescens*), eastern burningbush (*Evonymus atropurpurea*), bladdernut (*Staphylea trifolia*), sweetshrub (*Calycanthus floridus*), and painted buckeye (*Aesculus sylvatica*). The herb layer in the Basic Mesic Forest community is generally dense and very diverse, with species such as Christmas fern (*Polystichum acrostichoides*), wild ginger (*Asarum canadense*), doll's eyes (*Actaea pachypoda*), moonseed (*Menispermum canadense*), round-lobed hepatica (*Hepatica americana*), bloodroot (*Sanguinaria canadensis*), black cohosh (*Cimicifuga racemosa*), yellow ladyslipper (*Cypripedium pubescens*), ginseng (*Panax quinquefolius*), maidenhair fern (*Adiantum pedatum*), may-apple (*Podophyllum peltatum*), violets (*Viola* spp.), green violet (*Hybanthus concolor*), dutchman's britches (*Dicentra cucullaria*), Atlantic isopyrum (*Enemion biternatum*), little sweet betsy (*Trillium cuneatum*), smooth peavine (*Lathyrus venosus*), and yellow fumewort (*Corydalis flavula*) (Schafale and Weakley, 1990).

3.2.2 Mesic Mixed Hardwood Forest (Piedmont Subtype)

This natural community is found in similar landscape settings as the Basic Mesic Forest (Piedmont Subtype) community, but on acidic soils. It is also distinguished from the Basic Mesic Forest community by its sparser and less diverse herb layer, and absence of basic-loving plants such as green violet, doll's eyes, dutchman's britches, and little sweet betsy. Additional species, such as pawpaw, spicebush, eastern burningbush, bladdernut, and yellow fumewort, suggest Basic Mesic Forest where they occur on upland slopes. The canopy and understory layer in the Mesic Mixed Hardwood Forest community is similar to Basic Mesic Forest community, including species such as American beech, red oak, tulip poplar, red maple (*Acer rubrum*), flowering dogwood, hop-hornbeam, and American holly (*Ilex opaca*). Typical shrub species may include deerberry (*Vaccinium stamineum*), downy arrowwood (*Viburnum rafinesquianum*), American strawberry-bush (*Evonymus americana*), and sometimes mountain laurel (*Kalmia latifolia*). Herb species may include Christmas fern, violets, round-lobed hepatica, may-apple, witchgrasses (*Dichanthelium* spp.), licorice bedstraw (*Galium circaezans*), arrowleaf heartleaf (*Hexastylis arifolia*), little heartleaf (*H. minus*), woodland tick-trefoil (*Desmodium nudiflorum*), southern trout lily (*Erythronium umbilicatum* var. *umbilicatum*), fairywand (*Chamaelirium luteum*), beechdrops (*Epifagus virginiana*), common foamflower (*Tiarella cordifolia* var. *collina*), common alumroot (*Heuchera americana*), giant starwort (*Stellaria pubera*), rattlesnake fern (*Botrychium virginianum*), and lion's foot (*Prenanthes serpentaria*) (Schafale and Weakley, 1990).

3.2.3 Piedmont Longleaf Pine Forest

The Piedmont longleaf pine (*Pinus palustris*) community reaches its western limit in Wake County and follows the fall line between the Piedmont and Coastal Plain through the Carolinas (Wentworth, 1995). Longleaf pines are found in transitional communities alongside hardwood species such as maple, oak, flowering dogwood, as well as other pine species. These stands prove to be complex communities that harbor both Coastal Plain and Piedmont species, culminating in a rare fire dependent system for this area (Parker, 1998). Although most of these transitional communities no longer hold their extensive original territories, remnant stands have been found sparsely scattered throughout the Piedmont (Frame, 2001; Wentworth, 1995; Dennington, 1983).

One remnant stand of Piedmont Longleaf Pine Forest within the study watersheds exists in the Harris Research Tract (HRT), located in southern Wake County. This area is believed to be a remnant Piedmont Transitional Longleaf Pine Community (PTLC). The remnant forest was suggested by a combination of the abundance of longleaf pine and the HRT's location within the historically cited range of the PTLC. Schafale and Weakley (1990) quote Ashe and Pinchot (1897) as noting "a transitional forest of *Pinus palustris* with various dry oaks in Nash, Wake, Montgomery, Northhampton, and Halifax Counties." Ashe adds that "the area on which long-leaf pine is the dominant tree, or where it yet exists side by side with the loblolly pine, extends ... (within the transitional division) westward to Cary (in Wake County)." Ashe and Pinchot also state that "these (transitional) forests are best developed in the middle and southern parts of Nash County, the eastern part of Wake, and the western part of Montgomery." Species present within the HRT's longleaf pine community include longleaf pine, highbush blueberry (*Vaccinium corymbosum*), downy serviceberry (*Amelanchier arborea*), pipsissewa (Chimaphila maculata), American strawberry-bush, American beech, American holly, red cedar (*Juniperus virginiana*), tulip poplar, black cherry (*Prunus serotina*), willow oak (*Quercus phellos*), red oak, sassafras (*Sassafras albidum*), glaucous greenbrier (*Smilax glauca*), arrowwood (*Viburnum dentatum*), and muscadine (*Vitis rotundifolia*) (Parker, 1998). The Piedmont Longleaf Pine Forest community sites are rapidly disappearing due to the huge amounts of urbanization occurring in the Piedmont areas along the East Coast. To further exacerbate the problem, these remaining communities now are found in highly populated areas where prescribed burning is nearly impossible, preventing the reproduction of the longleaf pines and small fire-dependent shrubs (Frame, 2001).

3.2.4 Piedmont/Coastal Plain Acidic Cliff

This natural community occurs on stream bluffs where very steep to vertical slopes exist that are rocky or dry enough to prevent the formation of a closed tree or shrub community. It generally occurs on hard rock, but may occur in areas of soft material exposed by undercutting by a stream. A known occurrence of this community exists within the boundaries of Raven Rock State Park. The vegetation in the Piedmont/Coastal

Plain Acidic Cliff community is generally heterogeneous within and among sites. Most of the area is bare or moss- and lichen-covered rock. Typical mosses include *Grimmia laevigata*, *Aulocomnium heterostichum*, and *Bartramia pomiformis*. Herbs may include trailing arbutus (*Epigaea repens*), broomsedge (*Andropogon virginicus*), little bluestem (*Schizachrium scoparium*), northern oat grass (*Danthonia spicata*), Canada sanicle (*Sanicula canadensis*), rattlesnake hawkweed (*Hieracium venosum*), summer bluet (*Houstonia purpurea*), greater coreopsis (*Coreopsis major*), hairy lipfern (*Cheilanthes lanosa*), galax (*Galax urceolata*), early saxifrage (*Saxifraga virginiensis*), partridgeberry (*Mitchella repens*), alumroot (*Heucheria* spp.), and rockcap fern (*Polypodium virginianum*). Scattered trees and shrubs may occur in crevices or other areas of deeper soil. These species may include Virginia pine (*Pinus virginiana*), shortleaf pine (*P. echinata*), red cedar, chestnut oak (*Quercus montana*), scarlet oak (*Q. coccinea*), southern red oak (*Q. falcata*), red oak, American beech, red maple, flowering dogwood, sourwood (*Oxydendrum arboreum*), mountain laurel, blueberry (*Vaccinium* spp.), and huckleberry (*Gaylussacia* spp.) (Schafale and Weakley, 1990).

3.2.5 Piedmont/Mountain Bottomland Forest

This natural community occurs along floodplain ridges and terraces other than active levees adjacent to the river channel. The canopy is dominated by tulip poplar, sweetgum (*Liquidambar styraciflua*), cherrybark oak (*Quercus pagoda*), swamp chestnut oak (*Q. michauxii*), American elm (*Ulmus americana*), sugarberry, green ash (*Fraxinus pennsylvanica*), loblolly pine (*Pinus taeda*), shagbark hickory (*Carya ovata*), and bitternut hickory (*C. cordiformis*). Understory trees include ironwood, southern sugar maple, red maple, flowering dogwood, American holly, and pawpaw. Shrubs, herbs, and vines may include painted buckeye, American strawberry-bush, giant cane (*Arundinaria gigantea*), false nettle (*Boehmeria cylindrica*), Christmas fern, sedges (*Carex* spp.), honewort (*Cryptotaenia canadensis*), jumpseed (*Polygonum virginianum*), jack-in-the pulpit (*Arisaema triphyllum*), violets, golden ragwort (*Senecio aureus*), Virginia wild rye (*Elymus virginicus*), bluestem goldenrod (*Solidago caesia*), heartleaf aster (*Aster divaricatus*), river oats (*Chasmanthium latifolium*), slender spikegrass (*C. laxum*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), crossvine (*Bignonia capreolata*), greenbrier (*Smilax* spp.), and grape (*Vitis* spp.).

3.2.6 Piedmont/Mountain Levee Forest

This natural community occurs on natural active levees and point bar deposits on large floodplains. While the overall flora community is similar to the Piedmont/Mountain Bottomland Forest, the presence of river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), and boxelder (*Acer negundo*), distinguishes this community from the Piedmont/Mountain Bottomland Forest community.

3.3 Soils

There are 57 soils series within the study watersheds of which 13 comprise approximately three-fourths of the total occurrences (Figure 3.3). These primary series in order of most occurrences are Mayodan, Cecil, Creedmore, Wagram, Norfolk, Appling, Dothan, White Store, Herndon, Worsham, Faceville, Wehadkee, and Pacolet. Descriptions of the 13 primary series are presented in Table 3.3.

Table 3.3. Soil Series Descriptions for the Study Watersheds (USDA 1970, 1994)

Series	Description
Appling	Consisting of sloping to strongly sloping well-drained soils of the Piedmont uplands, these soils are found on side slopes and rounded divides that have an elevation difference of about 50 feet. Mostly formed as a forested series, the soil is strongly acidic. A significant portion has had lime applications, and therefore has been used intensively for cultivation. These soils are formed from weathered granite, gneiss, schist, and other acidic rocks. Water capacity is medium. Permeability is moderate.
Cecil	Consisting of gently sloping to steep well-drained soils of the Piedmont uplands, these soils are found on side slopes and on rounded divides that have an elevation difference of about 75 feet. Mostly a forested series, the soil is moderately to strongly acidic. Formed from weathered gneiss, schist and other acidic rocks. The water table remains below the solum. Water capacity is medium. Permeability is moderate.
Creedmore	Consisting of gently sloping to moderately steep moderately well-drained soils of the Piedmont uplands, these soils are found on rounded divides that have an elevation difference of about 50 feet. Mostly a forested series, the soil is very strongly acidic. A significant portion has had lime applications, and therefore has been used intensively for cultivation or as pasture. Formed from weathered sandstone, mudstone and shale of the Triassic age. The water table remains below the solum, however during wet seasons, there is a perched water table. Water capacity is medium to high. Permeability is slow.
Dothan	Consisting of nearly level to sloping well-drained soils of the Coastal Plain uplands, these soils are found on broad divides on the Upper Coastal Plain. Dothan is formed in loamy Coastal Plain sediments. The soil is strongly to moderately acidic except where there have been lime applications. Permeability is moderate.
Faceville	Consisting of gently sloping to sloping well-drained soils of the Coastal Plain uplands, these soils are found on broad, smooth, rounded divides that have an elevation difference of about 20 feet. These soils are also found on terraces along large streams. Mostly formed as a forested series, the soil is very strongly acidic except in areas where there has been lime applications. Most of the acreage is in forested areas. These soils are formed in Coastal Plain sediment and alluvial deposits. The water table remains below the solum. Water capacity is medium. Permeability is moderate.
Herndon	Consisting of gently sloping to moderately steep well-drained soils of the Piedmont uplands, these soils are found on side slopes and on rounded divides that have an elevation difference of about 50 feet. Mostly formed as a forested series, the soil is very strongly acidic except in areas where there have been lime applications. Most of the acreage is in forested areas. These soils are formed from weathered phyllite. The water table remains below the solum. Water capacity is medium. Permeability is moderate.
Mayodan	Consisting of gently sloping to moderately steep, well-drained soils that are deep or moderately deep over hard rock, these soils are found on rounded divides that have an elevation difference of about 50 feet. Mostly a forested series, the soil is strongly acidic. Formed from weathered sandstone, mudstone and shale of the Triassic age. The water table remains below the solum. Water capacity is medium.

Series	Description
Norfolk	Consisting of nearly level to sloping well-drained soils of the Coastal Plain uplands, these soils are found on broad flats and on smooth, rounded divides that have an elevation difference of about 20 feet. Mostly formed as a forested series, the soil is strongly acidic. A significant portion has had lime applications, and therefore has been used intensively for cultivation, however, part remains as forest or pasture. These soils are formed in Coastal Plain sediment. The water table remains below the solum. Water capacity is medium. Permeability is moderate.
Pacolet	Consisting of moderately steep well-drained soils, these soils are found on upland side slopes along the Cape Fear River. Mostly formed as a forested series, the soil is very strongly acidic except in areas where there has been lime applications. These soils are best suited for forested areas. Pacolet soils are formed in material weathered from acid crystalline rocks. Water capacity and permeability are moderate. This series is highly susceptible to erosion.
Wagram	Consisting of nearly level to sloping somewhat excessively drained soils of the Coastal Plain uplands, these soils are found on side slopes and broad, smooth, rounded divides that have an elevation difference of about 20 feet. Mostly formed as a forested series, the soil is medium to very strongly acidic. A significant portion has had lime applications, and therefore has been used intensively for cultivation, however, part remains as forest or pasture. These soils are formed in Coastal Plain sediment. The water table remains below the solum. Water capacity is low. Permeability is moderate.
Wehadkee	Consisting of nearly level poorly drained soils, these soils are found on the flood plains of most of the streams in the study area. Mostly formed in fine loamy alluvial material, the soil is strongly to very strongly acidic except in areas where there has been lime applications. Most of the acreage is in mixed hardwoods and some pine areas. The water table is approximately at the surface during wet seasons. Water capacity is medium. Permeability is moderate to moderately rapid. Flooding is frequent and floodwaters remain for a long time.
White Store	Consisting of gently sloping to moderately steep moderately well-drained soils of the Piedmont uplands, these soils are found on rounded divides that have an elevation difference of about 50 feet. Mostly formed as a forested series, the soil is very strongly acidic except in areas where there has been lime applications. Most of the acreage is in forested areas. These soils are formed from weathered sandstone, shale, and mudstone of the Triassic age. Water capacity is high. Permeability is slow.
Worsham	Consisting of nearly level to gently sloping poorly drained soils of the Piedmont uplands, these soils are found at the head of drainageways, on foot slopes and in slight depressions. Mostly formed from translocated soils, the soil is strongly acidic except in areas where there has been lime applications. Most of the acreage is in forested areas. The water table is approximately at the surface during wet seasons. Water capacity is medium. Permeability is moderately slow.

Nine different hydric soil series were found in the project area. They are Bibb, Chewacla, Grantham, Plummer, Rains, Roanoke, Toisnot, Wehadkee, and Worsham. Figure 3.4 displays the location of hydric soils in the project area.

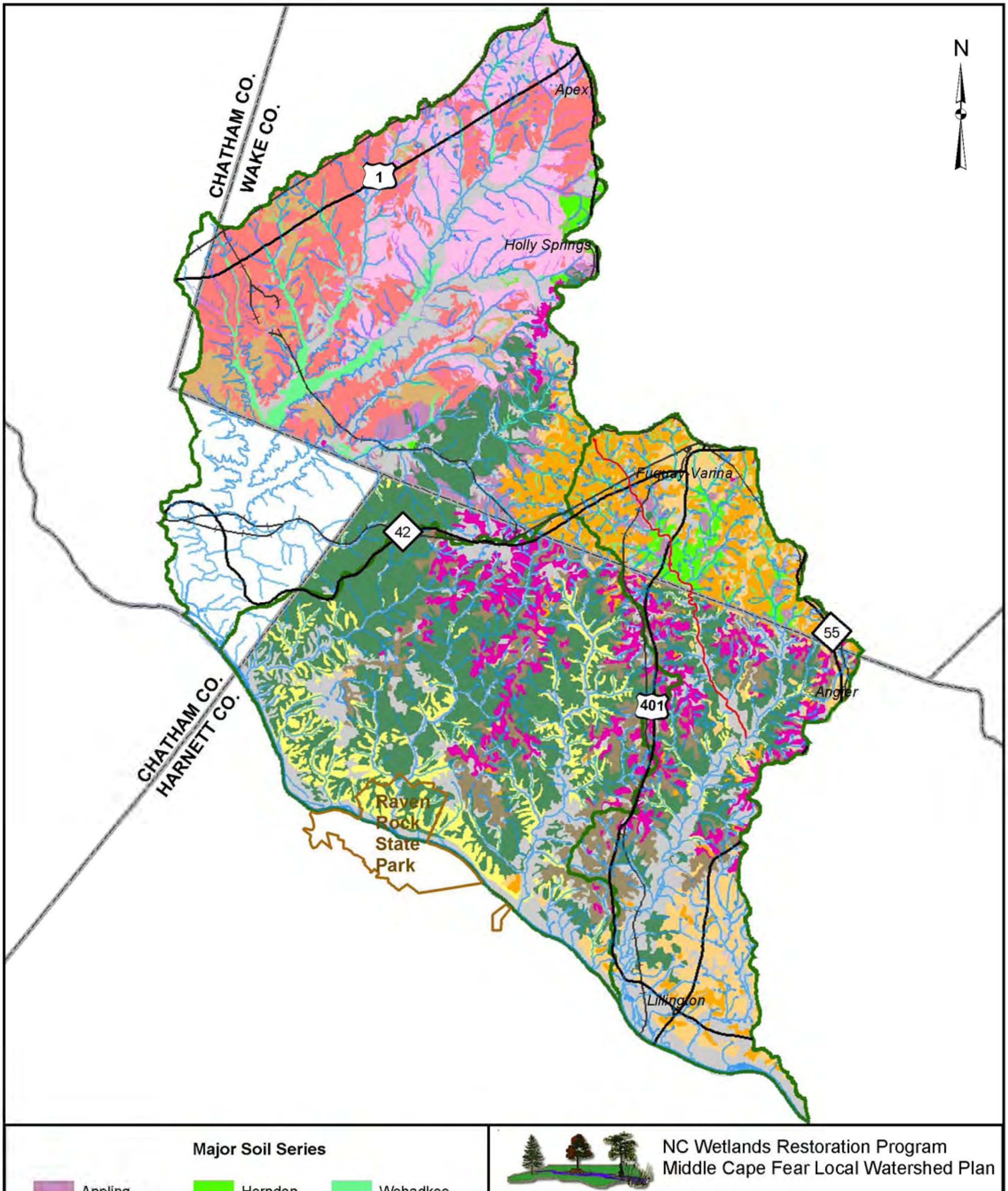
3.4 National Wetlands Inventory

The US Fish and Wildlife Service has mapped wetlands units in the project watersheds as part of the National Wetlands Inventory (NWI) (Figure 3.5). Table 3.4 provides descriptions of the mapping units that appear in the study area. For the purpose of simplification, units are only shown to four alphanumeric digits.

The majority of NWI wetlands in the study watersheds are Palustrine. The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, emergents, mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean derived salts is below 0.5 parts per thousand (ppt). Wetlands lacking such vegetation are also included if they exhibit all of the following characteristics: are less than 8 hectares (20 acres); do not have an active wave-formed or bedrock shoreline feature; have at low water a depth less than 2 meters (6.6 feet) in the deepest part of the basin; have a salinity due to ocean-derived salts of less than 0.5 ppt.

One wetland type in the study area is mapped as Lacustrine. The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: situated in a topographic depression or a dammed river channel; lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; total area exceeds 8 hectares (20 acres).

Wetlands along the mainstem Cape Fear River are mapped as Riverine. The Riverine System includes all wetlands and deepwater habitats contained in natural or artificial channels periodically or continuously containing flowing water or which forms a connecting link between the two bodies of standing water. Upland islands or Palustrine wetlands may occur in the channel, but they are not part of the Riverine System.



NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 3.3. Major Soil Series
(Data not available for Chatham County)

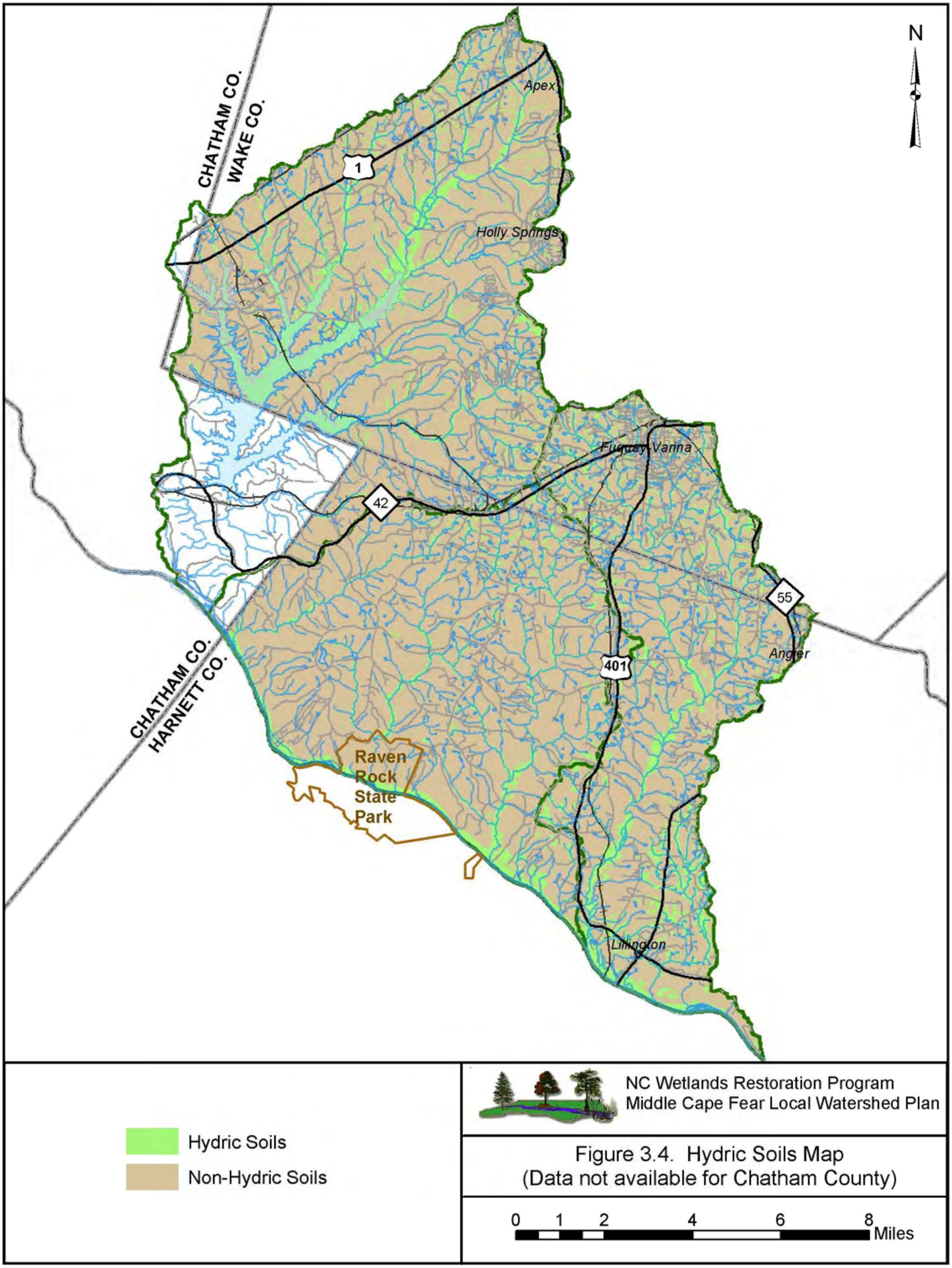
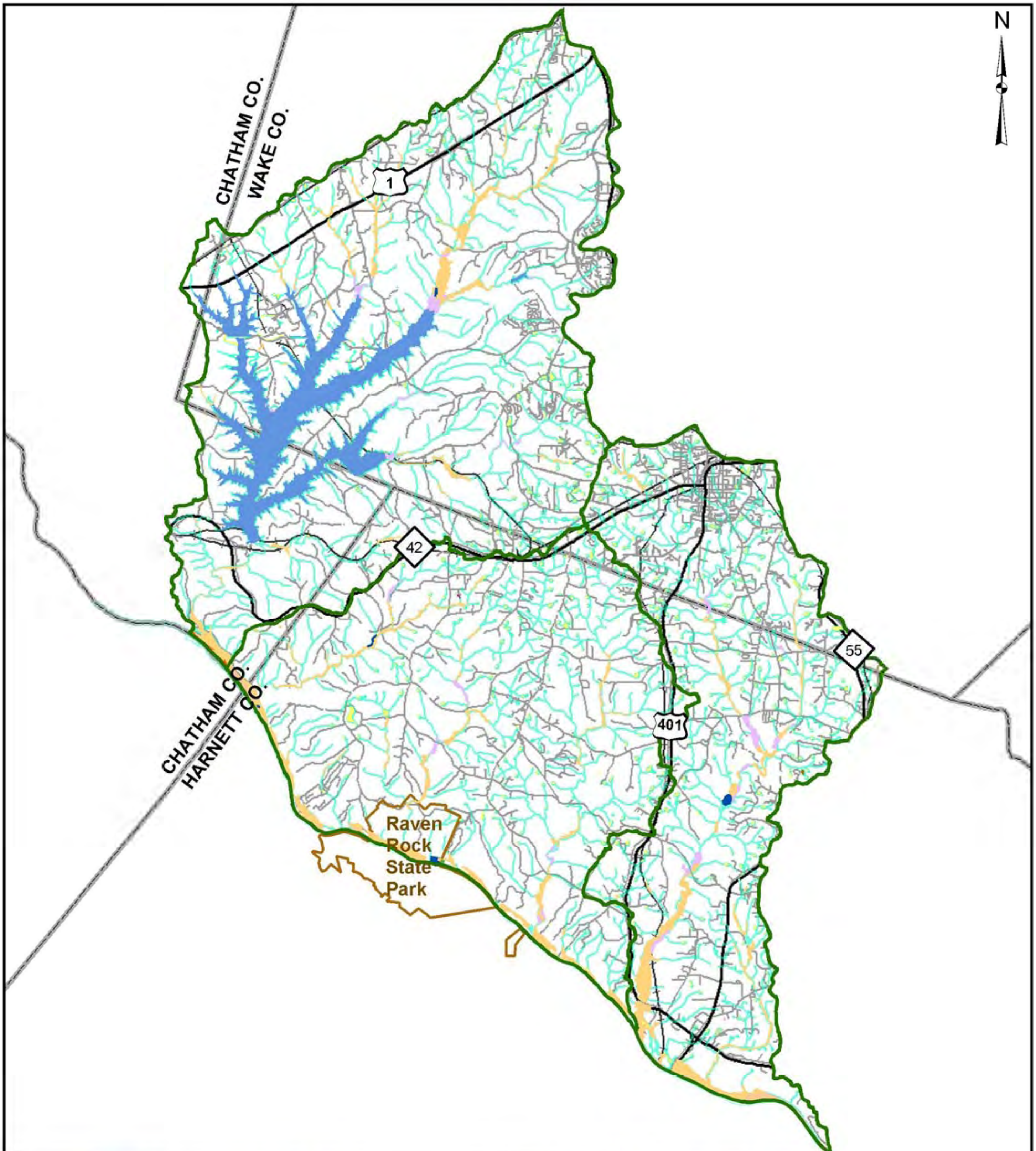


Figure 3.4. Hydric Soils Map
(Data not available for Chatham County)



L1UB		PFO5	
PAB3		PSS1	
PEM1		PSS4	
PEM2		PUBH	
PFO1		R2UB	
PFO4		R3UB	

NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 3.5. National Wetlands Inventory

0 1 2 4 6 8 Miles

Table 3.4. National Wetlands Inventory Mapping Codes

Mapping Code	Name	Description
L1UB	Lacustrine Unconsolidated Bottom	*Unconsolidated Bottom* includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%.
PAB3	Palustrine Aquatic Bed Rooted Vascular	*Aquatic Bed* includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. *Rooted Vascular* species occur at all depths in the photic zone. They often are in sheltered areas that have little water movement, and can also be found in the flowing water of the Riverine System, where they may be streamlined or flattened in response to high water velocities. Some species are characterized by floating leaves.
PEM1	Palustrine Emergent Persistent	*Emergent* is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. *Persistent* is dominated by species that normally remain standing at least until the beginning of the next growing season. This subclass is found only in the Estuarine and Palustrine systems.
PEM2	Palustrine Emergent Nonpersistent	*Emergent* is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. *Nonpersistent* wetlands are dominated by plants which fall to the surface of the substrate or below the surface of the water at the end of the growing season so that, at certain seasons of the year, there is no obvious sign of emergent vegetation.
PFO1	Palustrine Forested Broad-Leaved Deciduous	*Forested* is characterized by woody vegetation that is 6 m tall or taller. *Broad-leaved Deciduous* is woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (Fraxinus nigra).
PFO4	Palustrine Forested Needle-Leaved Evergreen	*Forested* is characterized by woody vegetation that is 6 m tall or taller. *Needle-leaved Evergreen* is woody gymnosperms with green, needle-shaped, or scale-like leaves that are retained by plants throughout the year; e.g. black spruce (Picea mariana).
PFO5	Palustrine Forested Dead	*Forested* is characterized by woody vegetation that is 6 m tall or taller. *Dead* is dominated by dead woody vegetation taller than 6 m (20 feet). They are most common in, or around the edges of, man-made impoundments and beaver ponds.
PSS1	Palustrine Scrub-Shrub Broad-Leaved Deciduous	*Scrub-Shrub* includes areas dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees (saplings), and trees or shrubs that are small or stunted because of environmental conditions. *Broad-leaved Deciduous* is woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (Fraxinus nigra).
PSS4	Palustrine Scrub-Shrub Needle-Leaved Evergreen	*Scrub-Shrub* includes areas dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees (saplings), and trees or shrubs that are small or stunted because of environmental conditions. *Needle-leaved Evergreen* is dominated by young or stunted trees such as black spruce or pond pine.
PUBH	Palustrine Unconsolidated Bottom Permanently Flooded	*Unconsolidated Bottom* includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%. *Permanently Flooded* means that water covers the land surface throughout the year in all years.

Mapping Code	Name	Description
R2UB	Riverine Lower Perennial Unconsolidated Bottom	*Lower Perennial* is characterized by a low gradient and slow water velocity. There is no tidal influence, and some water flows throughout the year. The substrate consists mainly of sand and mud. The floodplain is well developed. Oxygen deficits may sometimes occur. *Unconsolidated Bottom* includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%.
R3UB	Riverine Upper Perennial Unconsolidated Bottom	*Upper Perennial* is characterized by a high gradient and fast water velocity. There is no tidal influence, and some water flows throughout the year. This substrate consists of rock, cobbles, or gravel with occasional patches of sand. There is very little development. *Unconsolidated Bottom* includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%.

4 Land Use and Historic Trend Analysis

Land use change is a primary factor in water quality and habitat degradation. Increasing population and development pressures contribute to the degradation of water resources, including changes in water flow and storage, input of nonpoint source pollutants, and increases in soil erosion. One of the most important ways land use relates to water quality is through imperviousness. Water quality degrades in direct proportion to the amount of land that is paved over or otherwise developed.

Within the study watersheds, it is important to understand how land use is changing over time. A successful local watershed plan will need to address development pressures and forecast the potential impact of changing land use. The following sections review land use changes in the study watersheds, including population development, agricultural and silvicultural land uses, and transportation.

4.1 Population and Development

The three study watersheds lie within a rapidly growing region of the North Carolina Piedmont. While land use is still primarily forested (Figure 4.1 and Table 4.1), open space is rapidly being converted to residential and commercial uses. Growth is particularly significant in the headwaters of the three watersheds. The Towns of Apex, Fuquay-Varina, and Holly Springs have experienced rapid growth of between 73% and 912% over the last decade, as evidenced by the Census data shown in Table 4.2. The counties have experienced similar growth with Wake County's population projected to increase by 500,000 people in the next 20 years.

4.1.1 Town of Apex

The Town of Apex experienced growth of approximately 307% between the 1990 and 2000 Censuses. Using the 2000 Census figure as the base population and adding each subsequent quarter's estimate, the Town estimates the current population of Apex on June 30, 2003 as 27,588. The estimated population increase for 2003 is 2.5%. It is estimated that Apex is adding an average of 3.7 people per day in 2003. Residential building has been significant, as shown in Table 4.3. This conversion of open space to developed uses is expected to continue into the future. The Apex 2010 Land Use Plan shows currently forested areas in the White Oak Creek subwatershed classified as low density residential, major employment center, industrial, and commercial. An Atlanta developer is currently planning to turn 350 acres at the southwest corner of NC 55 and US 1 into a large shopping center, surrounded by townhouses, apartments, and offices.

Figure 4.1. Land Use (LandSat, 1994)

Table 4.1. Land Use in the Project Watersheds based on 1994 LandSat Data

Sub-Watershed	Total Land Area (mi^2)	% Forested	% Agriculture	% Urban	% Water	% Other*
White Oak Creek	15.1	88%	8%	3%	<1%	--
Little White Oak Creek	8.3	89%	4%	1%	6%	--
Thomas Creek	4.6	73%	6%	4%	17%	1
Tom Jack Creek	9.2	66%	3%	2%	29%	<1%
Utley Creek	9.5	83%	2%	1%	14%	--
Cary Branch	6.7	84%	7%	<1%	8%	--
Buckhorn Creek	13.9	67%	29%	1%	2%	<1%
Harris Lake Arm	3.6	75%	<1%	1%	23%	1%
Below Harris Lake	9.1	96%	3%	1%	1%	<1%
Total for HU 03030004020010	80.0	81%	9%	2%	9%	<1%
Parkers Creek	9.7	82%	16%	1%	1%	<1%
Upper Avents Creek	8.1	57%	42%	1%	<1%	--
Lower Avents Creek	12.6	84%	14%	--	2%	--
Upper Hector Creek	10.9	67%	33%	<1%	1%	--
Lower Hector Creek	12.5	71%	28%	<1%	1%	--
Total for HU 03030004030010	53.8	73%	25%	<1%	1%	<1%
Kenneth Creek	16.5	52%	4%	1%	1%	--
Upper Neills Creek	8.0	46%	52%	1%	1%	--
Middle Neills Creek	8.2	60%	39%	--	1%	<0%
Lower Neills Creek	7.3	58%	41%	1%	1%	--
Dry Creek	6.3	41%	54%	1%	2%	2%
Total for HU 03030004040010	46.3	52%	44%	3%	1%	<1%

* Other includes indeterminate land cover, unconsolidated sediment, unmanaged herbaceous upland, and unmanaged herbaceous wetland.

Table 4.2. Population Growth 1990-2000 for Selected Geographic Areas

Geographic Area	1990 Population	2000 Population	% Growth	1990 Housing Units	2000 Housing Units	% Growth
Harnett County	67,822	91,025	34%	27,896	38,605	38%
Wake County	423,380	627,846	48%	177,146	258,953	46%
Chatham County	38,759	49,329	27%	16,642	21,358	28%
Town of Apex	4,968	20,212	307%	1,826	3,375	85%
Town of Holly Springs	908	9,192	912%	335	3,642	987%
Town of Fuquay-Varina	4,562	7,898	73%	1,959	3,375	72%

Table 4.3. Town of Apex Building Permits

Year	Single-Family Permits**	Multi-Family Permits	Non-Residential Permits	Total Permits
1991	127	14	4	145
1992	177	4	5	186
1993	178	0	8	186
1994	275	0	17	292
1995	442	180	21	643
1996	889	3	31	923
1997	858	749	42	1,649
1998	1,222	216	68	1,506
1999	1,137	280	104	1,521
2000	834	0	67	901
2001	832	56	25	913
2002	496	331	21	848
2003	142*	37*	3*	182*

* Includes first and second quarters only.
** Through September 30, 2001, single-family included single-family detached homes and townhouses.

4.1.2 Town of Fuquay-Varina

The Town of Fuquay-Varina is currently developing a land use plan that will be published during 2003 or 2004. Like Holly Springs, Fuquay-Varina has experienced tremendous growth over the last two decades and expects this growth to continue into the future (Table 4.4). The Town experienced more residential development in the earlier part of the twentieth century compared to Holly Springs due in part to the installation of a water and sewer system in 1937.

Table 4.4. Fuquay-Varina Area Population Projections (Fuquay-Varina, 2003)

Limits	Census 2000	Est. 2002	Proj. 2005	Proj. 2010	Proj. 2015	Proj. 2020	Proj. 2025	Proj. 2030
Corporate	7,898	9,334	11,013	14,510	19,118	25,188	33,186	43,724
ETJ[1]	n/a	3,870	4,229	4,902	5,683	6,588	7,638	8,854
Juris-diction[2]	n/a	13,204	15,242	19,413	24,801	31,777	40,824	52,578
USA[3]	n/a	15,530	16,970	19,673	22,806	26,439	30,650	35,532
Total Growth Manage-ment Area[4]	n/a	28,734	32,212	39,086	47,607	58,215	71,474	88,109

[1] Fuquay-Varina extra-territorial jurisdiction (ETJ)
[2] Combination of existing corporate limits and ETJ
[3] Urban Services Area (USA) under Wake County's jurisdiction
[4] Includes all political sub-areas

4.1.3 Town of Holly Springs

The Town of Holly Springs has experienced the most significant growth of the municipalities in the study watersheds. Although founded in 1876, the Town saw little development after the Great Depression due to lack of public infrastructure. In the late 1980s, the Town installed water and sewer systems which resulted in a substantial increase in residential development. By the mid-1990s, it was estimated that a family moved into Holly Springs every day, and this growth is expected to continue (Table 4.5). The town estimates that the population of Holly Springs could reach 25,000 citizens if all the existing, approved lots are built upon without approving any additional subdivisions or individual lots. In 1998, the Town published a ten-year comprehensive plan to address development issues and introduce policies to guide growth. The study area included a significant amount of land owned by Progress Energy around Harris Lake that the Town considers to be suitable for development. In total, the Town's development study area covers more than a third of hydrologic unit 03030004020010, in an area that is predominantly undeveloped.

Table 4.5. Holly Springs Population Projections (Holly Springs, 1998)

Year	Projected Population
1990	1,024
1995	3,030
1997	5,597
1998	6,652
2000	9,652
2005	15,652
2010	20,452

4.2 Analysis of Historic Aerial Photography

Historical land use in the study watersheds has been primarily rural, both agricultural and silvicultural. The goal in analyzing historical aerial photography was to describe, both qualitatively and quantitatively, the historical change in land use. Initially it was believed that land uses have shifted to more urban uses based on the population increase described previously. Through aerial photography analysis, we were able to confirm the initial beliefs by showing the migration from a predominantly rural land use to a greater urban composition, with the largest conversion in land from agricultural to urban uses.

Aerial photographs from a variety of resources (Wake County Soil and Water Conservation District (WCSWCD), North Carolina Department of Transportation (NCDOT), SPOT Image Corporation) were utilized in CAD and GIS applications to determine land uses. The images were analyzed to determine land use acreages. Due to quality issues associated with the older photographs, certain land use estimates likely contain some error; however, such error is not severe enough to cause the trend from rural to urban land use to become unreliable. Through site visits, it is clear that much development has occurred in the watershed, and therefore the trend towards urban land use is supported. Another limitation of the analysis is that the historic photographs cover all of the study watersheds in Wake County, but not all of Harnett County and none of Chatham County. The missing data were unobtainable; however, it is believed that these areas have had the same trend in land use change as the rest of the study area due to their proximity to the City of Raleigh. This belief is also supported by site visit observations. The data summary in this section only refers to the portion of the study area where historical aerial photographs were obtainable.

Aerial photographs dating from 1949 and 1969 and more recent digital aerial photographs from 2003 emphasized the transition from rural to urban land uses. Figure 4.2 demonstrates such a transition. The figure shows the increase in urbanization around the Fuquay-Varina area. Pink shading represents the urban land use determined from 1949 WCSWCD aerials and red shading represents the shift to a larger urban land use for the same area based on 2003 SPOT imagery.

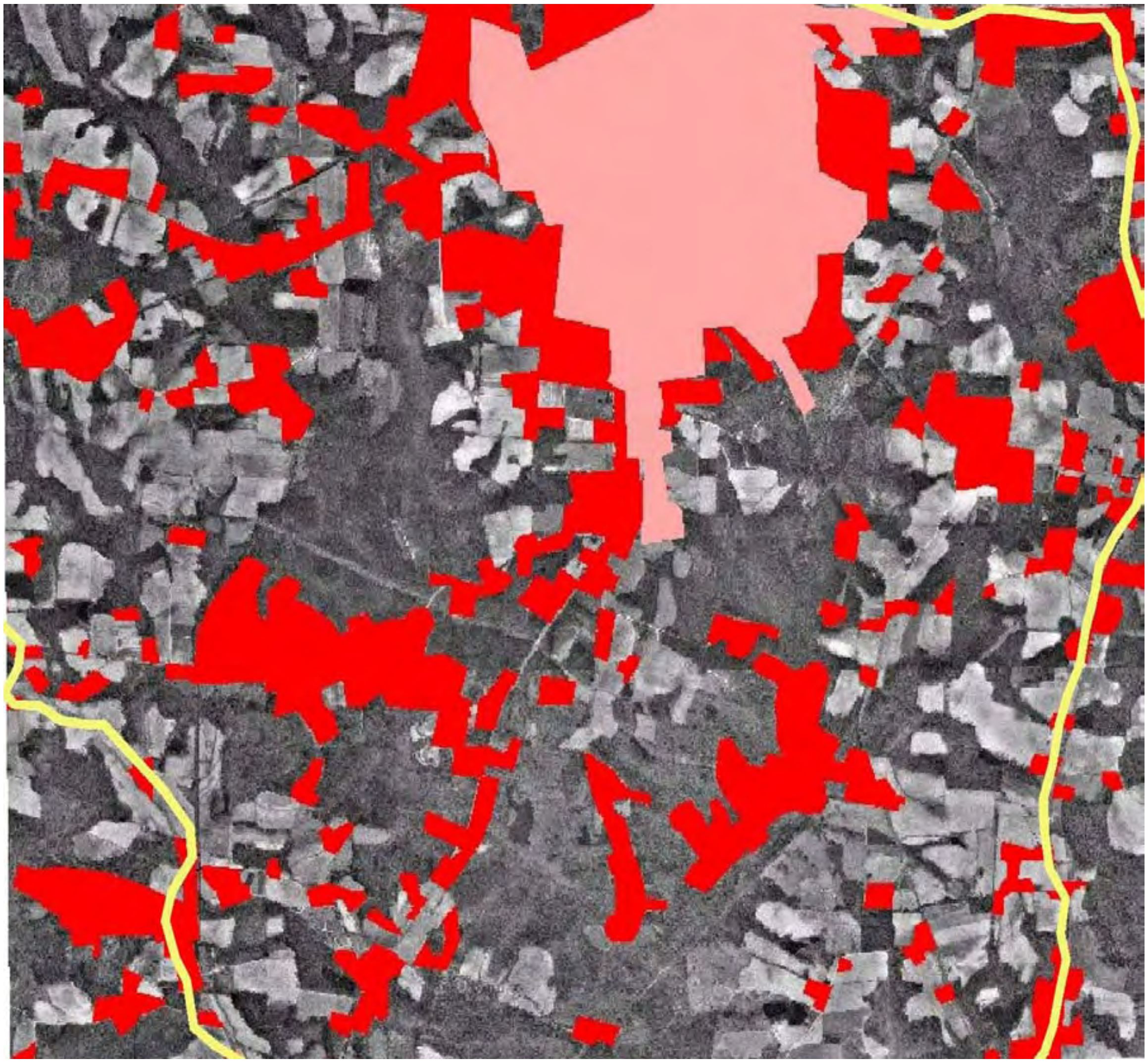


Figure 4.2. Land Use Change in the Fuquay-Varina Area - pink represents urban land uses based on 1949 aerial photography while red represents the increase in urban land uses based on 2003 aerial photography; Kenneth Creek watershed boundary is shown in yellow

Total change in land use in the area analyzed is shown in Table 4.6. Due to the enormous impact of the formation of Harris Lake when the Shearon Harris Nuclear Plant was constructed, the acreages from the lake have been separated out.

Table 4.6. Land Use Acreages in Selected Area of Watershed for 1949 and 2003

	Excluding Harris Lake		Harris Lake		Total Analyzed	
Land Use	**1949**	**2003**	**1949**	**2003**	**1949**	**2003**
Agriculture	25,954	13,375	683	0	26,638	13,375
Urban	1,248	10,001	0	0	1,248	10,001
Forest	51,746	55,573	3,485	0	55,232	55,573
Open Water	0	0	0	4,169	0	4,169
Total	**78,949**		**4,169**		**83,117**	

The transition as a whole for the watershed is graphically shown in Figure 4.3.

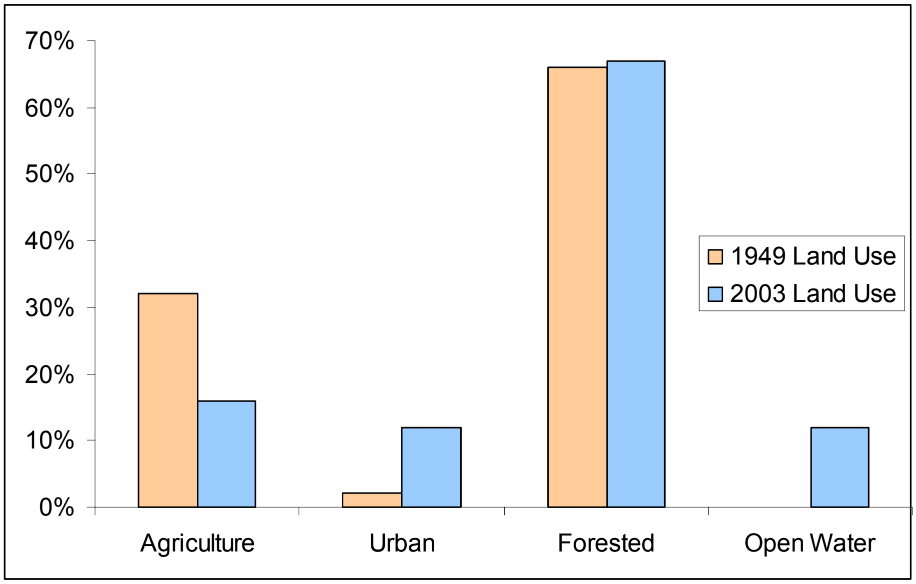


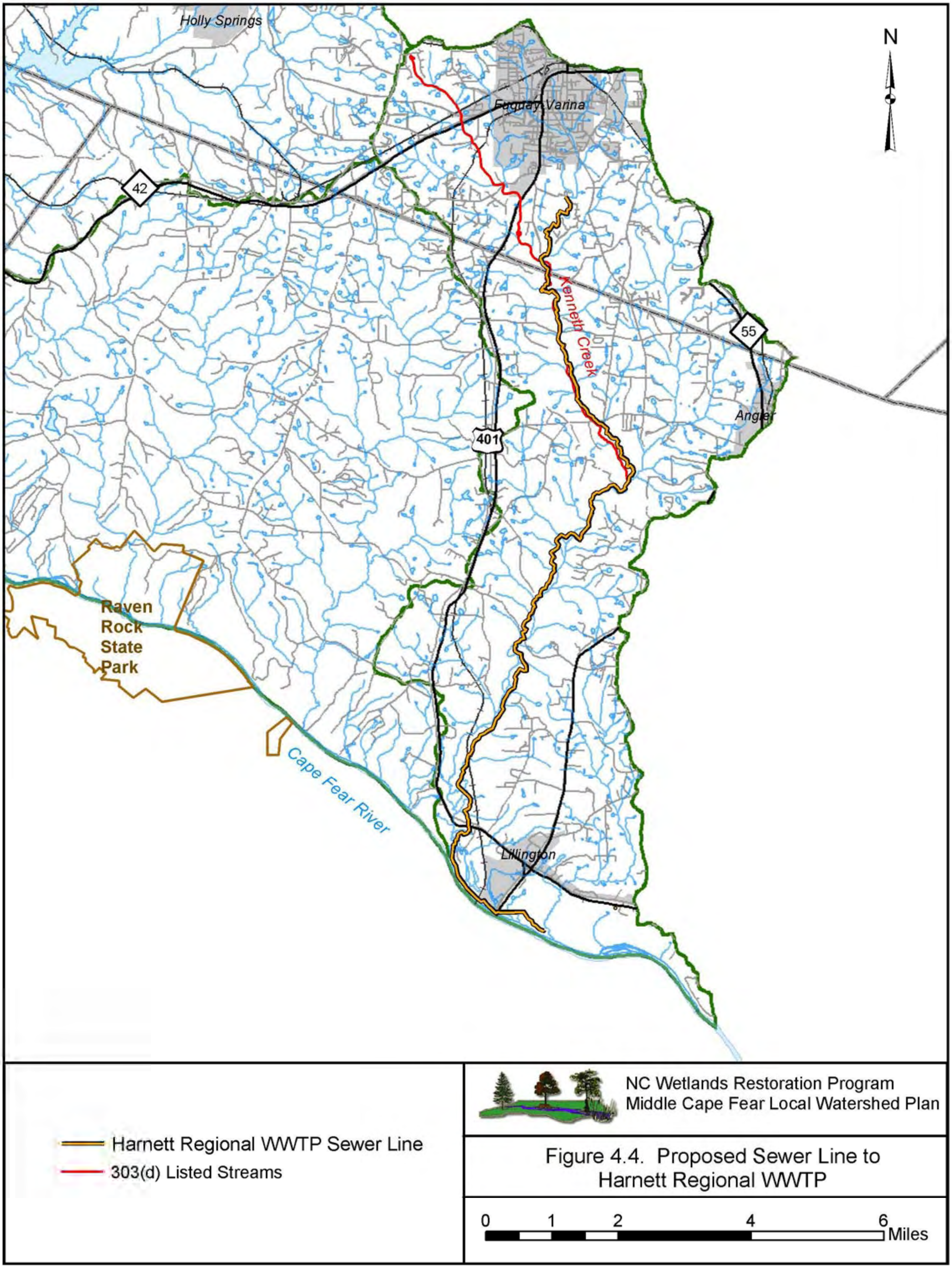
Figure 4.3. Estimated Land Use Percentages for Years 1949 and 2003

4.3 Roads and Infrastructure

The towns of Angier, Fuquay-Varina, and Holly Springs currently operate wastewater treatment facilities in the study watersheds (see Section 6.1 for details). In 2005, the Harnett County regional facility in Lillington will become operational and the existing Kenneth Creek Wastewater Treatment Plant (WWTP) operated by Fuquay-Varina will shut down. A new 6-foot sewer line is currently being planned to carry wastewater from Fuquay-Varina to Lillington. The line will follow Kenneth Creek to its confluence with Neills Creek, and then Neills Creek downstream to Lillington (Figure 4.4). The project will allow development in areas that currently use septic systems.

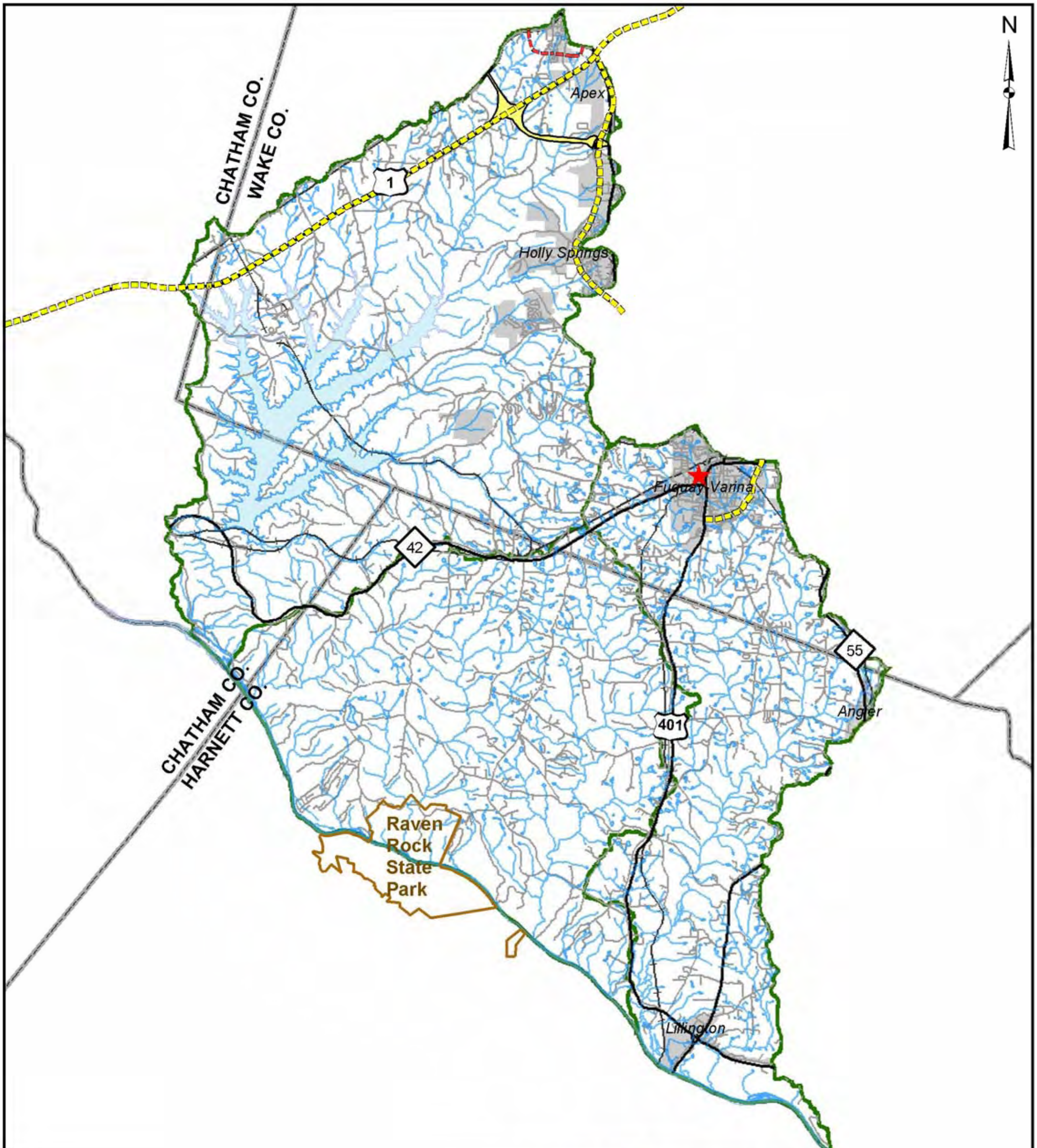
Along with the population increases in the urban areas of the watersheds has come an increase in demand for roadway facilities. A number of projects have been initiated by municipalities on their own or in cooperation with NCDOT. Figure 4.5 shows existing and planned roadways within the study watersheds.

The recently constructed Apex Peakway encircles downtown Apex and connects North Salem Street and Hughes Street in the study area. The new road has already attracted new business to the area. The planned Peakway Market Square, located just outside the project watershed at the intersection of NC 55 and the Apex Peakway, will offer 56,000 square feet of mixed use development opportunities.



NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 4.4. Proposed Sewer Line to Harnett Regional WWTP



NCDOT Roadway TIP Projects
NCDOT TIP Bridge Replacement Projects
Western Wake Freeway (proposed)
Apex Peakway

NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 4.5. Proposed Transportation Projects

0 1 2 4 6 8 Miles

There are five projects listed in the NCDOT 2002-2008 Transportation Improvement Program (TIP) within the study area (Table 4.7). Three of these projects, two parts of the NC 55 Bypass and an improvement to a section of US 1, are currently under construction. The Fuquay-Varina Loop has already been completed. A bridge will be replaced on SR 1108 (Wake Chapel Rd) in 2004.

Table 4.7. Projects Listed in the 2002-2008 Transportation Improvement Program

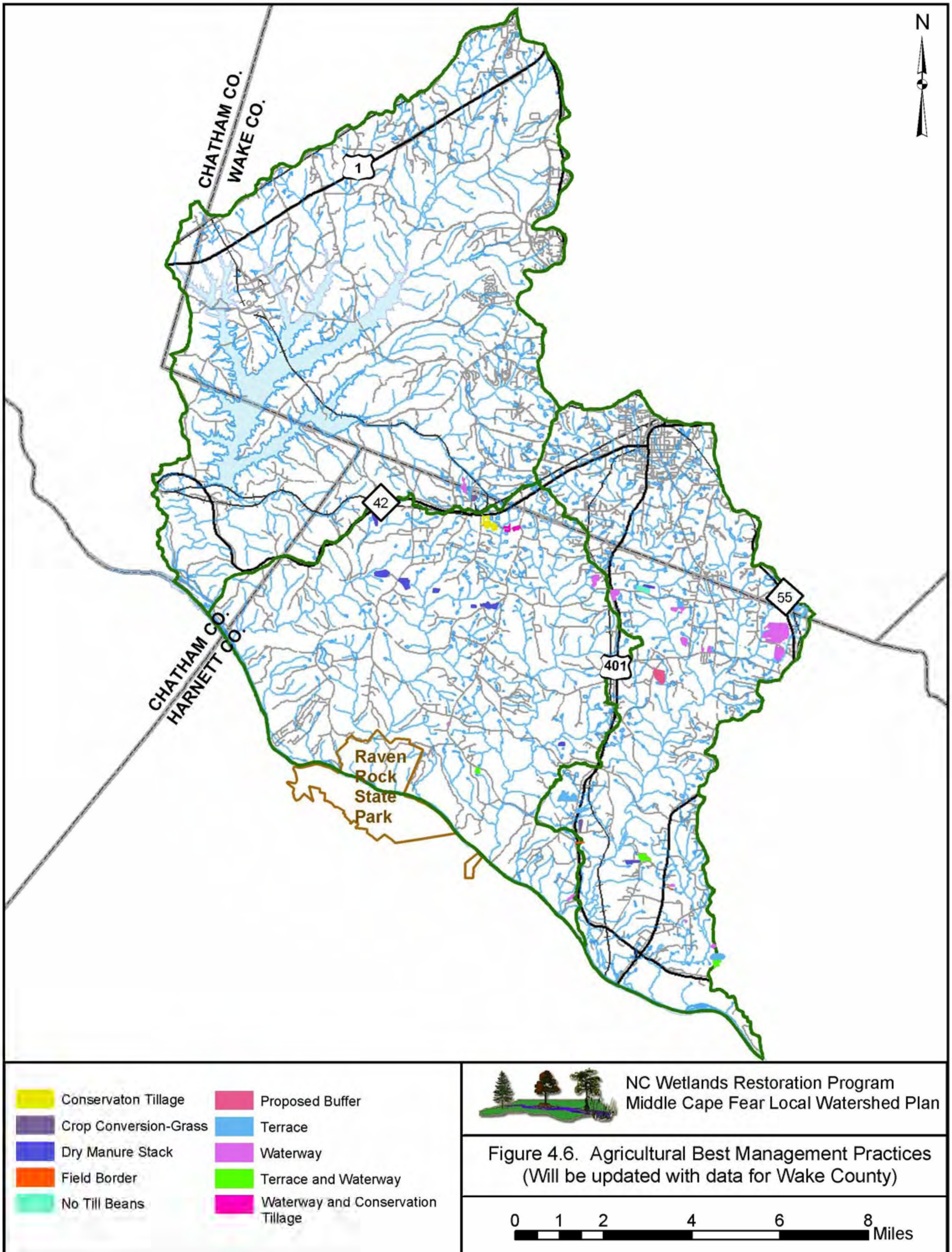
TIP No.	Description	Status
R-2500	US 1 from North of US 15-501 to US 64 - widen to four-lane divided	Under construction
R-2905	NC 55 from the Proposed Holly Springs Bypass to North of US 1	Under construction
R-2541	NC 55 – Holly Springs Bypass from SR 1114 (Ralph Stevens Loop Rd) to SR 1448 (Bobbitt Rd)	Under construction
R-2826	Fuquay-Varina Loop From US 401 S To US 401 N At SR 1107 E Academy Street	Completed
B-3256	Replace Bridge 337 over Norfolk Southern Corporation on SR 1108	Construction to begin in 2004

NCDOT also proposed to build the Western Wake Freeway within the project study area. The freeway is identified in the post-2008 TIP as project number R-2635. NCDOT is currently preparing an environmental impact statement for the project. The freeway will have six lanes and traverse the extraterritorial jurisdictions of Apex and Cary, as well as the Apex municipal limits. The Western Wake Freeway will serve as a link in the Raleigh Outer Loop (I-540) and will tie to the Northern Wake Freeway at NC 55 near Alston Avenue (SR 1630), north of Cary, and to the Southern Wake Freeway (TIP Nos. R-2721 and R-2828) at the Holly Springs (NC 55) Bypass south of Apex.

4.4 Agricultural Land Use and Practices

Agricultural land uses in the study watersheds were surveyed for the purposes of characterizing the watershed and providing data for future use in the modeling phase of the project. Figure 4.6 shows an inventory of best management practices in the Harnett County portion of the watershed based on discussions with county Natural Resources Conservation Service staff. Similar work is underway for Wake County. Only a small amount of land in Chatham County within the study watersheds is used for agricultural purposes.

Tables 4.8 through 4.10 summarize county agricultural statistics based on data from the NC Department of Agriculture and Consumer Services. Of the three counties in the project watersheds, Harnett County has the greatest acreage of harvested cropland. Cotton and soybeans are the largest crops in the county. Both Harnett and Chatham Counties have significant numbers of livestock, especially turkeys and chickens. However, poultry operations in Chatham County are not prevalent in the study watersheds.



NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 4.6. Agricultural Best Management Practices
(Will be updated with data for Wake County)

Table 4.8. Census of Agriculture (1997) County Statistics (NCDACS, 2002)

County	Number of Farms	Total Land in Farms (ac)	Average Farm Size (ac)	Harvested Cropland (ac)
Chatham	956	112,923	118	21,713
Harnett	626	116,004	185	52,193
Wake	772	113,201	147	37,385

Table 4.9. County 2001 Crop Production (NCDACS, 2002)

	Acres Harvested						
County	**Tobacco**	**Cotton**	**Soybeans**	**Corn**[1]	**Small Grains**[2]	**Sweet Potatoes**	**Hay**
Chatham	645	500	1,400	1,600	1,070	*	16,100
Harnett	4,915	18,500	24,800	3,900	6,920	1,600	4,200
Wake	5,690	300	15,400	200	4,750	400	5,000

[1] Includes corn for silage
[2] Includes wheat, barley, and oats
* Counties not harvesting more than 200 acres of sweet potatoes were not published.

Table 4.10. County Livestock Totals (NCDACS, 2002)

	Number						
County	**Hogs and Pigs**	**Cattle**	**Beef Cows**	**Milk Cows**	**Broilers Produced**	**Turkeys Raised**	**All Chickens**
Chatham	5,900	32,100	16,800	1,300	39,000,000	*	800,000
Harnett	62,000	9,400	4,300	*	24,000,000	*	*
Wake	1,600	10,300	3,900	*	*	*	*

* Counties with fewer than 200 milk cows, 500,000 broilers or turkeys, or 50,000 chickens were not published.

In addition to the livestock in the study watersheds, there are also a significant amount of horses, especially around the Harris Lake watershed. According to the 1996 North Carolina Equine Survey, there were 2,200 horses in Chatham County, 1,400 horses in Harnett County, and 4,100 horses in Wake County. There are no statistics available at a smaller scale than the county level.

A "windshield survey" was performed to assess crops, agricultural practices, and BMPs in the study area. This data will be useful in later phases of the project for both calibration of the water quality model and assessment of watershed functions. Additionally, the data allow comparison to existing land use estimates for verification and extrapolation of field survey results to watershed wide estimates.

The survey included assessment of agricultural lands chosen at random throughout the study area. The results are biased by the fact that observations included only those practices that could be seen from roadways. The following conclusions were drawn based on the windshield survey:

(1) The primary crops grown in the study watershed are soybeans, corn, tobacco, and cotton.

(2) Field borders are the most common BMP in the study watersheds. Often, these borders are not maintain and are overgrown.
(3) Forestry is most prevalent around Harris Lake (HU 03030004020010)
(4) Livestock are not widespread in the study area. The most commonly observed animals were horses, turkeys, chickens, and goats.

4.5 Silviculture

A significant portion of land within the study watersheds is used for silviculture, particularly in the vicinity of Harris Lake, as evidenced by site visits and tax parcel data. Most forest land within Chatham, Harnett, and Wake Counties is privately or industry owned (Table 4.11). There are no government-owned forests within the study area.

Table 4.11. County Forestry Statistics (NCFA)

County	Land (acres)				
	Total	Forest	Government Owned	Forestry Industry Owned	Privately Owned
Chatham	439,090	302,103	12,887	32,000	257,216
Harnett	384,710	221,237	8,279	7,683	205,275
Wake	537,133	246,464	15,821	2,021	228,631

Privately owned forests in North Carolina are subject to the state's Forest Practices Guidelines Related to Water Quality (FPGs), which outline nine performance standards or rules that went into effect January 1, 1990. Compliance with these rules provides persons engaged in forestry-related land-disturbing activities an exemption from permitting requirements of the NC Sedimentation Pollution Control Act of 1973 as amended in 1989. The FPGs are subject to periodic review by a "Technical Advisory Committee" and are administered by the NC Division of Forest Resources (DFR).

Forestry Best Management Practices (BMPs) are recommended forest management techniques developed to support compliance with the FPGs. The BMPs are focused on minimizing environmental impacts of forestry operations such as timber harvesting, tree planting, and prescribed burning. DFR assists landowners, loggers, and others engaged in forestry activities with BMP implementation through education, training, and technical support. The Division developed a BMP manual to address soil conservation and water quality protection during forest management operations. The BMPs are not enforceable but represent developed and tested practices and techniques specific to North Carolina's forestry industry that, when followed, ensure compliance with the FPGs.

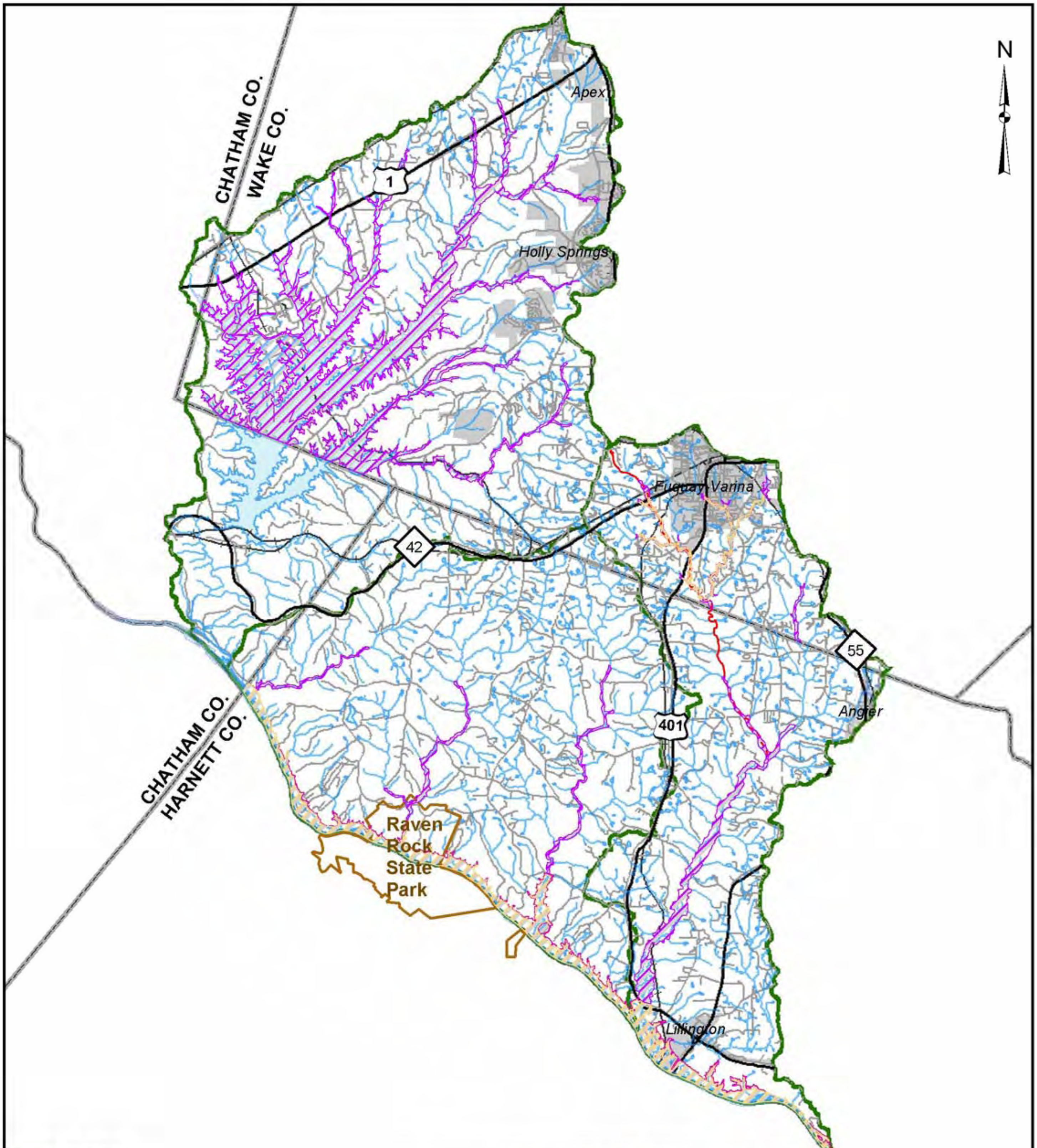
Statistics on forestry practices on individual private land parcels are not maintained by DFR, so it is not possible to fully assess the impact of silviculture in the study area. However, in March 2003 the Division published an interim report on forestry BMP implementation in North Carolina. The primary goals of this survey are to determine what level of BMP implementation is occurring on "active" logging sites throughout the state and assess the implemented BMP practices for strengths and weaknesses with regard to water quality protection. County-specific data are not yet available; however, statistics have been prepared by physiographic region. Proper implementation of BMPs was high in the Piedmont (88%). The mean FPG compliance score in the Piedmont was 89%.

4.6 FEMA Flood Mapping

Federal Emergency Management Agency (FEMA) digital Q3 flood data for the project watersheds were analyzed to determine the general proximity of Special Flood Hazard Areas (Figure 4.7). These maps are based on scans of existing Flood Insurance Rate Maps (FIRMs). FIRMs are used for floodplain management, regulation of new construction, and determination of flood insurance requirements.

Within the project watersheds, the mapped FEMA hazard zones generally follow the mainstem streams and the area around Harris Lake. The floodplain of the Cape Fear River is designated Zone AE (areas inundated by 100-year flooding for which base flood elevations (BFEs) have been determined), and Zone X500 (areas inundated by 500-year flooding). A few scattered, smaller areas around the river have also been designated as Zone X (areas that are outside the 100- and 500-year floodplains). Areas around Harris Lake and its tributaries are predominantly designated Zone A (areas inundated by 100-year flooding for which no BFEs have been determined). Small areas around the lake are also designated Zone X, in areas of higher elevation near the Harris Nuclear Power Plant. The lower sections of Parkers, Avents, and Hector Creeks (generally downstream of Baptist Grove and Ball Roads) also have been designated Zone A. Neills Creek is designated Zone A downstream of its confluence with Kenneth Creek as well as upstream of the Wake/Harnett County line. Kenneth Creek is designated Zone A just upstream of its confluence with Neills Creek. Farther upstream near the Town of Fuquay-Varina, Kenneth Creek and a number of its tributaries are designated Zone AE.

It should be noted that the Q3 flood data is currently being updated by a team of state agencies. This team is creating new digital FIRM based on new elevation data (Light Detection and Ranging (LIDAR) products) and community-based plans and information. New topographic data is currently being developed for the Cape Fear River basin. These data will then be used to estimate flooding extents on the new FIRM maps. Preliminary LIDAR data bare-earth elevation data are currently available and will be used in the modeling phase of the LWP project.



Flood Zones

- A (An area inundated by 100-year flooding, for which no base flood elevations (BFEs) have been determined)
- AE (An area inundated by 100-year flooding, for which BFEs have been determined)
- X (An area that is determined to be outside the 100- and 500-year floodplains)
- X500 (An area inundated by 500-year flooding; an area inundated by 100-year 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 100-year flooding)

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Middle Cape Fear Local Watershed Plan

Figure 4.7. FEMA Map
(Data not available for Chatham County)

0 1 2 4 6 8 Miles

5 Local Ordinances, Rules, and Programs

The Towns of Apex, Holly Springs, and Fuquay-Varina and Chatham, Harnett, and Wake Counties have jurisdiction over land use in the project watersheds. These governments have zoning and land use restrictions that affect how development occurs. In some cases, these jurisdictions have specific zoning, sediment control, and/or stormwater-related rules and programs that address watershed protection. These rules and programs are outlined below. This information will be helpful later in the project in making recommendations for new ordinances and programs to improve and protect watershed functions.

5.1 Town of Apex

The Town of Apex Planning and Community Development Department provides coordinated guidance and regulation of the growth and development of the Town through the review of subdivision and site development plans; creation and implementation of long-range land use, transportation, and hazard mitigation plans; enforcement of the Town's Unified Development Ordinance (UDO); and provision of professional advice and technical expertise to the citizens, elected officials, appointed boards and committees, and other departments of the Town of Apex. The Town UDO sets forth regulations for the Town's extra-territorial jurisdiction (ETJ) that govern the subdivision, development, and use of land. It implements the goals and policies of the Apex 2010 Land Use Plan, and serves to promote land use planning and prevent adverse impacts on the environment.

The Apex 2010 Land Use Plan shows the development of the Town within the White Oak Creek subwatershed continuing south and west to the proposed Western Wake Freeway (I-540) (Figure 5.1). Currently forested areas are predominantly classified as major employment center and commercial land uses.

The UDO includes Watershed Protection Overlay Districts that serve "to ensure the availability of public water supplies at a safe and acceptable level of water quality, to ensure protection of public water supplies for recreational and aesthetic purposes, to minimize sedimentation of streams, and to protect the environment, health, and general welfare of present and future residents of the Town and Triangle Region." The overlay districts are divided into Primary districts within water supply watersheds and Secondary districts outside these watersheds. The following activities are exempted from the requirements of the overlay districts: single family lots, two acre lots, existing development, redevelopment, expansions, developments exempted by state law, central business district development, and completed applications for development.

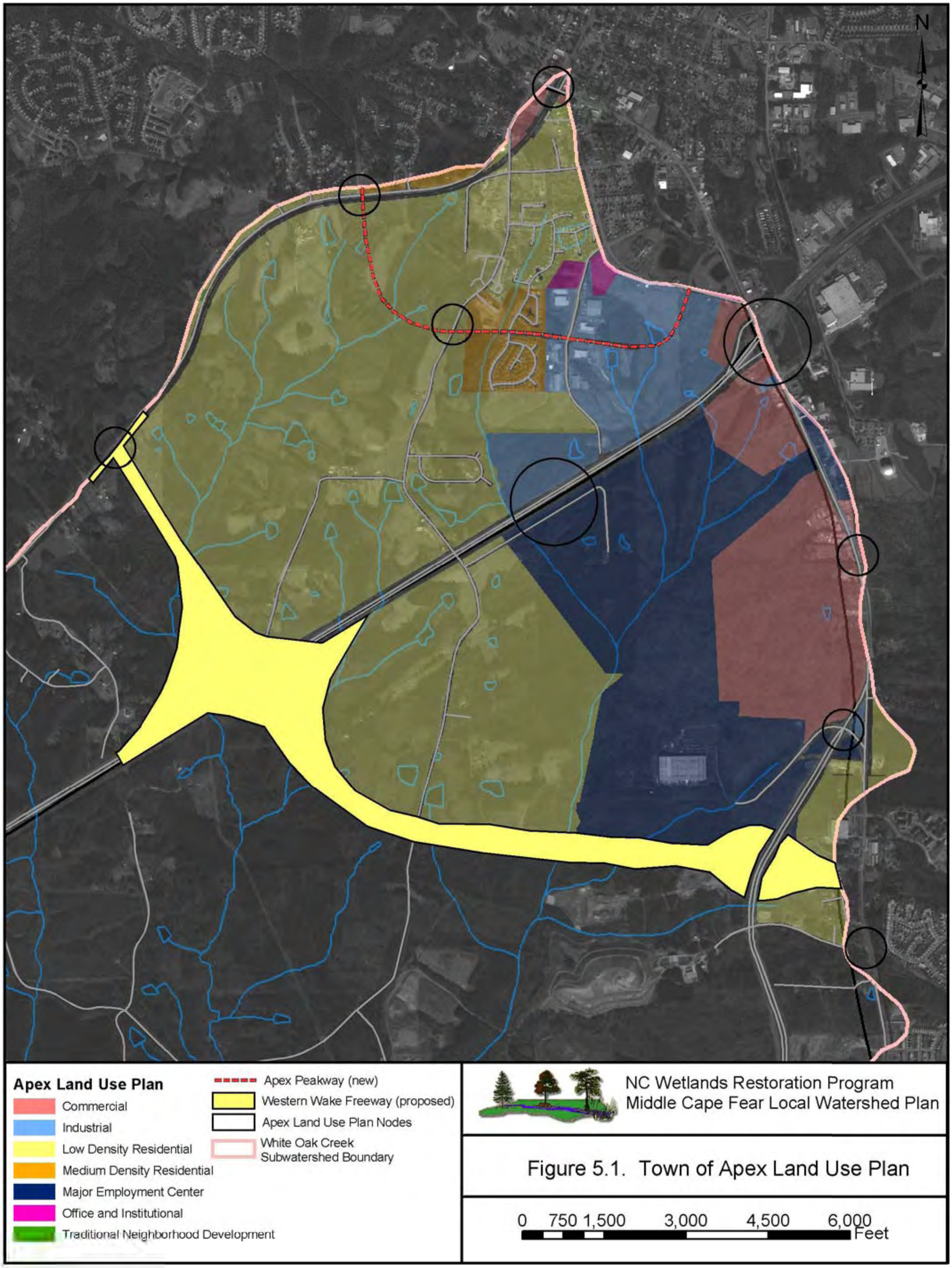


Figure 5.1. Town of Apex Land Use Plan

The Town of Apex offers proposed development not exempted from the regulations with low-density, high-density, and clustered development options (Table 5.1). These options allow different sized lot development based on which stormwater and riparian buffer options are chosen. Requirements for storm water controls are outlined in the UDO and must include wet detention ponds for high-density development. Clustering of development is allowed under either the low-density or high-density options provided compliance with the additional standards that require minimization of stormwater runoff and a plat certificate that prevents further subdivision or development.

Table 5.1. Standards for Town of Apex Watershed Protection Overlay Districts

Option	District	Storm Water Control Structures	Riparian Buffers for Perennial Streams	Riparian Buffers for Intermittent Streams	Riparian Buffers for Lakes and Ponds
Low-Density (built-upon area not to exceed 12% of total lot(s) area)	Primary	N/A	Vegetated buffer not less than 100 feet	Vegetated buffer not less than 50 feet	Vegetated buffer not less than 50 feet; 100 feet for lakes or ponds that join perennial streams
	Secondary	N/A	Vegetated buffer not less than average of 100 feet, minimum of 60 feet	Vegetated buffer not less than 50 feet	Vegetated buffer not less than 50 feet; 100 feet for lakes or ponds that join perennial streams
High-Density (built-upon area to comply with limitations for underlying district)	Primary	Must control first one-inch of rainfall	Vegetated buffer not less than 100 feet	Vegetated buffer not less than 50 feet	Vegetated buffer not less than 50 feet; 100 feet for lakes or ponds that join perennial streams
	Secondary	Must control first one-inch of rainfall	Vegetated buffer not less than average of 100 feet, minimum of 60 feet	Vegetated buffer not less than 50 feet	Vegetated buffer not less than 50 feet; 100 feet for lakes or ponds that join perennial streams

5.2 Town of Fuquay-Varina

The Town of Fuquay-Varina has created an open space development option to achieve a number of purposes including protection of natural drainage ways and stream corridors, minimization of environmental impacts, and improvement of water quality. The open space protected by the option includes primary areas defined as sensitive environmental areas considered legally "unbuildable," including wetlands and streams, creeks, ponds, reservoirs, and stormwater management facilities for watershed protection; 100-year floodplains; stream buffers, natural areas, and wildlife habitats and corridors (identified by a botanist/biologist or considered a buffer according to Neuse River basin regulations); and state, county, or federally listed historic and archaeological sites. The option also protects secondary areas defined as woodlands; farmland; natural slopes of 15% to 25%; other historic and archaeological sites; public and/or private recreation areas and facilities; and corridor buffers (e.g., other stream buffers and land that serves as buffers between different developments).

The open space criteria provide that a minimum of 10% of the gross land area in the development be preserved as dedicated open space, and that 20% of the dedicated open space be maintained as common green area. Primary areas are to be given first priority when determining the percentage of dedicated open space, and secondary areas may be considered once the primary areas have been addressed. Based on the percentage of dedicated open space provided, the densities and minimum lot sizes shown in Table 5.2 apply to each of the Town's residential zoning districts. Figure 5.2 shows the locations of these zoning districts within the study watersheds.

According to the criteria, stream buffers shall be provided along both sides of a waterway as designated by NC DWQ or the US Army Corps of Engineers, where applicable. Where these regulations do no apply, the following criteria must be met: fifty feet on either side of streams that appear as blue lines on US Geological Survey (USGS) topographic maps, twenty feet on either side of tributaries delineated on Wake County soils maps, or twenty feet around the perimeter of a lake or pond proposed in a project.

The Town of Fuquay-Varina has developed a 28-acre environmental park along Kenneth Creek within the study area. The Carroll Johnson Environmental Education Park, off Wagstaff Road, offers walking trails and interpretive signage. The Town has proposed to build an environmental education center and outdoor classroom at the site. Plans are currently underway to pave a 1.5 mile greenway "heritage trail" that will connect the environmental park to South Park, closer to downtown. Funding for the greenway is being supplied by NCDOT under TIP number E-4402. The greenway will incorporate one of the existing trails along Kenneth Creek.

Currently, the Town of Fuquay-Varina does not have any stormwater regulations or town-specific sedimentation protection requirements.

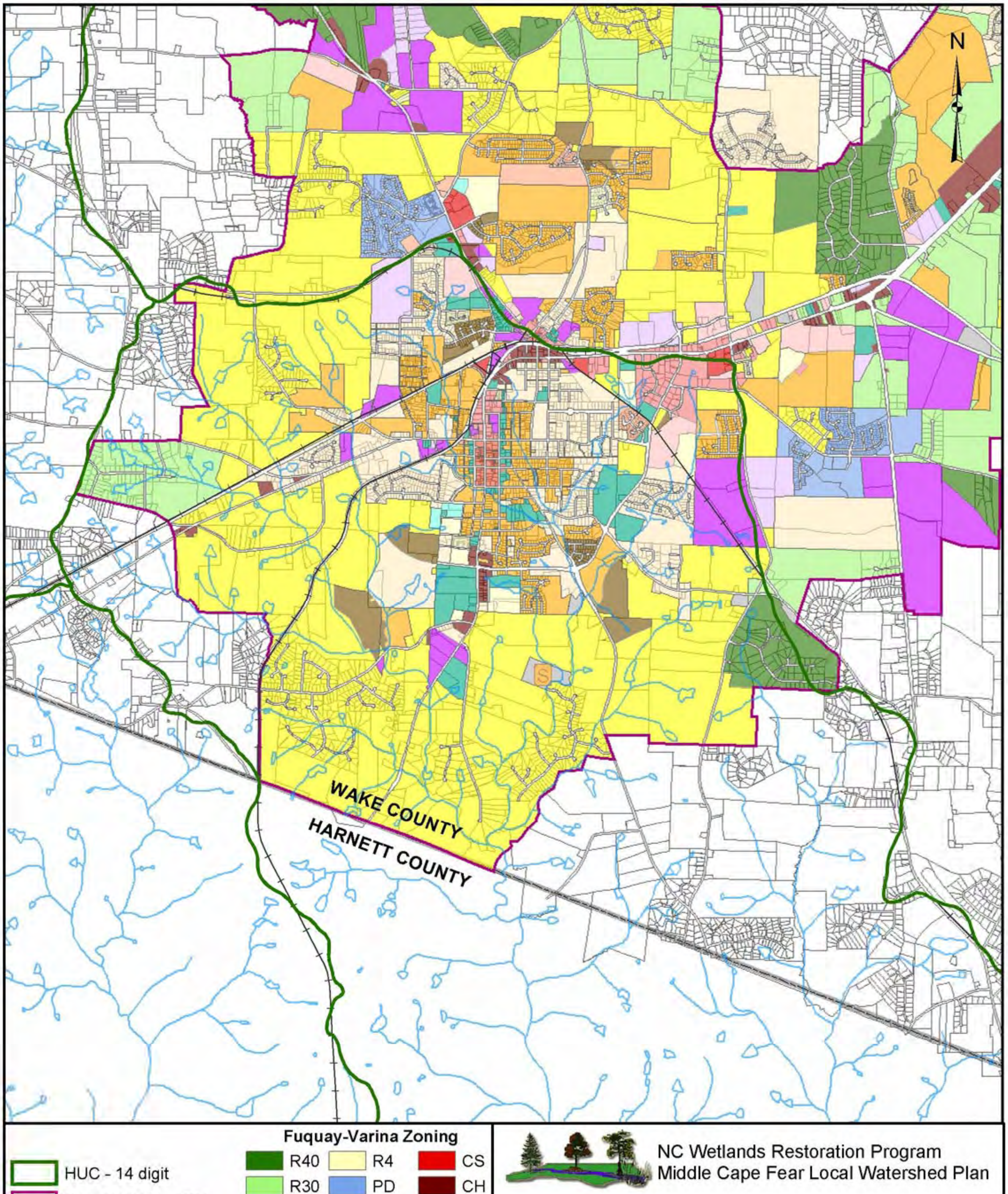


Figure 5.2. Fuquay-Varina Zoning

Table 5.2. Town of Fuquay-Varina Open Space Development Requirements

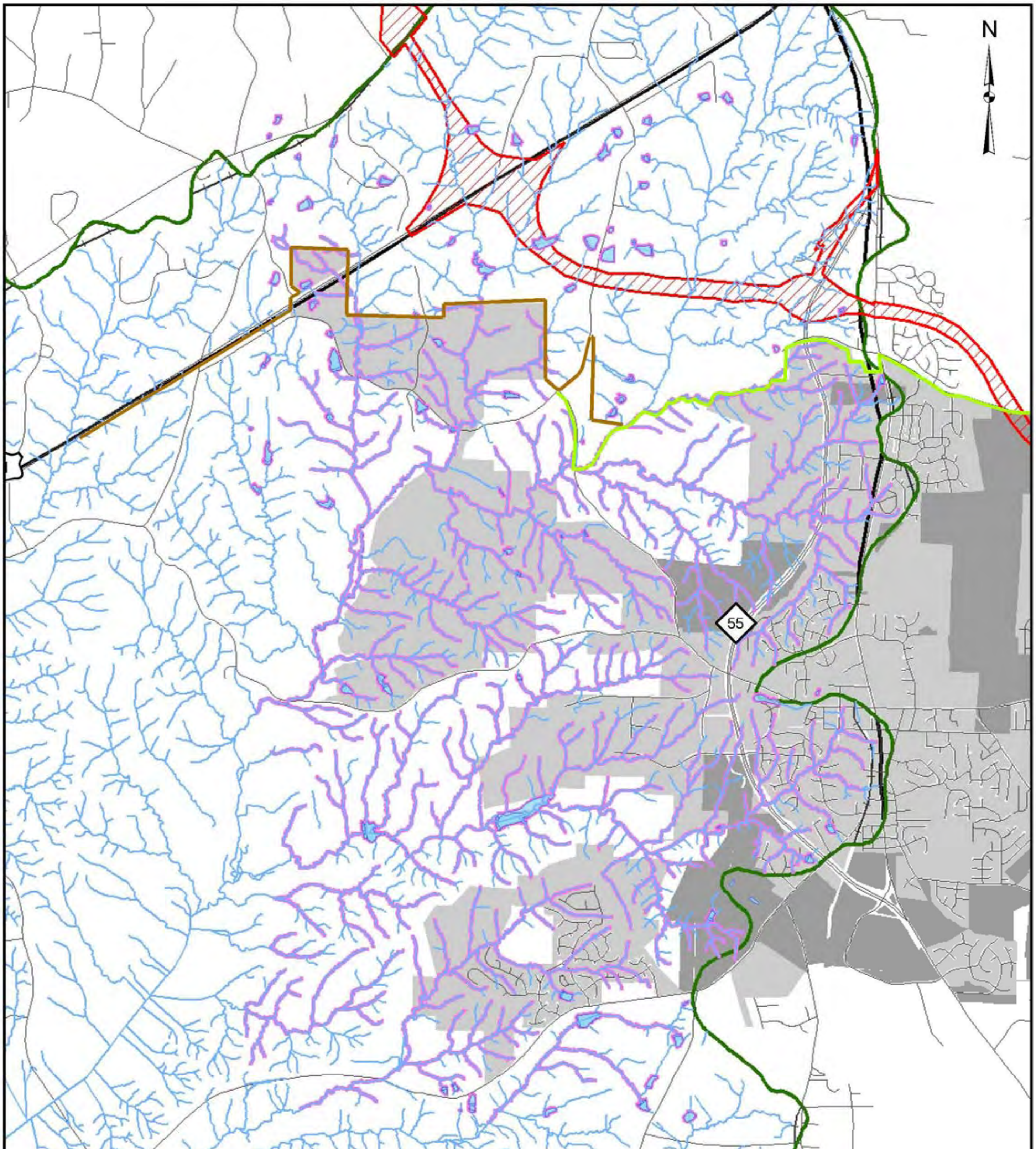
Zoning	10% Dedicated Open Space Requirement		18% Dedicated Open Space Requirement		25% Dedicated Open Space Requirement and 100% Primary Areas as Open Space	
	Minimum DU/A*	Minimum Lot Size (ft^2)	Minimum DU/A	Minimum Lot Size (ft^2)	Minimum DU/A	Minimum Lot Size (ft^2)
R-40	1.09	25,000	1.09	20,000	1.09	16,000
R-30	1.45	20,000	1.45	15,000	1.45	12,000
R-20	2.18	15,000	2.18	12,000	2.18	10,000
R-15	2.90	10,000	2.90	8,000	2.90	7,000
R-10	4.35	9,000	4.35	7,000	4.35	Avg. 6,000
R-8	5.48	8,000	5.48	Avg. 7,000	5.48	Avg. 5,000
R-6	7.08	6,000	7.08	Avg. 6,000	7.08	Avg. 4,000
R-4	10.00	4,000	10.00	Avg. 4,000	10.00	Avg. 2,000

*DU/A is dwelling units per acre

5.3 Town of Holly Springs

The Town of Holly Springs adopted a ten-year comprehensive growth plan in 1998 to address various elements of growth including land use and open space. The study area for the plan included land outside the Town's current ETJ, including the area bounded by US 1 to the west and the proposed Western Wake Expressway to the north, and to the Town of Fuquay-Varina's ETJ to the south and east (Figure 5.3). This area includes land owned by Progress Energy around Harris Lake that the Town considers suitable for development. However, the Nuclear Regulatory Commission regulates development in close proximity to nuclear power plants and their restrictions would supercede any local zoning.

To protect water quality, the Town of Holly Springs designates all areas within 1,000 feet of a substantial waterway as low density residential (no more than two dwelling units per acre). Most of the land near Harris Lake under the Town's jurisdiction also has this designation. Acceptable development types within this classification are subdivisions with conventional layouts and lot sizes of one area or more, and cluster developments and Planned Unit Developments (PUDs) whose overall densities are less than two units per acre. Cluster developments use only the most "buildable" land and preserve the other portions. PUDs allow mixing of land uses as well as mixing of densities and must be evaluated for compliance with the Town's land use plan. The Town encourages PUDs in order to evaluate each proposal based on principles of good design rather than zoning code compliance.



Cape Fear 30' Buffer
Town Limits
Town Planning Jurisdiction
Apex Proposed Boundary
Apex Boundary Update
Future Outer Loop

The Town of Holly Springs requires a 30-foot riparian buffer on all perennial and intermittent streams in the Cape Fear River basin within the Town's jurisdiction that appear on a 1:24,000 scale topographic map or on the most recent version of the Wake County Soil Survey.

NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 5.3. Holly Springs GIS Map

0 0.25 0.5 1 1.5 2 Miles

The growth plan acknowledges that destruction of forested areas and increased impervious surfaces lead to increased runoff. Stormwater control measures such as retention ponds and drainage-ways can be required of new development to help mitigate their impact on the overall system. However, the Town does not have specific stormwater management requirements.

The Town of Holly Springs adopted an Open Space Master Plan in 2002 to develop a preservation program to identify land parcels and green corridors for uses including water quality protection, recreation, and wildlife habitat protection. Watershed protection was considered in the evaluation of land parcels. The plan recommends protection of a number of areas within the study watersheds through acquisition, land regulation, or land management.

In 2002, the Town also adopted a sedimentation control ordinance to prevent water pollution from sedimentation, prevent accelerated erosion of water bodies, and prevent damage to property by sedimentation. The ordinance defines mandatory standards for land-disturbing activities that are more stringent than those in the NC Sedimentation Pollution Control Act. In addition, it sets forth requirements for timbering operations within the Town's corporate and extraterritorial jurisdiction.

The Town of Holly Springs adopted riparian buffer protection rules for the Cape Fear River basin in June 2003. These rules require any proposed project or subdivision within the Town or its ETJ to provide riparian buffers on both sides of all perennial and intermittent streams including lakes, ponds, and other bodies of water. All features indicated on the most recent US Geological Survey (USGS) topographic map or Soil Survey of Wake County must provide a 30-foot wide riparian buffer. Of this buffer, 20 feet must be undisturbed and the remaining 10 feet must be a stable vegetated area. The Town has outlined a number of permitted uses within the buffer. Where there are conflicts between mapping and actual field conditions, the Town sets a required buffer length based on the drainage area at the location.

Currently the Town is preparing a "Green Plan" which will evaluate environmental conditions in the Town's jurisdiction and make recommendations for improvement. This document should be completed in the fall of 2003. The Town is also currently preparing its application for a National Discharge Pollutant Elimination System (NPDES) permit for stormwater discharges under Phase II of the Environmental Protection Agency's (EPA) stormwater program. Phase II requires municipalities to have stormwater education programs and address illicit discharges and construction site runoff.

The Town of Holly Springs has also been investigating the concept of water reclamation in which wastewater is treated to make it reusable for other applications. As part of this effort, the Town submitted a reuse grant application to the Clean Water Management Trust Fund (CWMTF) for a project where the Town has mandated the use of reclaimed water for irrigation uses at a proposed golf course and surrounding mixed use development. The Town has also left in place force mains that were abandoned in sanitary sewer upgrade projects so they may be used as components of a future reuse system. The Town also hired a consultant to prepare a Reclaimed Water Master Plan, applied to the State for funding assistance in building the initial infrastructure for such a system, and installed turbidity monitors at its wastewater treatment plant to collect pertinent data.

5.4 Chatham County

The Chatham County Land Use Development Plan sets forth land conservation and development policies with the stated goal of balancing development with conservation. The plan strives to encourage compact communities with a mix of activities and an integrated approach to protecting open space. The county is considering cluster development and other measures to encourage preservation of open space. Protection of agricultural land is a key component of the plan.

Chatham County has a water supply watershed protection ordinance; however, the portion of the county within the study area is not part of a water supply watershed.

5.5 Harnett County

The majority of the study area outside the three municipalities is under the jurisdiction of Harnett County, and most of the study watersheds within Harnett County are designated as Water Supply Watersheds (WS-IV) by the North Carolina Division of Water Quality (see Figures 2.2 and 2.3). A very small portion of WS-III categorized watershed is located just southwest of Lillington.

Development limits set forth in the Harnett County Water Supply Watershed Management and Protection Ordinance within the WS-IV watershed are only required for development activities that require an erosion/sedimentation control plan under State law or activities that are approved local government programs. These regulations are intended to promote the development of a moderate to high land use pattern. This results in single-family residential developments with no more than two dwelling units per acre. No residential lots shall be less than half an acre unless approved for a cluster development. Within the cluster developments, the built-upon areas must be located to minimize stormwater runoff. This will help minimize impacts to receiving waters and to minimize stormwater flow. Any remaining areas not built upon shall remain in a “vegetated or natural state” and title will be transferred to a homeowners association, a local government as a park or open space, or to any other type of organization for conservation and preservation as a permanent easement. In addition to these residential rules, other types of residential development and any non-residential developments are restricted to a 24% built-on area. Other regulations allow non-residential developments to occupy ten percent of the watershed with a seventy percent built upon area when approved as a Special Nonresidential Intensity Allocation.

Regulations for the WS-III watersheds are similar to the WS-IV rules; however, the regulations apply to all activities, not only those with erosion/sedimentation control plan or a local government program requirement.

The ordinance also states that buffer zones shall be maintained in all watersheds for all development activities. A minimum distance of thirty feet of vegetative buffer is required for all perennial waters indicated on USGS topographic maps. Should the waters not be indicated on the USGS maps, but be determined as perennial waters by local government studies, then the buffer zone regulation applies. The ordinance allows for artificial streambank and shoreline stabilization.

No new development is allowed inside the buffer zones. Exceptions to this rule allow for minor diminutive increases in impervious areas and for public projects where no reasonable alternative exists.

5.6 Wake County

Wake County's Land Use Plan, adopted in 1997, sets forth policies intended to influence development within Wake County's planning jurisdiction. The policies of the plan are principally associated with its Land Use Classifications. A very small portion of Wake County is part of the Cape Fear River water supply watershed. The Land Use Plan restricts development in areas classified as Watershed Critical Areas at the lowest density (up to 0.5 dwelling per acre). Areas beside main streams and lakes (500 feet on each side) are restricted to the next lowest density (up to 1.75 dwellings per acre, if municipal water and sewer are extended). The plan permits cluster subdivisions, neo-traditional subdivisions, planned unit developments, and other innovative designs. Some density incentives apply for clustering.

A number of proposed greenways within the study watersheds appear in Wake County's Land Use Plan. The White Oak Creek Greenway (near Holly Springs New Hill Road) would link two planned Holly Springs' parks and Harris Lake County Park. The Little Branch Greenway would tie to the planned White Oak Creek Greenway and also lead to the planned Harris Lake County Park. The Utley Creek Greenway would link the planned Holly Springs' passive recreation park and Harris Lake County Park.

The Wake County Water/Sewer Plan, adopted in 1998, was developed to address the logical and orderly expansion of water and sewer service in a manner consistent with the community's values for economic development, environmental protection, and natural resource management. The County views the successful implementation of the Plan as the first major step toward a fully integrated, countywide environmental management and resource protection program. Such a program will ultimately address water supply, treatment, and distribution; wastewater collection, treatment, reuse, and disposal; residuals management; stormwater management; and other important natural resource preservation and restoration issues in the County.

Wake County is currently developing an Open Space Plan with a goal of eventually protecting a minimum of 30 percent of the county's land area, or roughly 165,000 acres. The County has partnered with each of its 12 municipal governments to support open space planning. The County awarded monetary grants and asked that each municipal government devise and adopt a local open space plan. The County has used these municipal plans as the basis for a county-wide open space plan, combining the recommendations of each to form an interconnected system.

The Wake Board of Commissioners approved an effort to develop a comprehensive watershed management plan in November 2000. The Wake County Watershed Management Plan was completed in January 2003. As part of the plan's development, existing data on water quality were reviewed and new data were collected to characterize the County's watersheds. Each of 81 watersheds defined within the county was assessed as healthy, impacted, or degraded. The Wake County portions of the Harris Lake and Kenneth/Neills Creek watersheds were assessed as "healthy." However, the classification for the Harris Lake watershed was based on land use information and not field visits or water quality monitoring.

The Wake County Watershed Management Plan presented a series of recommendations to enable growth to continue within the County while protecting its water resources, particularly those that have the highest resource value. The strategies include:

- Riparian Buffers - 100-foot buffers should be applied to perennial streams within the priority watersheds within Wake County and other watersheds within the county should have a minimum of a 50-foot buffer.
- Floodplain Protection - There should be no development or filling in the 100-year floodplain with the exception of what would be needed for utilities and infrastructure.
- Stormwater Runoff - In priority and healthy watersheds, efforts should be made to minimize imperviousness using incentives, offset fees, and other means. Offset fees can be used to purchase open space or implement stormwater management practices to offset higher levels of imperviousness. Local governments should begin to use and encourage stormwater controls, such as low impact design (LID) site planning principles, to address stormwater volume impacts. A pilot study should be conducted to examine the long-term effectiveness of LID.
- Conservation Subdivisions - The County and local governments should review their ordinances to ensure they allow conservation subdivisions which allow greater density of development in exchange for preserving large tracts of land. Where there is municipal water and sewer available to a site, a minimum of 30 percent open space should be preserved to qualify as a conservation subdivision. Density bonuses should be provided to developers that conserve 40 and 50 percent open space. In the unincorporated areas of the County, environmentally sensitive areas should be preserved with the major intent to protect water quality.
- Open Space Preservation - The Wake County Open Space Plan, when adopted, should be followed to obtain permanently protected open space within the County.
- Erosion and Sediment Control - Most areas of the current erosion and sediment control ordinances do not need to be revised, but there needs to be better implementation of the current regulations.

- Septic Systems - Improve data tracking of septic systems with the County. Educate homeowners about septic systems and the maintenance issues involved with them. Develop a certification program for people who install septic tanks and require that a certified person install all septic tanks in Wake County.
- Public Education - Inventory education programs. Develop prioritized list of watershed education needs. Determine which needs are met through current education program. Develop education programs where needed. Assign responsibility for new education program.
- Restoration - Prioritize watersheds for restoration including: degraded watersheds that contain priority resources; impacted watersheds that contain priority resources; and watersheds that are degraded, but land use characteristics indicate they may be successfully restored in the short term.

These recommendations will be taken into account and built upon as specific recommendations are developed through the Middle Cape Fear local watershed planning process.

6 Existing Water Quality

6.1 Point Source Discharges

There are six permitted individual NPDES dischargers in the study watersheds (Table 6.1). Three are municipal wastewater treatment plants (Apex, Holly Springs, and Fuquay-Varina), one is the cooling water from the Shearon Harris Nuclear Plant, and the remaining two are small residential discharges.

Table 6.1. NPDES Dischargers in the Study Watersheds

Permit	Facility	# Pipes	Major/ Minor	Permitted Flow (MGD)	Stream/Hydrologic Unit
NC0028118	Fuquay-Varina/ Kenneth Creek WWTP	1	Major	1.2	Kenneth Creek (HU 03030004040010)
NC0039586	Shearon Harris Nuclear Plant	7	Major	0.05	Harris Reservoir (HU 03030004020010)
NC0048101	Senter's Rest Home	1	Minor	0.0048	UT to Kenneth Creek (HU 03030004040010)
NC0055051	Country Lake Estates Assn.	1	Minor	0.09	UT to Buckhorn Creek (HU 03030004020010)
NC0063096	Town of Holly Springs WWTP	1	Minor	1.5	Utley Creek (HU 03030004020010)
NC0082597	Town of Angier WWTP	1	Minor	0.5	Cape Fear River (HU 03030004040010)

Violations within the past five years recorded at State Central Files are noted in Table 6.2. The minor dischargers have the majority of violations with Senter's Rest Home holding the most at 157 violations of its domestic wastewater permit in the time frame. The facility is currently under a Water Quality Special Order by Consent (SOC) until 2006. SOCs can be granted if a facility is unable to consistently comply with the terms, conditions, or limitations in an NPDES Permit. They can only be issued if the reasons causing the non-compliance are not operational in nature (i.e., they must be tangible problems with plant design or infrastructure).

The Fuquay-Varina WWTP had 3 violations during the period from July 2001 to July 2002 for permit limits and monitoring (Fuquay-Varina, 2002). This facility will be replaced by the new Harnett County regional WWTP in 2005.

Table 6.2. NPDES Dischargers Violations

Permit Number	Violation Type	No.	Concentration Range*	Allowable Amount**
NC0028118	BOD	10	20.71 to 62.00 mg/l	Variable – 16 to 30 mg/l
	TSS	3	32 to 63 mg/l	Variable - 30 to 45 mg/l
	Flow	4	1.29 to 1.34 MGD	1.20 MGD
	Fecal Coliform	4	561 to 19941 per 100 ml	400 per 100 ml
	Mercury	32	0.2 to 0.6 ug/l	0.012 ug/l
	Zinc	1	Insufficient monitoring	2 per month necessary
	Lead	2	44.0 to 53.0 ug/l	25.0 ug/l
	Residual Chlorine	1	Insufficient monitoring	2 per month necessary
	Chronic *Ceriodaphnia dubia****	1	Fail due to Survival and Reproduction	
NC0039586	Toxicity limitation	1	Single violation	
NC0048101	BOD	96	5.1 to 99 mg/l	Variable – 5 to 15 mg/l
	TSS	4	32 to 57 mg/l	Variable 30 to 45 mg/l
	Flow	5	0.0057 to 0.0083 MGD	0.0048 MGD
	NH3 as N	33	2.79 to 17.1 mg/l	Variable 2 to 4 mg/l
	Fecal Coliform	19	460 to 60000 per 100 ml	Variable 200 to 400 per 100 ml
NC0055051	BOD	32	15 to 238 mg/l	Variable 5 to 15 mg/l
	TSS	2	31.2 to 61.0 mg/l	Variable 30.0 to 45.0 mg/l
	NH3 as N	2	2.2 to 18.5 mg/l	2 mg/l
	Fecal Coliform	1	10,100 per 100 ml	400 per 100 ml
NC0063096	BOD	4	11.12 to 77.1 mg/l	7.5 to 33 mg/l
	TSS	4	49.3 to 165.7 mg/l	30 to 45 mg/l
	Flow	8	0.5083 to 0.613 MGD	0.50 MGD
	NH3 as N	4	2.83 to 6.00 mg/l	2.00 mg/l
	Fecal Coliform	15	208.4 to 1409 per 100 ml	200 to 400 per 100 ml
	Upstream Fecal	1	> 1200 mg/l	
NC0082597	Flow	3	0.51 to 0.545 MGD	0.50 MGD
	Fecal Coliform	1	473 per 100 ml	400 per 100 ml

* Certain violations are for the lack of sufficient sampling or a fail/pass test and therefore do not have concentration amounts or limits.
** Concentration limits vary according to the time frame of sampling. Daily, weekly, and monthly sampling limits may have differing tolerances for the same violation type.
*** C*eriodaphnia dubia,* a tiny aquatic invertebrate, is used as an indicator organism to measure toxicity in water. When the levels in the water are toxic to this organism, the decrease in reproductivity and survival of the species serves as an indicator of how the rest of the biological community will respond.

6.2 Review of Existing Monitoring Data

Water quality data collected from July 1998 through April 2003 by the Middle Cape Fear River Basin Association indicates that nutrients (nitrogen and phosphorus) are the most problematic parameters of concern especially at Kenneth Creek at Chalybeate Springs Road (SR 1441). Total nitrogen (TN) and phosphorus (TP) levels were consistently elevated (highest during low flow periods) indicating point source input such as Fuquay-Varina's WWTP. Conductivity levels also corresponded directly with the nutrient levels at this site, further indicating point source impacts.

The TN levels for Kenneth Creek at Chalybeate Springs Road ranged from 0.6 mg/l to 5.56 mg/l with an average of 1.99 mg/l. The TP levels for the site ranged from 0.04 mg/l to 1.24 mg/l with an average of 0.4 mg/l. Natural TN and TP levels in unpolluted systems are typically less than 1 mg/l and 0.1 mg/l respectively. These problems should be alleviated when the WWTP is taken off line in 2005.

Elevated nutrient and fecal coliform levels experienced in Avents Creek at River Road just outside Raven Rock State Park corresponded directly to elevated turbidity and total suspended solids (TSS) levels, indicating non-point source input such as agricultural runoff during rain events. Further investigation should be warranted to guide the implementation of appropriate best management practices within the Avents Creek watershed.

6.3 NC DWQ Benthic Monitoring - March 2003

In accordance with a Memorandum of Agreement with NCWRP, DWQ combined scheduled basinwide monitoring in the study watersheds with benthic macroinvertebrate monitoring requested specifically for this project. DWQ's Biological Assessment sampled 12 benthos sites as part of this effort. Habitat assessments and physical/chemical monitoring (temperature, dissolved oxygen, conductivity, and pH) were also conducted at the sites.

Several data summaries (metrics) can be produced from benthos samples to detect water quality problems. These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index. EPT taxa richness criteria have been developed by DWQ to assign water quality ratings (bioclassifications). "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution.

Twelve sites in the study watersheds were sampled in March 2003 (lower Parkers Creek site was sampled in April 2003) (Table 6.3 and Figure 6.1). The purpose of the sampling was to characterize present water quality in an area with several HQW streams, and where impacts have been documented from the Town of Fuquay-Varina WWTP. Coverage by prior DWQ benthos sampling was expanded by adding additional sampling sites on streams previously sampled and by sampling new streams.

Data were not collected at streams in the Triassic Basin due to impacts from the 2002 drought. It should be noted that although adequate flows were available during March 2003 for the sampled streams, the drought may have caused changes in the relative impacts of point and nonpoint sources of pollution. However, compared to Triassic Basin and Slate Belt streams sampled during the Cape Fear basinwide assessment, the sampled streams, with their coastal plain characteristics, appeared to be less impacted by the drought.

This survey overall indicated little change from data that were as much as 15 years old. Of the three streams with HQW designation, Avents Creek and Hector Creek have maintained their Excellent bioclassification at their previously sampled lower watershed locations. However, a mid-watershed site on Hector Creek (SR 1427) received a Good bioclassification, primarily because of habitat problems. Coopers Branch, a tributary of Hector Creek also received a Good bioclassification. Parkers Creek was borderline Excellent in 1988, and received a Good bioclassification in 2003, but EPT values were 28 and 26 suggesting no real change in water quality. Extremely orange, turbid water after a thunderstorm was noted, indicating the potential for decline as residential development increases. A new headwater site on Parkers Creek indicated a diverse, intolerant community even though the site was too small to rate (drainage area = 0.8 square miles).

Table 6.3. Summary of DWQ Monitoring

Hydrologic Unit	Stream	Location	Bioclassification
03030004030010	Parkers Creek	SR 1403 (Cokesbury Rd)	Not Impaired
03030004030010	Parkers Creek	SR 1450 (Ball Rd)	Good
03030004030010	Avents Creek	SR 1418 (River Rd)	Excellent
03030004030010	Hector Creek	SR 1427 (Baptist Grove Rd)	Good
03030004030010	Hector Creek	SR 1412 (Christian Light Rd)	Excellent
03030004030010	Coopers Branch	SR 1403 (Kipling Rd)	Good
03030004040010	Kenneth Creek	SR 1100 (Wagstaff Rd)	Good
03030004040010	Kenneth Creek	SR 1441 (Chalybeate Springs Rd)	Poor
03030004040010	Neills Creek	SR 1441 (Chalybeate Springs Rd)	Not Rated
03030004040010	Neills Creek	SR 1403 (Cokesbury Rd)	Fair
03030004020010	Little Branch	SR 1153 (Old Holly Springs-Apex Rd)	Not Rated
03030004020010	Buckhorn Creek	SR 1119 (Buckhorn Duncan Rd)	Good

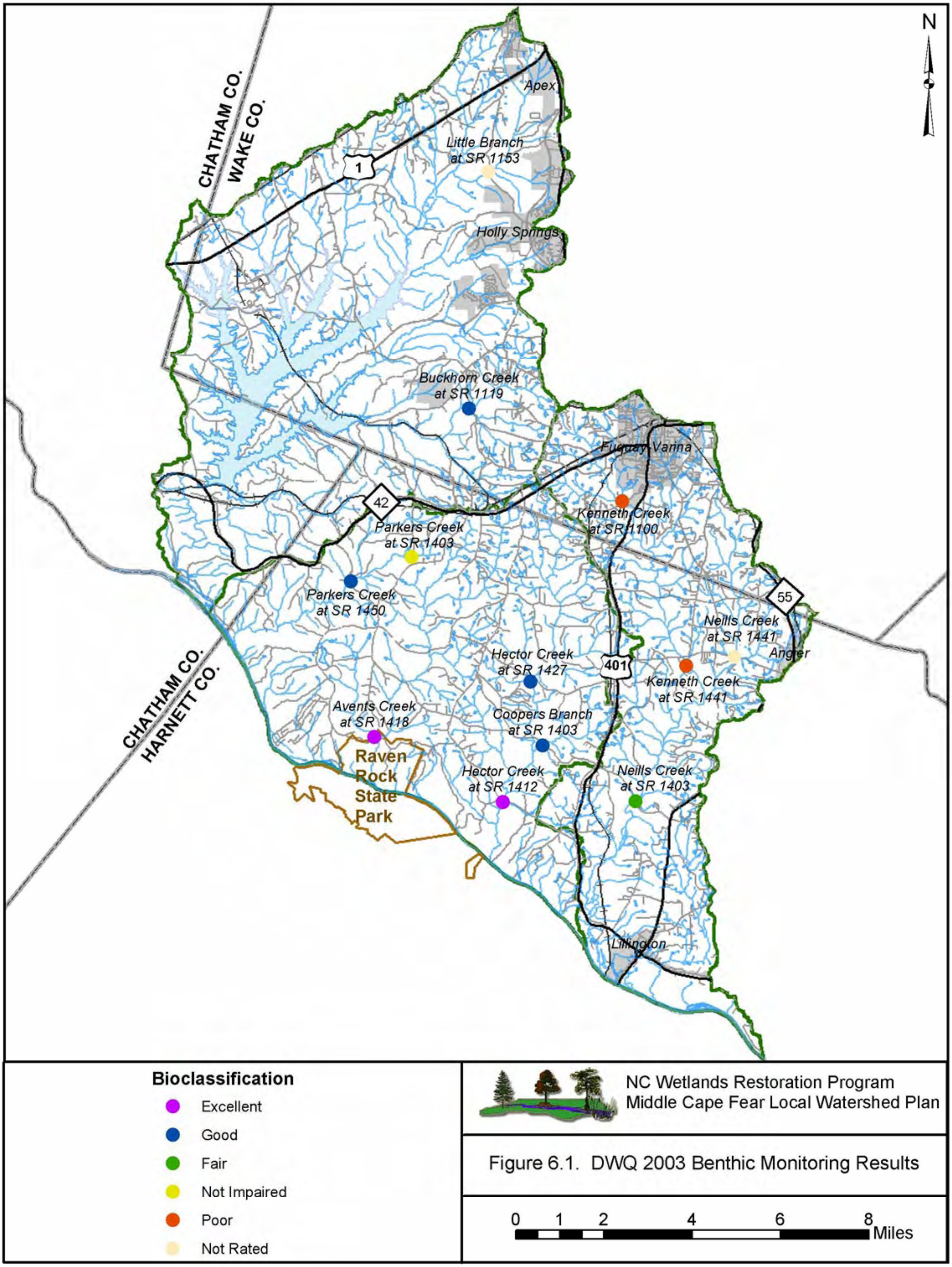


Figure 6.1. DWQ 2003 Benthic Monitoring Results

Kenneth Creek has been sampled three times since 1993 and the same Poor water quality rating has been found each time at sites below the Fuquay-Varina WWTP. An upstream site above the downtown area, but still in a residential area, was given a Good bioclassification. Neills Creek above Kenneth Creek declined from a Good-Fair rating in 1993 and 1998 to a Poor rating in 2003. The EPT fauna at this site was very odd - a fast growing winter stonefly was very abundant, but no year round fauna were found, and no mayflies at all were collected. It is suspected that a toxic event has impacted this stream. The downstream Neills Creek site declined from Good-Fair in 1988 to Fair in 2003, either because the WWTP effects reached farther downstream during the drought, or because of the same toxicity that may have affected the upstream site.

The other two streams not previously sampled were Little Branch, which is a Triassic Basin stream affected by the drought, but with a fauna similar to other Triassic Basin streams, and Buckhorn Creek above Harris Lake. Buckhorn Creek was given a Good bioclassification, but habitat problems such as severe erosion and sediment deposition were noted.

6.4 NC DWQ Fish Monitoring

NCDWQ collected fish data from Avents Creek, Hector Creek, and Kenneth Creek most recently in 1998 using the North Carolina Index of Biological Integrity (NCIBI) protocol (Table 6.4). The NCIBI incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The scores derived from this index are a measure of the ecological health of the waterbody and may not directly correlate to water quality. For example, a stream with excellent water quality, but with poor or fair fish habitat, may not be rated excellent with this index. However, a stream, which rated excellent on the NCIBI should be expected to have excellent water quality (NCDWQ, 2001).

Table 6.4. NC DWQ Fish Community Data Summary

Hydrologic Unit	Stream	Location	NCIBI
03030004030010	Avents Creek	SR 1418 (River Rd)	Fair
03030004030010	Hector Creek	SR 1412 (Christian Light Rd)	Fair
03030004040010	Kenneth Creek	SR 1441 (Chalybeate Springs Rd)	Poor

The fish community at the Hector Creek site rated only Fair. This is contributed to by large areas of bedrock present in Hector Creek preventing significant pool formation and providing only minimal cover for fish. NCIBI metrics that indicated the largest shortfalls in the fish community were the number of intolerant species, the percent of tolerant fish, and the percent of insectivores (NCDWQ, 1999).

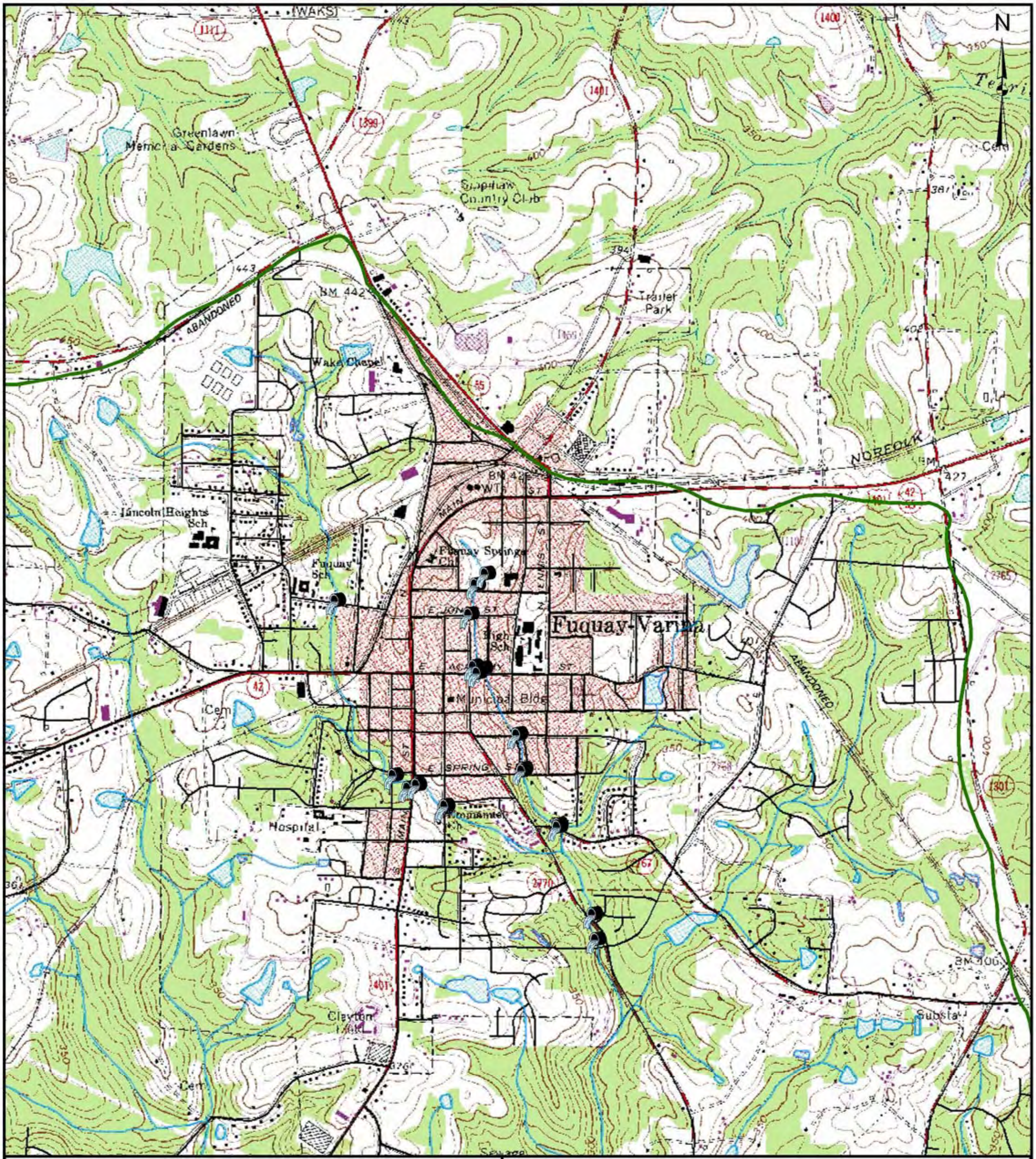
The fish community in Kenneth Creek rated Poor, similar to the Bioclassification at this site. No sucker or intolerant species were collected, indicating an unhealthy community at this site (NCDWQ, 1999).

A fish community sample was collected from Avents Creek in September 1998 as part of a statewide reference stream study. The stream received only a Fair rating (NCDWQ, 1999).

Fish tissue samples were collected from Cape Fear River at US 401 near Lillington during September 1998. Of the 22 samples analyzed for metals contaminants, one bowfin (*Amia calva*) sample contained mercury exceeding the EPA screening value of 0.6 ppm. The source of mercury is too difficult to determine. All other metals results were lower than EPA and FDA/NC limits (NCDWQ, 1999).

6.5 Stormwater Inventory

Buck Engineering completed a stormwater discharge survey for Fuquay-Varina and Holly Springs (Figures 6.2 and 6.3). The purpose of this inventory was to assess the outfalls and document any altered drainages. The survey documented the location, type, and size of the outfall; surrounding land use; damage, deposits, and stains; and site conditions. In general, the outfalls were in good condition with a few instances of deposits and concrete cracking/erosion. There was no evidence of significantly altered drainages.



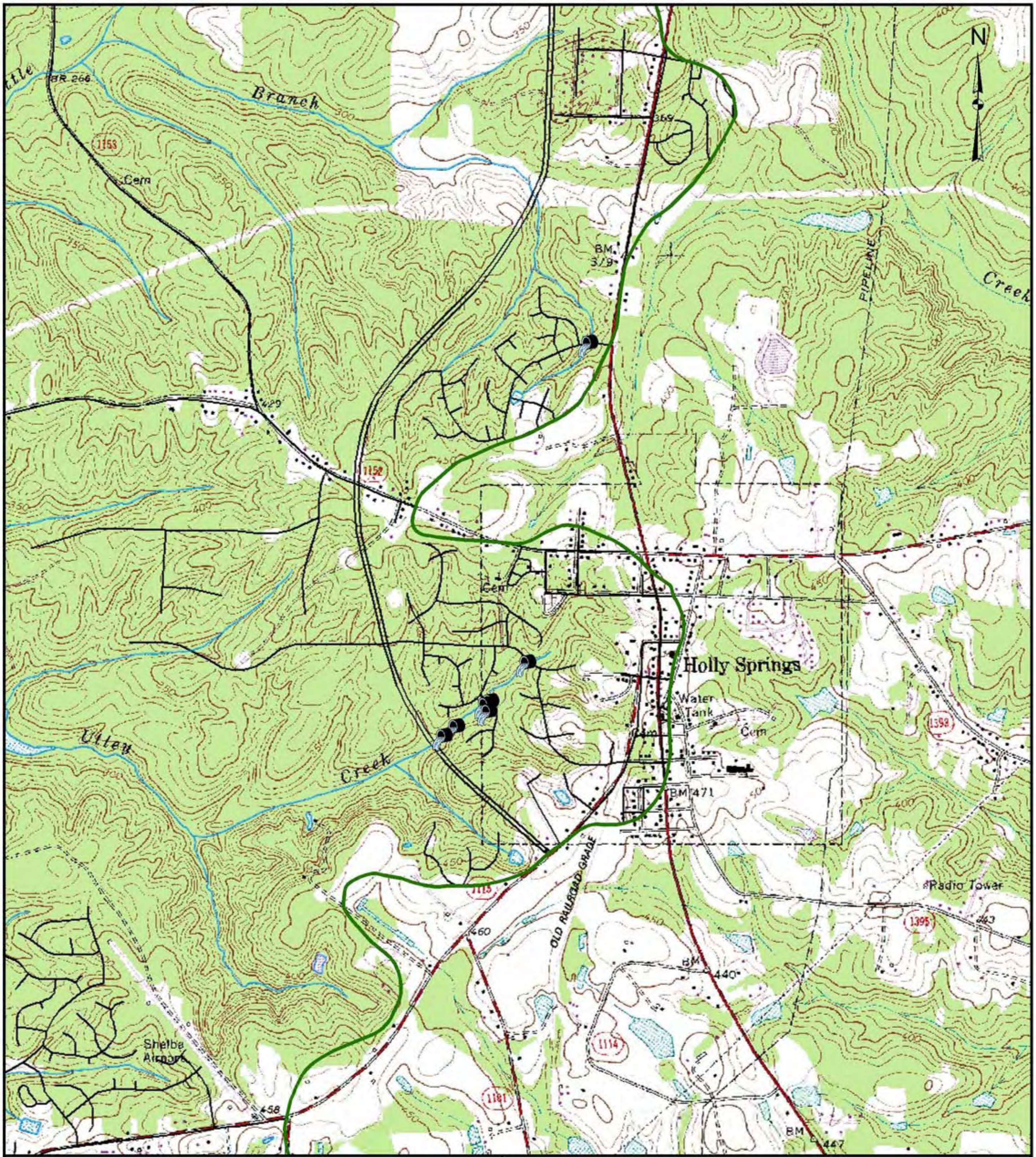
NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Stormwater Outfalls

HUC - 14 digit

Figure 6.2. Fuquay-Varina Stormwater Outfalls

0 0.125 0.25 0.5 0.75 1 Miles



Stormwater Outfalls

HUC - 14 digit

NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 6.3. Holly Springs Stormwater Outfalls

0 0.125 0.25 0.5 0.75 1 Miles

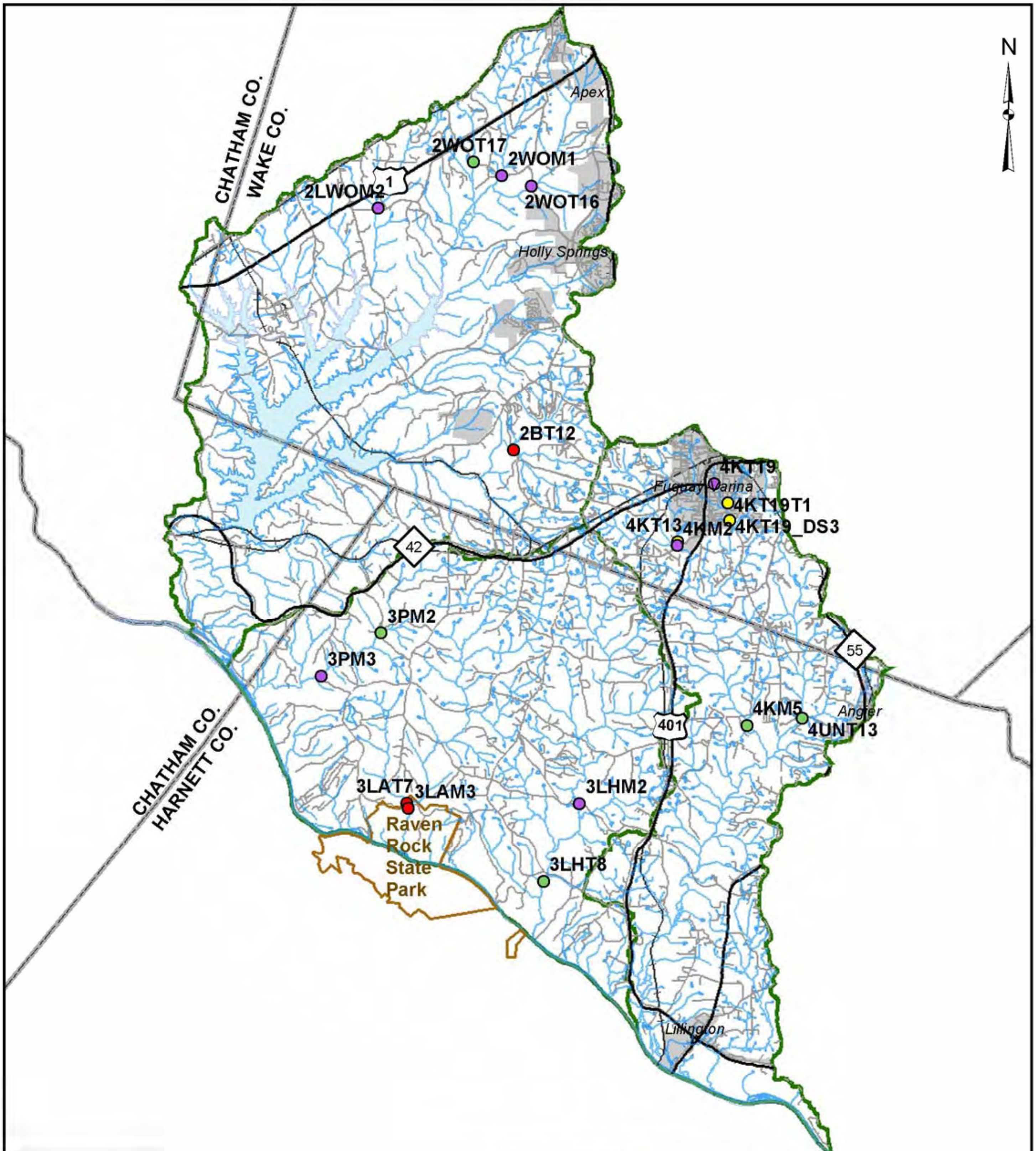
7 Restoration Opportunities

7.1 Potential Types of Projects

During field reconnaissance and stream survey trips, a number of sites were identified where opportunities exist to improve watershed functions (Figure 7.1). Described below are sites where specific action, such as BMP implementation, stream restoration, and buffer protection may develop as relatively important preservation and restoration opportunities for the watershed. This information will be enhanced, modified, and updated in future reports as data become available.

7.1.1 Control of Exotic Vegetation

Throughout much of the Kenneth Creek watershed and portions of the upper watersheds of Parkers and Avents creeks exotic vegetation is an important factor that limits the quality of riparian habitat and stream stability. As a result of heavy tree damage from Hurricane Fran in 1996, thick stands of privet and other exotic shrubs gained a foothold and continue to dominate many riparian areas. Examples of where control of exotic vegetation could have the most benefit include an unnamed tributary (UT) to Kenneth Creek upstream of Wagstaff Rd (SR 1100) along a greenway in Fuquay-Varina (site 4KT13). This stream reach has excellent stream pattern and dimension along with excellent substrate. Control of exotic vegetation at this site would help native plants become established and provide better habitat conditions, more diverse canopy conditions, and higher stream bank root densities. This effort would compliment potential stream restoration activities immediately downstream on Kenneth Creek (discussed below). Removal of exotic vegetation could also improve habitat conditions at many other sites including UTs to Kenneth Creek from below Academy Street to below Judd Parkway in Fuquay-Varina (site 4KT19_DS3) and the UT to Kenneth Creek at the existing Fuquay-Varina WWTP (site 4KT19T1) (Figure 7.2).



Potential Projects

- Control of Exotic Vegetation
- BMP Implementation
- Stream Restoration
- Stream Preservation

NC Wetlands Restoration Program
Middle Cape Fear Local Watershed Plan

Figure 7.1. Potential Project Sites

0 1 2 4 6 8 Miles

Figure 7.2. Privet Stand Below the Fuquay-Varina WWTP

7.1.2 Potential BMP Implementation

The current status of BMP implementation throughout the study area will be discussed in upcoming reports. However, it is clear at this time that a number of streams have been damaged by forestry activities. For example, riparian habitat at a UT to White Oak Creek at Woods Creek Rd (SR 1154) (site 2WOT17) and Parkers Creek at Ball Rd (SR 1450) southwest of Duncan (site 3PM2) (Figure 7.3) have been damaged by recent clear cuts. In such cases, careful implementation of forestry BMPs could have prevented bank erosion and water quality impacts from sediment and temperature effects. Since most of the wooded lots in the project area are privately owned, efforts to encourage private landowners to implement careful timber harvesting by streams could be an important management program for the portions of the watershed.

Figure 7.3. Recent Clear Cut on the Right Bank of Parkers Creek at Ball Road

The application of agricultural BMPs within the basin will also be discussed in future reports but clear examples of potentially important BMP sites include field edge BMPs at Kenneth Creek at Chalybeate Springs Rd (SR 1441) (site 4KM5) (Figure 7.4) and animal exclusion at the UT to Neills Creek at Chalybeate Springs Rd (SR 1441) west of Angier (site 4UNT13) and the UT to Hector Creek at Christian Light Rd (SR 1412) southwest of Kipling (site 3LHT8).

Figure 7.4. Ditch Leading Directly to Kenneth Creek at Chalybeate Springs Road.

7.1.3 Potential Restoration

Due to the disturbed nature of the study area many streams are candidates for stream restoration. However, four potential opportunities for stream restoration have already been identified during this first phase of the project:

(1) Three tributaries to Harris Lake in the White Oak Creek drainage form a cluster of potential restoration sites. These are Little White Oak Creek upstream of Friendship Rd (SR 1149) (site 2LWOM2), Big Branch at Woods Creek Rd (SR 1154) (site 2WOM1) and Little Branch at Old Holly Springs-Apex Rd (SR 1153) (site 2WOT16) (Figure 7.5). Each of these streams has reaches greater than 1,000 feet in length where incision is resulting in bank erosion and heavy sediment loading. Property surrounding these sites is in large tracts primarily controlled by either Progress Energy or Wake County.

(2) Parkers Creek from below Ball Road (SR 1450) (Site 3PM3) has long reaches where forestry activities have resulted in an unstable and widening channel. Potential restoration sites exist at least as far downstream as site 3PM3, more than one mile downstream. Large parcel tracts of greater than 50 acres surround this potential restoration site. In addition, Parkers Creek upstream of Ball Road has a shorter reach where the stream has been channelized.

(3) Kenneth Creek and its tributaries in Fuquay-Varina offer the best opportunity for urban stream restoration in the study area. A prime opportunity exists on Kenneth Creek above and below Wagstaff Road (SR 1100) (Site 4KM2). Here Kenneth Creek and a tributary are within an existing City greenway. Severe erosion below Wagstaff Road and poor habitat above the road could be addressed by a fair sized restoration project. A more problematic but potential urban restoration project, also in Fuquay-Varina, could be considered for a tributary to Kenneth Creek downstream of Academy St (4KT19). This tributary is severely incised and is eroding badly over a reach that involves many city blocks. In most places there is sufficient room adjacent to the stream to consider a natural channel design solution. However, multiple land owners and road crossings present significant complexity to this potential project.

(4) Hector Creek has several sites where sandy stream banks are being heavily eroded. A site at Kipling Rd (SR 1403) (site 3LHM2) shows the best potential for a restoration project where a deeply incised channel is rapidly widening.

Figure 7.5. Heavy Bank Erosion above Harris Lake

7.1.4 <u>Potential Preservation</u>

While many streams in the study area are heavily impacted by past and present land use, three distinct opportunities exist for preservation of unique streams. The first and most stable of these streams is Coopers Branch above Kipling Rd (SR 1403) (site 3LHT4).

The stream is in full contact with an extensive forested floodplain and exhibits excellent dimension, pattern, and profile. The landowners own extensive property adjacent to the stream and have interests in the natural history of the area.

A second stream with stable and unique feathers is the UT to Buckhorn Creek at Buckhorn Duncan Rd (SR 1119) (site 2BT12). This steep gradient stream (Rosgen "B" stream type) has intact and functional buffers, excellent aquatic habitat, and steep yet stable stream profile rarely found in the Piedmont.

A third opportunity exists near the confluence of two streams upstream of River Rd (SR 1418) just outside Raven Rock State Park. Mill Creek (site 3LAT7) and Avents Creek above a knick point (site 3LAM3) are well buffered streams that may be good candidates for preservation as they are contiguous with a large segment of Avents Creek presently protected as State Park. Mill Creek is particularly interesting as it is presently forming a stable stream channel within an over wide channel; completing its evolutionary cycle back to a stable pattern, dimension and profile from a disturbed state (Figure 7.6).

Figure 7.6. Mill Creek at River Road

7.2 NCWRP GIS Analysis – Potential Restoration/Enhancement Sites

NCWRP contracted with BLUE: Land Water Infrastructure, PA to perform a GIS analysis of the Middle Cape Fear River Basin to map potential stream and wetland restoration and enhancement sites. The GIS techniques used were based on methodologies developed by the NC Division of Coastal Management and utilized the US Department of Agriculture Natural Resources Conservation Service's digital soils layers, US Fish and Wildlife Service's National Wetlands Inventory (NWI), and the NC CGIA 1994 land use/land cover data. The purpose of the project was to allow agencies to determine historic wetland losses in the basin and allow for identification of restoration and enhancement opportunities.

Mapping includes a base wetland map of NWI polygons that were located on hydric soils and non-NWI polygons with forested land cover that were located on hydric soils; potential wetland restoration and enhancement sites that were located where either the site had an NWI polygon but non-forested cover or the site had hydric soils but no NWI polygon; and locations of potential stream impacts where streams crossed non-forested areas. Classes were used to describe the potential wetland restoration and enhancement areas (Table 7.1). Classes 1, 3, and 5 include potential sites converted to non-wetland status since the publication of NWI maps in North Carolina. Classes 2, 4, and 6 include potential sites converted to non-wetland status prior to the publication of the NWI maps in North Carolina. Classes 7, 8, and 9 include potential wetland enhancement sites.

The three map products are shown in Figure 7.7 and will be used later in this project during the assessment of watershed functions and identification of solutions to watershed deficits.

Table 7.1 NCWRP Potential Wetland Restoration and Enhancement Classes

Class	Appears on NWI?	Soil	Land Cover (1994)
1	Yes	Hydric soil or soil = water	Non-forested
2	No (upland)	Hydric soil or soil = water	Non-forested
3	Yes	Non-hydric soil with hydric inclusions	Non-forested
4	No (upland)	Non-hydric soil with hydric inclusions	Non-forested
5	Yes	Non-Hydric soils	Non-forested
6	Yes, with excavated or spoil modifier ("x" or "s")	Any	Any
7	Yes, partially drained modifier ("d")	Any	Any
8	Yes, with impounded modifier ("h")	Any	Any
9	No	Hydric soil	Pine forested land cover

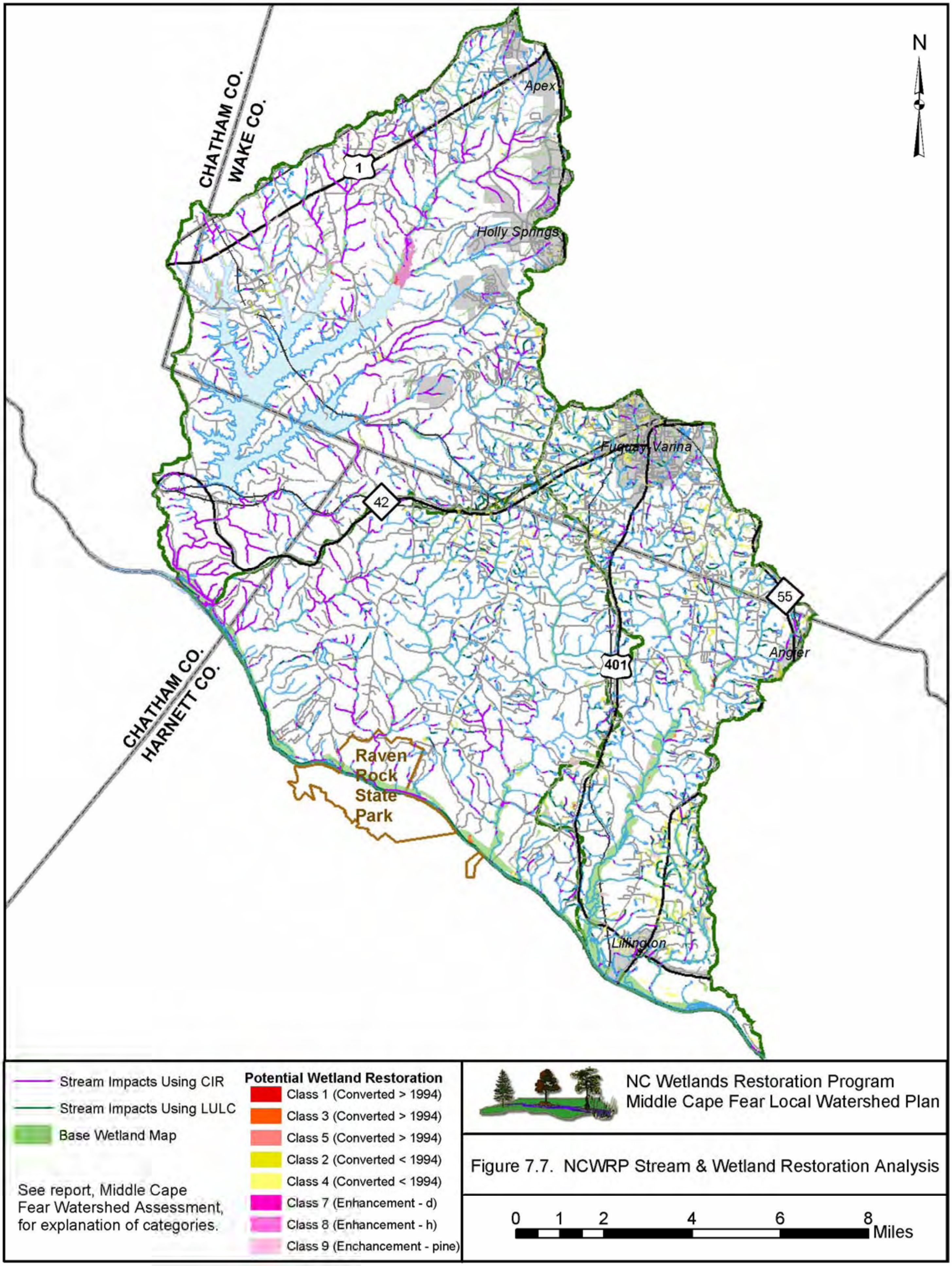


Figure 7.7. NCWRP Stream & Wetland Restoration Analysis

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