Middle Cape Fear
Local Watershed Plan

Technical Memorandum 5:
Conclusions and Recommendations

North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program

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Middle Cape Fear Local Watershed Plan

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Prepared For:

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1 Introduction

1.1 Background

The North Carolina Wetlands Restoration Program (NCWRP) contracted with Buck Engineering in 2002 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 the Local Watershed Planning (LWP) initiative that is currently administered by the North Carolina Ecosystem Enhancement Program (EEP). This Technical Memorandum presents project conclusions and recommendations for management actions based on work completed for the previous four project memos and recent efforts to prioritize management opportunities. The prioritization is based on a number of factors, including the functional assessment (Technical Memorandum 4), feasibility, and expected benefit. The information described in this memo identifies and prioritizes opportunities to address functional deficits.

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). The total land area for the HUs is approximately 180 square miles. 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 HUs 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.

Based on analyses performed in previous phase of the project, the three HUs were further divided into 12 functional assessment units (FAUs) with generally similar land use, landform, and riparian condition (Figure 1.2). The Parkers, Avents, and Hector Creek sub-watersheds represent the largest FAUs. Initially, it was thought that it would be necessary to split the upper and lower portions of these sub-watersheds into unique FAUs. However, land use in these sub-watersheds is homogeneous and stream types are consistent in both the headwater and downstream sections.

The Harris Lake and Dry Creek sub-watersheds, as well as small drainages flowing directly into the Cape Fear River, were excluded from the functional assessment process. Although nutrient management is a key concern for the management of Harris Lake, it was determined to be outside the relevant scope of issues important to the rest of the study area. Also, any sediment impacts within the drainage to Harris Lake are contained within the waterbody. The Dry Creek sub-watershed and the small drainages directly to the Cape Fear River have no monitoring data available, which impedes model calibration. Due to the small size of their land areas compared to the other drainages, these regions also have a limited impact on the water quality of Cape Fear River. Therefore, it was determined that it would be more cost-effective to apply project resources to the other parts of the study area.

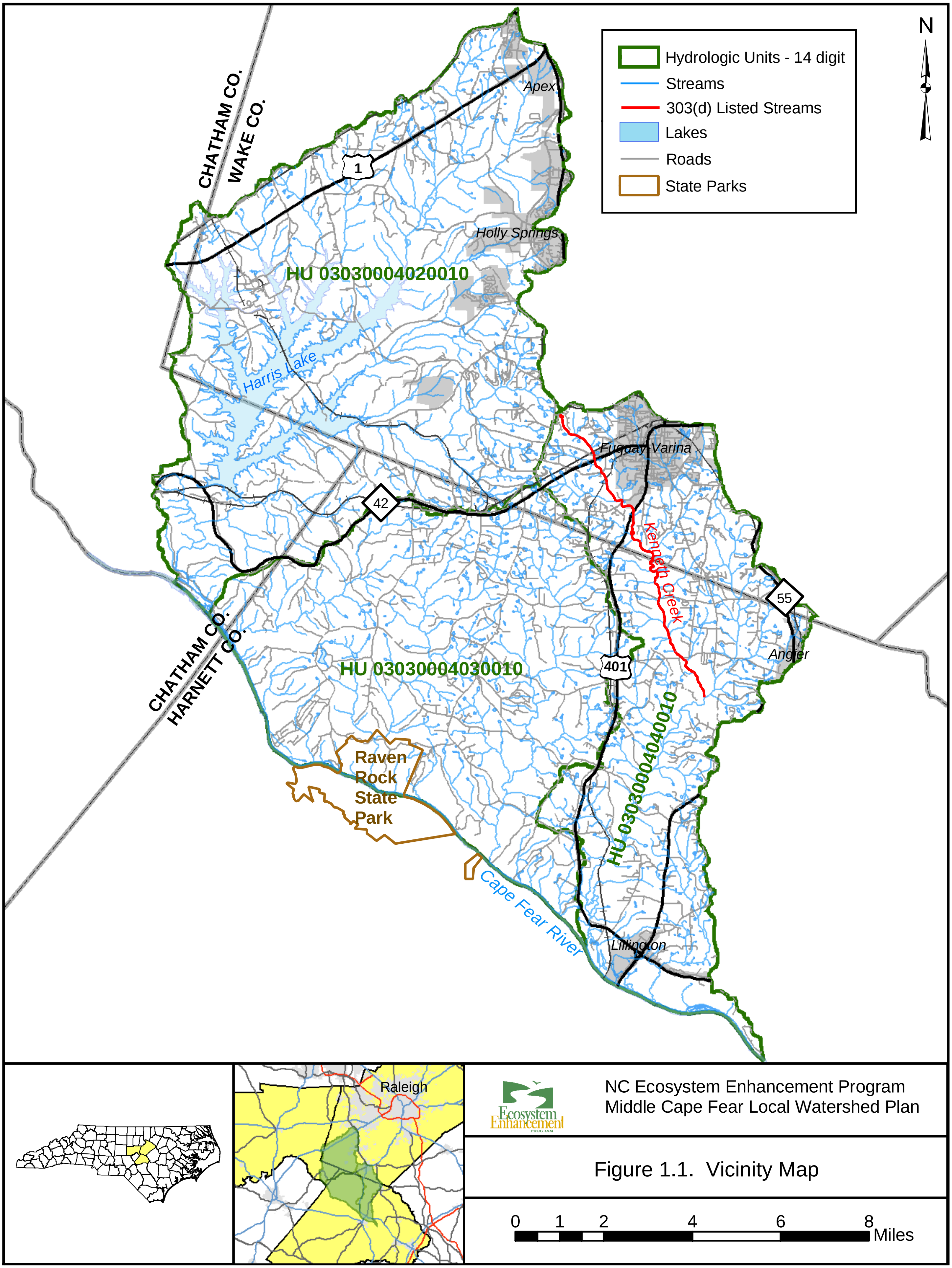

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Figure 1.1. Vicinity Map

2 Management Opportunities

Five management opportunity categories were assessed for their ability to maintain or improve watershed function:

1) preservation,
2) stream restoration,
3) agricultural BMPs,
4) stormwater BMPs,
5) land use controls.

This section provides descriptions of each of the first four opportunity categories and discusses their potential use in the project area. Land use controls are discussed in Section 4.

2.1 Preservation

Preserving high-quality stream reaches and adjacent forest is an important part of managing aquatic resources. Preservation involves identifying areas that provide good habitat, hydrology, and water quality functions, and protecting those areas to maintain functional benefits. Preservation can be accomplished through conservation easements or property purchase. Preservation can be relatively inexpensive because it avoids design and implementation costs.

2.1.1 Field-Identified Opportunities

Field work performed in earlier phases of the project included visits to numerous stream crossings throughout the project area. Preservation opportunities were noted when field staff encountered examples of healthy stream reaches and forested riparian buffers and catchments. Sites were also sought with relatively few landowners. This minimizes transaction costs and makes it easier to achieve consensus on preservation opportunities.

Five preservation opportunities were identified in the project area. They are described in Appendix 1. All of the sites have intact riparian buffers and good aquatic habitat. They represent unique conditions in the study area.

2.1.2 GIS-Identified Preservation Opportunities

As described in Technical Memorandum 1, the Biological Resources Division of the United States Geological Survey and North Carolina State University are sponsoring a habitat gap analysis in North Carolina (GAP). The purpose of this study is to assess the extent to which native animal and plant species are being protected. 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.

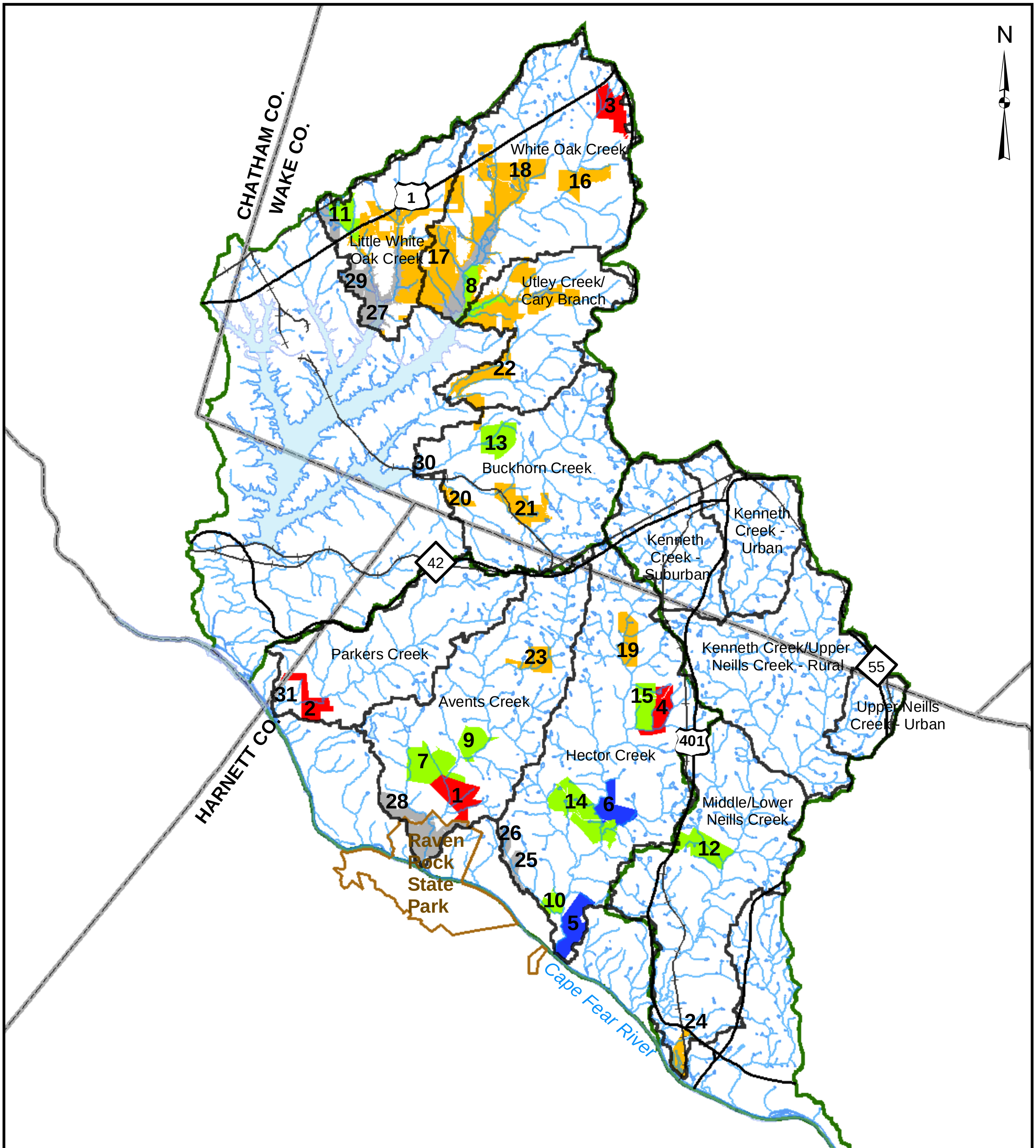
Habitat priorities for this project were determined based on consultation with the NC Wildlife Resources Commission, US Fish and Wildlife Service, NC Natural Heritage Program, and land trusts (Table 2.1). Sites are rated based on habitat quality.

Table 2.1. GAP Habitat Priorities

GAP Habitat Description	Priority Ranking	Explanation of Ranking
Agricultural Fields	Low	Common, impacted habitat
Agricultural Pasture/Hay and Natural Herbaceous	Low	Common, impacted habitat
Barren (bare rock and sand)	Low	Generally impacted habitat
Barren (quarries, strip mines, and gravel pits)	Low	Common, impacted habitat
Coastal Plain Dry to Dry-Mesic Oak Forest	Med-High	Late successional and provide high-quality habitat
Coastal Plain Fresh Water Emergent	Med-High	Water quality benefits, but very common
Coastal Plain Mixed Bottomland	Med-High	Water quality benefits, but very common
Coastal Plain Nonriverine Wet Flat Forests	Med-High	High-quality habitat for wildlife; bottomland systems provide water quality benefits
Coastal Plain Oak Bottomland Forest	High	Late successional and provide high-quality habitat; bottomland systems provide water quality benefits
Coniferous Cultivated Plantation	Low	Common, impacted habitat
Coniferous Regeneration	Low	Common, impacted habitat
Cypress-Gum Floodplain Forest	High	Late successional and provide high-quality habitat; bottomland systems provide water quality benefits
Dry Mesic Oak Pine Forests	Medium	Oak forests are late successional and provide high-quality habitat
Floodplain Wet Shrublands	Med-High	Good water quality benefits, but very common habitat
Mesic Longleaf Pine	High	Unique habitat
Peatland Atlantic White Cedar	High	Extremely unique habitat
Piedmont Deciduous Mesic Forest	Med-High	Good habitat benefits, but very common
Piedmont Dry-Mesic Oak and Hardwood Forests	Med-High	Late successional and provide high-quality habitat
Piedmont Dry-Mesic Pine Forests	Medium	Good wildlife benefits, but very common habitat
Piedmont Emergent Vegetation	Medium	Water quality benefits, but very common habitat
Piedmont Mixed Bottomland Forests	Med-High	Water quality benefits, but very common habitat
Piedmont Mixed Successional Forests	Low	Common, impacted habitat
Piedmont Oak Bottomland and Swamp Forests	High	Late successional and provide high-quality habitat; bottomland systems provide water quality benefits

GAP Habitat Description	Priority Ranking	Explanation of Ranking
Piedmont Submerged Aquatic Vegetation	Medium	Some water quality benefits, but usually backwaters of a lake (e.g., Harris Lake)
Piedmont Xeric Pine Forests	Low	Common, impacted habitat (assume plantation)
Piedmont Xeric Woodlands	Medium	Common, but may be later successional
Pocosin Woodlands and Shrubland	High	High because of uniqueness
Pond Cypress - Gum Swamps, Savannas, and Lakeshores	High	Late successional and provide high-quality habitat; bottomland systems provide water quality benefits
Residential Urban	Low	Common, impacted habitat
Riverbank Shrublands	Med-High	Provide stability for stream systems
Seepage and Streamhead Swamp	High	Can encompass high-quality and rare habitats
Urban High-Intensity Developed and Transportation Corridor	Low	Common, impacted habitat
Urban Low-Density Developed	Low	Common, impacted habitat
Xeric Longleaf Pine	High	Unique habitat
Xeric Pine-Hardwood Woodlands and Forests	Medium	Good habitat benefits, but very common

GAP data were used to locate potential preservation opportunities that were not identified during field surveys. These sites are typically located away from road crossings or in upland areas, and were not observed during field visits. To perform the analysis, the locations of all high and medium-high quality habitat in the study area were combined with parcel data. Parcels with areas less than 200 acres were then removed from the resultant dataset in order to limit the search to larger parcels. In most cases, only a fraction of the acreage of the parcel contained high or medium-high quality habitat. Therefore, the acreage of high and medium-high quality habitat within the parcels was summed and the percent high and medium-high quality habitat determined (Figure 2.1). Potential preservation sites are prioritized based on the percent high and medium-high quality habitat from Table 2.2.



Functional Assessment Units

Percent of Parcel with High/Medium-High Quality Habitat

- < 10%
- 10% - 20%
- 20% - 30%
- 30% - 40%
- > 40%

7 Priority Rank

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Figure 2.1. Parcels > 200 Acres with High and Medium-High Priority Habitat

0 1 2 4 6 8 Miles

Table 2.2. Potential Preservation: Percent High-Quality & Med-High Habitat

Rank	PIN	% High & Med-High Quality Habitat
1	0623-95-8251.000	60%
2	0614-35-8422.000	47%
3	0741606782	45%
4	0654-24-3186.000	41%
5	0642-21-5585.000	36%
6	0643-64-8175.000	31%
7	0623-68-8650.000	26%
8	0628955306	25%
9	0634-11-8109.000	25%
10	0632-92-5540.000	23%
11	0619788444	23%
12	0652-69-7689.000	23%
13	0637454017	22%
14	0643-32-5147.000	21%
15	0654-04-5846.000	21%
16	0740431039	19%
17	0730408350	18%
18	0730634462	17%
19	0645-82-8633.000	16%
20	0626777815	15%
21	0636862311	15%
22	0638575457	15%
23	0635-90-1255.000	14%
24	0650-56-4463.000	12%
25	0632-56-8360.000	10%
26	0632-48-3572.000	8%
27	0618420089	7%
28	0613-82-9215.000	6%
29	0619147086	5%
30	0627123577	4%
31	0604-86-0726.000	3%

2.2 Stream Restoration

Human activity has significantly altered the natural structure and functions of streams throughout the study area. Agricultural practices over the past decades have resulted in the straightening, dredging, and relocation of streams. Removal of vegetation from stream banks has left stream channels without the protection of densely rooted soil and limited shade for aquatic habitats. Road construction and development have also resulted in stream channelization and buffer disturbance. Further, the majority of study area streams now exhibit flashier hydrology than the streams in their natural condition. Such streams typically experience higher flood flows and experience more severe reductions in flow during droughts than unimpacted streams.

Many of these changes to the watershed and streams have negatively impacted the study area. Unstable stream banks and eroding stream beds have led to excessive sedimentation and the loss of aquatic habitat. Bedform diversity has been reduced in many reaches and water quality has likely been impacted by the loss of riffles (e.g., reduced oxygenation). Also, many streams are now incised and rarely access their floodplains.

Stream restoration attempts to address the loss of stream and floodplain functions by constructing and promoting the maintenance of stable streams. Stable streams are configured so that their width and depth (dimension), slope (profile), and meander pattern through the valley allow the stream to carry its flow and sediment without aggrading or degrading over time. Measurements of stable dimension, pattern, and profile are determined by locating and surveying stable streams that exhibit natural fluvial processes. By restoring stable dimension, pattern, and profile, a stream can be returned to an equilibrium state where balanced erosive and aggrading processes maintain stream form and habitat over time.

Stream restoration does not necessarily return a stream to its pre-disturbance condition; rather, it creates a dimension, pattern, and profile that will be stable and maximize functions given the constraints of existing land use and infrastructure. However, streams are generally restored to a configuration that resembles its natural condition as nearly as possible.

Stream restoration is particularly effective at reducing sediment pollution and subsequent habitat loss. In the North Carolina Piedmont, erosion rates on unprotected and unstable stream channels have ranged as high as 5 to 10 tons per year per linear foot (Jessup, 2004). Erosion at this rate can damage floodplains, property, and structures along the eroding reach and impair aquatic functions for miles downstream (Waters, 1995).

Buck Engineering identified nine significant restoration sites within the project area. They are described in Appendix 2. Each of these sites represents an opportunity to stabilize shifting stream banks, control hundreds of tons of sediment pollution per year, reestablish and enhance acres of riparian habitat and wetlands, and restore natural aquatic habitat. By providing these diverse and enduring environmental benefits, stream restoration projects like the ones suggested can become key elements in efforts to protect streams. A well-planned and constructed stream restoration project can complement other water resource projects and achieve far-ranging improvements in watershed health.

2.3 Agricultural BMPs

In this report, agricultural best management practices (BMPs) refer to measures that address both traditional agriculture (i.e., farming) as well as forestry. These practices are designed to maintain more natural interaction between agricultural operations and water resources. For example, farming BMPs include prevention of soil erosion by use of contour tillage and minimization of nutrient loss through fertilizer application education or filter strips. Forestry BMPs are operational techniques used to protect water quality during timber harvesting, such as riparian management zones, and methods to protect waterways and non-target vegetation from contact with pesticides and fertilizer.

Inadequate agricultural and forestry practices were noted during field visits to the project area. Based on these observations, six BMP opportunities were identified. They are described in Appendix 3. The opportunities address impacts from timber clear cutting, fertilizer application, and livestock access to stream channels. Implementation of these management recommendations will improve watershed functions, particularly habitat and water quality functions. Hydrologic function is typically less impacted by agriculture as this land use still allows water to infiltrate the soil profile.

2.4 Stormwater BMPs

When pervious land cover is replaced with pavement or rooftops, stormwater runoff increases in volume and velocity through the stream network. If left unabated, stormwater runoff can adversely impact aquatic resources by delivering increased contaminant concentrations and by changing the timing, volume, and location of stormwater discharges. Pollutants that have been associated with stormwater runoff include oils, semi-volatile organics, antifreeze, tars, soaps, fertilizers, pesticides, solvents, salts and metals (Bales et al., 1999; Burton and Pitt, 2001; Davis et al., 2001). The hydrologic impacts from unabated stormwater runoff include erosion from downcutting or widening; subsequent impairment of a stream's ability to access its floodplain; and habitat degradation that results when increased peak flows wash away microhabitat (e.g., sticks, leaf packs, and other woody debris).

Stormwater impacts may be minimized with the installation of structural BMPs, including stormwater ponds or wetlands, bioretention areas, sand filters, or grassy swales. Detailed descriptions of each of these practices may be obtained from Hunt and Lucas (2003). Specific BMP selection depends on the size of the catchment area, the percent of impervious cover in the catchment area, and amount of land available for BMP implementation.

It should be noted that many BMPs may need to be implemented to observe measurable improvements in watershed function. When several BMP options are available, implementation should begin in areas with the greatest potential for improved function and additional steps installed to the extent feasible.

2.4.1 Retrofit BMPs versus New-Construction BMPs

Stormwater BMPs may be retrofitted to treat runoff from an already developed site, or they may be incorporated into the designs for new development. BMPs for new development are typically more cost effective and easier to install than retrofit BMPs. However, as a general rule, new development BMPs should only be expected to maintain watershed function when installed in areas previously consisting of pervious land cover.

New development BMPs are especially necessary in areas where rapid and widespread development replaces forested and herbaceous/pasture land; otherwise, significant loss of watershed function should be expected. Two sectors of the project area that are expected to experience such growth in the near future are the White Oak FAU near Apex and the Middle/Lower Neills Creek FAU between Fuquay-Varina and Lillington (see Section 4.1). It is recommended that stormwater ordinances be implemented in advance of this suburban expansion to promote new development BMPs and mitigate possible loss of watershed function.

Retrofit stormwater BMPs, though expensive and challenging to install, can improve watershed function by reducing impacts from currently developed land. Since urban land has been shown to be a major source of pollution and stormwater, it is not surprising that improvements can be made by installing retrofit BMPs. Implementing stormwater BMPs can reduce contamination associated with roads, parking lots, rooftops, lawns, vegetable gardens, industrial areas, and construction sites.

2.4.2 Identified Stormwater BMPs

A feasibility study was conducted to search for suitable retrofit BMP locations. The study results do not include design specifications for the BMPs, nor, in some cases, the type of BMP. The search focused on areas that generated significant stormwater runoff and had sufficient space to treat it within urban areas along NC Highway 55 (Angier, Fuquay-Varina, Holly Springs, and Apex).

Seven retrofit stormwater BMP opportunities were identified. They are described in Appendix 4. Generally, the chosen sites would treat runoff from approximately 1- to 20-acre catchments. They include measures to address runoff from parking lots, industrial areas, and commercial lots. Stormwater wetlands or bioretention areas are probably the most appropriate BMPs for the sites.

3 Management Strategy Prioritization

This section describes the methods used to rank the identified management opportunities, considering watershed needs and expected benefits. Priority matrices (Section 3.1) were used as the primary decision criteria, but high-quality habitat (based on GAP data), modeling results, and feasibility were used to adjust ratings as necessary. This resulted in rankings within each of four management opportunity categories: preservation, stream restoration, agricultural BMPs, and stormwater BMPs.

3.1 Prioritization Matrices

Priority matrices were developed by applying a priority classification (High, Medium, or Low) to combinations of opportunity type and functional status for each of the watershed functions (habitat, hydrology, and water quality). Table 3.1 shows the matrix framework.

Table 3.1 Sample Priority Matrix Based on Assessment Rating.

Opportunity	**Priority Classification**		
	Functioning	**Functioning at Risk**	**Not Functioning**
Preservation			
Stream Restoration			
Stormwater BMPs			
Agricultural BMPs			

During development of the matrices, a high priority was placed on opportunities that would result in the greatest benefit per function level and a low priority on opportunities that would provide minimal benefit. The approach to evaluating each type of opportunity is described below.

3.1.1 Preservation

Preservation is as a practice that maintains the status quo. For this reason, higher priorities were assigned to *Functioning* systems. Since preservation alone will not improve the quality of a less functioning system, lesser priorities were assigned to systems that are *Not Functioning*.

3.1.2 Stream Restoration

Stream restoration can improve all watershed functions, in some circumstances. A *Functioning* system is not likely to require stream restoration, so a low priority was assigned. Stream restoration is most beneficial for a system that is *Functioning at Risk*. In this case, the watershed has probably not reached the level of development (i.e., percentage of impervious cover) that causes highly erosive storm flows, which can reduce the effectiveness of stream restoration measures. Consequently, when it appeared that high impervious cover caused a *Not Functioning* rating, the priority for stream restoration was reduced to medium. In fact, if the watershed is built out (i.e., once impervious cover reaches approximately 30-40%), then a low priority was applied to restoration.

3.1.3 Agricultural BMPs

Unlike stormwater, the threat from agricultural and forestry practices in the study area is diminishing because land use is rarely converted to agriculture or forestry; rather, it is most common for land cover to be converted from forestry or agriculture to developed land. To assign priority classifications, however, it was assumed that agriculture/forestry was a primary cause of habitat degradation. Consequently, the same priority classifications were assigned as for stormwater BMPs.

3.1.4 Stormwater BMPs

Degradation by stormwater increases as impervious cover increases. These impacts are probably the single greatest threat in the project watershed, as urban land use in the area increases. To assign priority classifications, it was assumed that stormwater was a primary cause of habitat degradation. Consequently, high priorities were assigned to *Not Functioning* and *Functioning at Risk* FAUs. To maintain a *Functioning* system, medium priority on stormwater BMPs were assigned.

3.2 Application of Prioritization Matrices

The prioritization matrices are shown in Tables 3.2, 3.3, and 3.4.

Table 3.2 Habitat Priority Matrix Based on Assessment Rating.

Opportunity	Priority Classification		
	Functioning	Functioning at Risk	Not Functioning
Preservation	High	Medium	Low
Stream Restoration	Low	High	Medium
Stormwater BMPs	Medium	High	High
Agricultural BMPs	Medium	High	High

Table 3.3 Hydrology Priority Matrix Based on Assessment Rating.

Opportunity	Priority Classification		
	Functioning	Functioning at Risk	Not Functioning
Preservation	High	Medium-High	Low
Stream Restoration	Low	High	Medium
Stormwater BMPs	Medium	High	High
Agricultural BMPs	Low	Medium	High

Table 3.4 Water Quality Priority Matrix Based on Assessment Rating.

Opportunity	Priority Classification		
	Functioning	Functioning at Risk	Not Functioning
Preservation	High	Medium	Low
Stream Restoration	Low	Medium	Medium
Stormwater BMPs	Medium	High	High
Agricultural BMPs	Medium	High	High

For each opportunity, Buck Engineering assigned functional ratings for the FAU where the opportunity is located. For example, a restoration opportunity is located in the Little White Oak FAU. This assessment unit had *Functioning at Risk* habitat, *Functioning* hydrology, and *Functioning at Risk* water quality functions (see Technical Memorandum 4). Therefore, according to the habitat matrix (Table 3.2), stream restoration in a *Functioning at Risk* FAU yields a priority classification of High. Using the same approach, hydrology and water quality functions result in low and medium priorities, respectively.

The individual opportunities were ranked within each of the four categories: preservation, stream restoration, agricultural BMPs, and stormwater BMPs. The ranking procedure began with comparison of the results from the prioritization matrices. Priority ratings from the three functions (habitat, hydrology, and water quality) were weighted equally. Thus, we compared the average priority rating for each opportunity. This produced a first-cut ranking within the various opportunities. It should be noted that this screening produced many opportunities with similar rankings.

3.3 Other Consideration Factors

When rankings were similar or equal, other factors such as modeling results and presence of high-quality habitat, were examined. Restoration and preservation opportunities that fell within or adjacent to unique and valuable terrestrial habitat as identified by GAP data were assigned more favorable priority rankings. For example, a restoration opportunity in the Parkers Creek FAU was originally designated as the lowest of nine restoration opportunities. However, due to its medium-high quality habitat, this opportunity was promoted over two sites in the Kenneth Creek watershed where no significant terrestrial habitat was present. In this and other cases, Buck Engineering felt that restored riparian habitat would both complement and be supported by nearby high-quality environments and, therefore present a more comprehensive, and potentially more successful, project.

Likewise, modeling results were used to adjust final opportunity priorities and resolve tie scores. In catchments where modeling predicted that land cover conditions were generally sufficient to support good water quality, preservation opportunities were promoted in the rankings. Also, where the model suggested excellent assimilative capacity for instream sediment due to active floodplain processes, the rank of BMP opportunities were reduced. This was, in effect, an acknowledgement of the ability of the stream to accommodate its current sediment load.

Finally, where conditions suggested that opportunity implementation would be problematic or likely face unusual hurdles, opportunity ranks were reduced.

Applying best professional judgment was most necessary for ranking stormwater BMPs, because all opportunities had an average priority rating of High, and none of them were located in an area with high-quality habitat. BMP feasibility and the expected benefit of implementation were used to rank the opportunities.

3.4 Results

Results are provided in the Table 3.5 and shown in Figure 3.1. The final rankings should be interpreted by local governments as a preliminary list of the most feasible and beneficial opportunities. It is important to note, however, that all of the listed opportunities are viable projects.

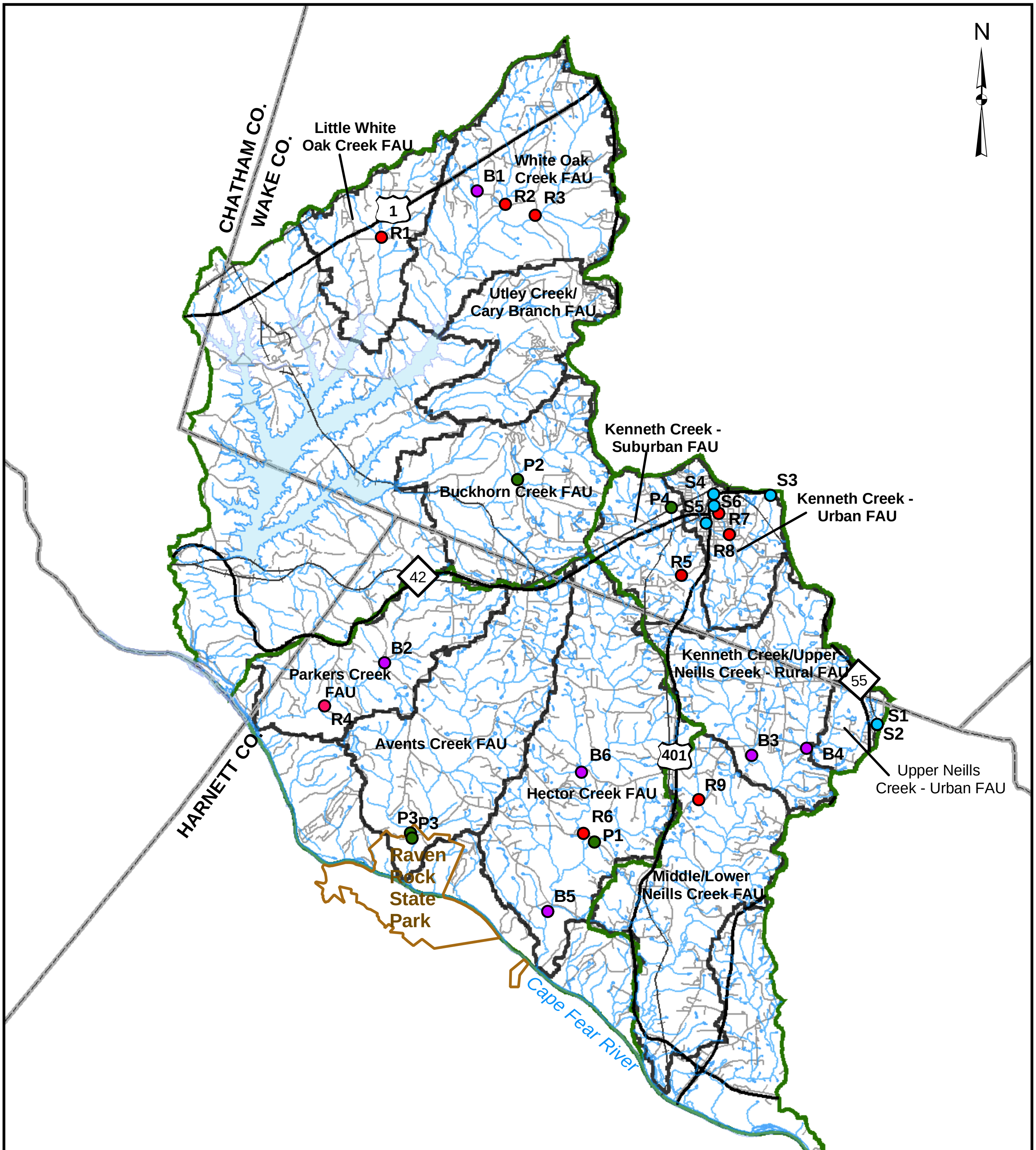
Large-scale improvements in function should not be expected by implementing a single opportunity in a FAU. More likely, a group of practices will be needed to improve function. With this in mind, local governments or other watershed stakeholders may wish to group practices to improve the chances of restoring function in a tributary or higher order stream. Further clustering of BMPs or practices in other tributaries would improve the chances of restoring function to FAUs.

In addition, it should be noted that the opportunities presented in this report were identified during the field assessment of the study area, which was limited to road crossings. The opportunities presented are not comprehensive. There are likely many other similar opportunities that could be identified if additional resources were devoted to the assessment.

Table 3.5 Opportunities to Improve/Maintain Watershed Functions.

Opportunity ID	FAU Assessment (Habitat/Hydrology/ Water Quality)*	FAU Opportunity Priorities	Initial Priority Ranking	High-quality Habitat (GAP)	Final Priority Ranking	Location
P1	F/F/FR	H/H/M	2	YES (close proximity)	**2**	Coopers Branch trib to Hector Creek
P2	FR/FR/F	M/M-H/M	4 (tie)		**3**	UT to Buckhorn Creek
P3	F/F/F	H/H/H	1	YES (Med-High)	**1**	Mill Creek and Avents Creek
P4	FR/FR/FR	M/M-H/M	4 (tie)		**5**	UT to Kenneth Creek
P5	FR/F/FR	M/H/M	3		**4**	UT to White Oak Creek
B1	FR/F/FR	M/L/H	3	YES (Med-High)	**1**	UT to White Oak Creek
B2	F/F/F	M/L/M	6	YES (close proximity)	**6**	Parkers Creek (close to R4)
B3	FR/FR/NF	H/M/H	1 (tie)	YES (High)	**3**	Kenneth Creek
B4	FR/FR/NF	H/M/H	1 (tie)		**2**	UT to Neills Creek
B5	F/F/FR	M/L/H	4 (tie)	YES (Med-High)	**5**	UT to Hector Creek
B6	F/F/FR	M/L/H	4 (tie)	YES (Med-High)	**4**	Hector Creek
R1	FR/FR/NF	H/H/M	1	YES (Med-High)	**1**	Little White Oak Creek
R2	FR/F/FR	H/L/M	3 (tie)	YES (close proximity)	**3**	Big Branch (White Oak Creek FAU)
R3	FR/F/FR	H/L/M	3 (tie)		**6**	Little Branch (White Oak Creek FAU)
R4	F/F/F	L/L/L	9	YES (Med-High)	**7**	Parkers Creek (close to B2)
R5	NF/NF/NF	M/M/M	3 (tie)		**4**	Kenneth Creek
R6	F/F/FR	L/L/M	8	YES (Med-High)	**5**	Hector Creek
R7	NF/NF/NF	L-M/L-M/M	6 (tie)		**9**	UT to Kenneth Creek
R8	NF/NF/NF	L-M/L-M/M	6 (tie)		**8**	UT to Kenneth Creek
R9	FR/FR/NF	H/H/M	2		**2**	UT to Neills Creek
S1	NF/FR/NF	H/H/H	3		**3**	UT to Neills Creek (Factory site)
S2	NF/FR/NF	H/H/H	5		**5**	UT to Neills Creek (Medical Dr. site)
S3	NF/NF/NF	H/H/H	2		**2**	UT to Kenneth Creek (CVS site)
S4	NF/NF/NF	H/H/H	6		**6**	UT to Kenneth Creek (N Fuquay-Varina)
S5	NF/NF/NF	H/H/H	1		**1**	UT to Kenneth Creek (SW Fuquay-Varina)
S6	NF/NF/NF	H/H/H	4		**4**	UT to Kenneth Creek (NE Fuquay-Varina)

* F = Functioning, FR = Functioning at Risk, NF = Not Functioning



- Preservation Sites
- Restoration Sites
- Agricultural BMP Sites
- Stormwater BMP Sites

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Figure 3.1. Opportunity Sites

0 1 2 4 6 8 Miles

4 Land Use Controls

4.1 Land Use Impacts

A survey of local governments and agencies was conducted to determine likely development patterns in the study area over the next ten to fifteen years. Results of this survey were used to produce a map and GIS data layer of possible land use patterns in the year 2020. Due to existing and planned infrastructure, it is anticipated that most new development during this period will be concentrated in portions of the watershed that support or will support major transportation corridors. Several catchments within the study area are predicted to have minor land use changes between now and 2020. The anticipated future land use data layer was used to support SWAT model runs to assess the impact of development over the next ten to fifteen years. The model was then used to determine the mitigative effects of possible moderate and aggressive planning measures to control impact of growth on the functional state of the watershed.

4.1.1 Past Land Use Trends

Long-term land use trend data are not available for the exact catchments that make up the study area. However, data derived from 1949 aerial photography in the general area suggest relatively stable land use over the past fifty years. Agricultural land use has decreased significantly as urban and suburban areas have been established, a trend seen throughout much of North Carolina. However, much of the lost of agricultural land in the watershed during the past fifty years was the result of the construction of Harris Lake (Figure 4.1). Overall, forest cover has remained relatively stable over time.

The recent history of land use patterns in the study area indicates that urban development is rapidly becoming an important feature of the landscape. While no major urban centers are located within the study area, the influence of migration to the Triangle (Raleigh, Durham, and Chapel Hill) area is evidenced in US Census data. Between the 1990 and 2000 Census periods, the three counties comprising the study area experienced a 45% growth in population. During this same period, the three largest municipalities in the study area, while still quite small, experienced population growth approaching, and in one case exceeding, 100% growth (Table 4.1). These growth rates were not due to annexation of existing areas; rather, they were primarily due to new housing (i.e., population density growth closely tracked with population growth).

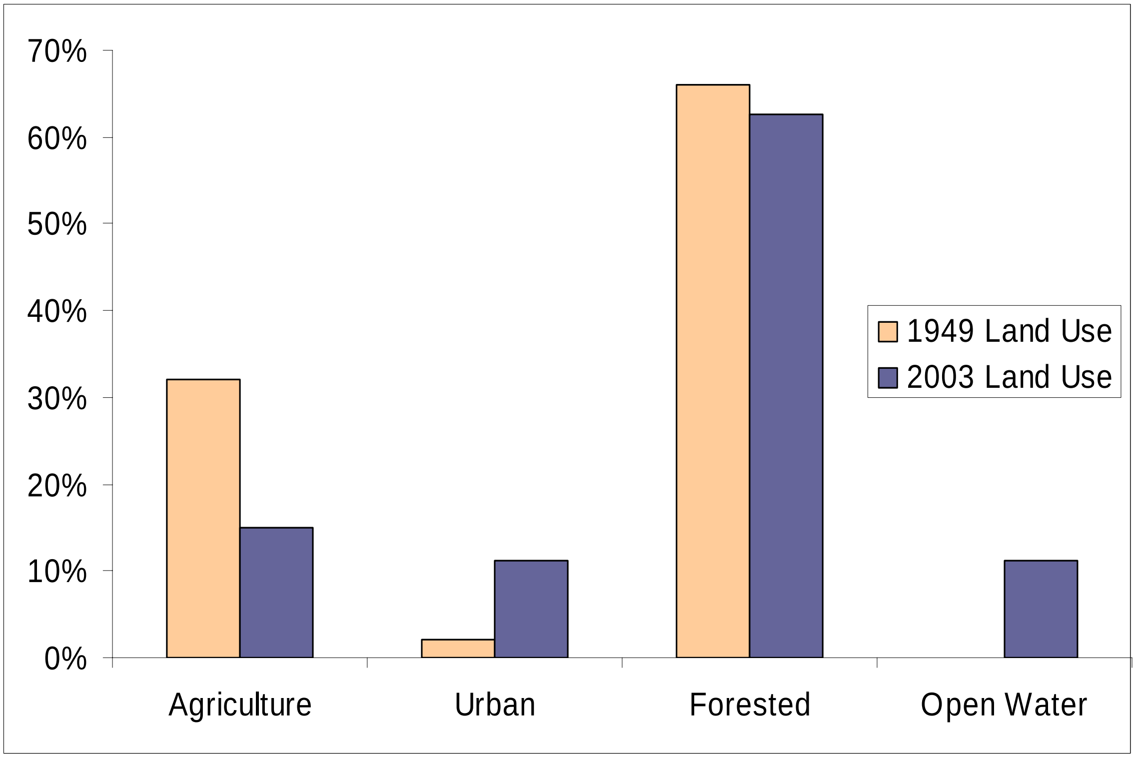


Figure 4.1 Broad Land Use Types in the Vicinity of the Study Area, 1949 and 2003.

Table 4.1. Census Data for Communities in and Surrounding the Study Area.

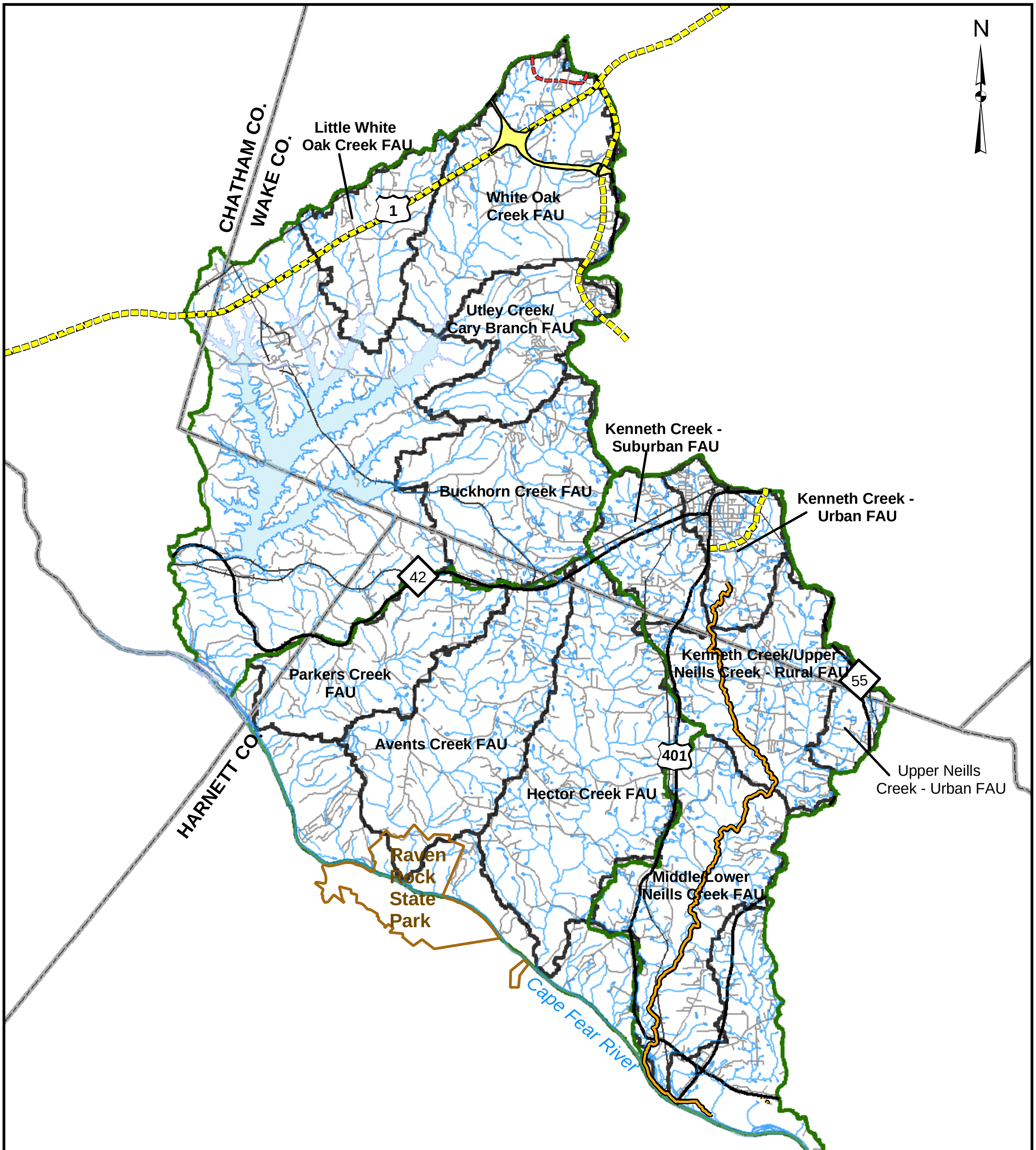
Geographic Area	1990 Population	2000 Population	% Growth	1990 Housing Units	2000 Housing Units	% Growth
Harnett County	67,822	91,025	34%	27,896	38,605	38%
Wake County	423,380	627,846	48%	177,146	258,953	46%
Chatham County	38,759	49,329	27%	16,642	21,358	28%
Town of Apex	4,968	20,212	307%	1,826	3,375	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%

4.1.2 Anticipated Future Land Use

Current land use plans from the towns of Apex, Holly Springs, Fuquay-Varina and Wake and Harnett counties were reviewed to determine likely areas for residential, commercial, and industrial growth. These plans were discussed with representatives of the local governments to further define areas where future urban growth was likely. This land use information was supplemented with plans for roads, sewer lines, and other infrastructure as provided by the NC Department of Transportation and Wake and Harnett County planning offices. Likely spurs to rapid growth are three new or planned major roads (the Apex Peakway, NC 55 bypass of Holly Springs, and the US 401 Fuquay-Varina loop), as well as a major sewer line to the future Harnett County regional wastewater treatment plant (Figure 4.2).

The infrastructure data were used to construct a GIS data layer describing anticipated land use conditions for the year 2020 (Figure 4.3). In general, widespread low and medium density urban development, along with some associated commercial development, is anticipated along the upper reaches of White Oak Creek, Little White Oak Creek, Utley Creek, Kenneth Creek, and Neills Creek. The percentage of various land use types in the study area under present conditions, as well as those anticipated in 2020, are presented in Table 4.2.

Urban development was categorized based on density of impervious surface. High density development, typical of truly urban downtown environments, was defined as areas where impervious surfaces make up more than 50% of total land area and curb densities are greater than 0.05 miles per acre. Medium density development was defined as urban areas with approximately 25% impervious surface and moderate curb density. Low density development was defined as residential areas where impervious surface area is less that 10% of total area and curbs are uncommon.



Harnett Regional WWTP Sewer Line

Western Wake Freeway (proposed)

NCDOT Roadway TIP Projects

Apex Peakway

NC Ecosystem Enhancement Program
Middle Cape Fear Local Watershed Plan

Figure 4.2. Major Infrastructure Relevant to Potential Study Area Development

0 1 2 4 6 8 Miles

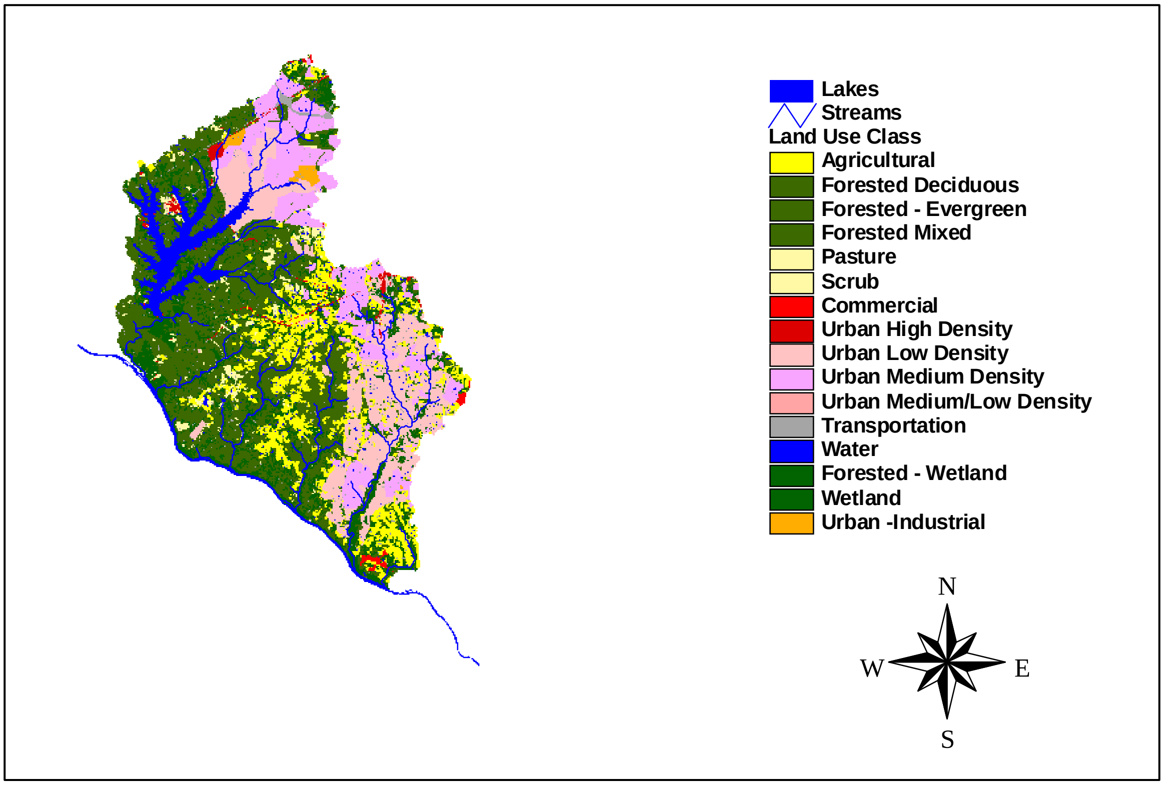


Figure 4.3 Anticipated Land Use in 2020.

Table 4.2 Existing and Anticipated Land Use of the Study Area: 2004 and 2020.

Land Use	Percent of Watershed Area		% Change
	2004	2020	
Agricultural	18.1	11.6	-6.5
Commercial	0.4	0.6	0.2
Forest-Mixed	47.9	36.2	-11.8
Industrial	0.4	0.6	0.2
Pasture	2.7	2.3	-0.4
Residential-High Density	0.8	1.0	0.2
Residential-Medium Density	2.3	11.5	9.2
Residential-Low Density	1.5	14.9	13.3
Transportation	1.4	1.7	0.3
Wetlands-Forested	18.9	14.1	-4.8
Wetlands-Mixed	0.5	0.3	-0.2

4.1.3 Likely Impacts from Anticipated Development

To determine the likely impacts from anticipated development described above, the SWAT model (see Technical Memorandum 3) was used to compare hydrologic and instream pollution conditions for existing and anticipated future land use. Model catchments were nested to report export conditions from each of the FAUs (Figure 4.4).

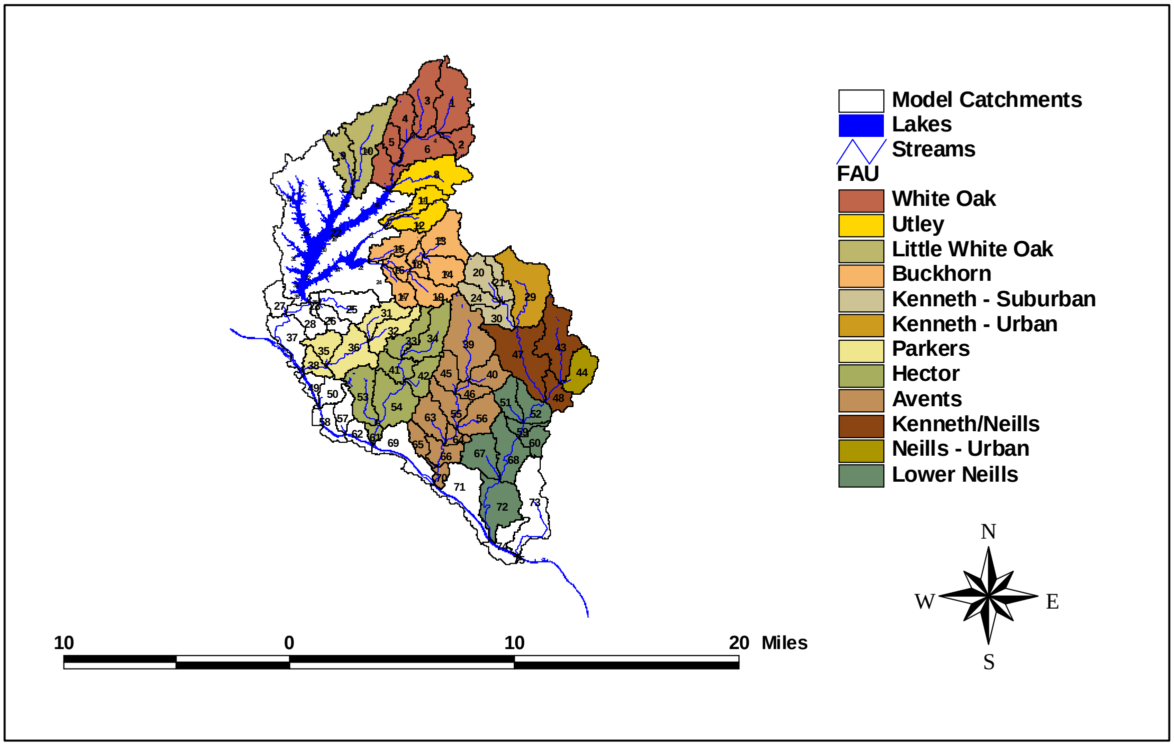


Figure 4.4 Model Catchments Nested within FAUs.

Hydrology is predicted to be significantly affected by future development. While the total discharge from the study area is unlikely to be affected, streams are predicted to become flashier, with higher peak flows and lower discharge during dry periods. In general, larger flood events in study areas streams are predicted to have peak flows 5% to 15% higher under anticipated 2020 conditions than under current lands use (Figure 4.5).

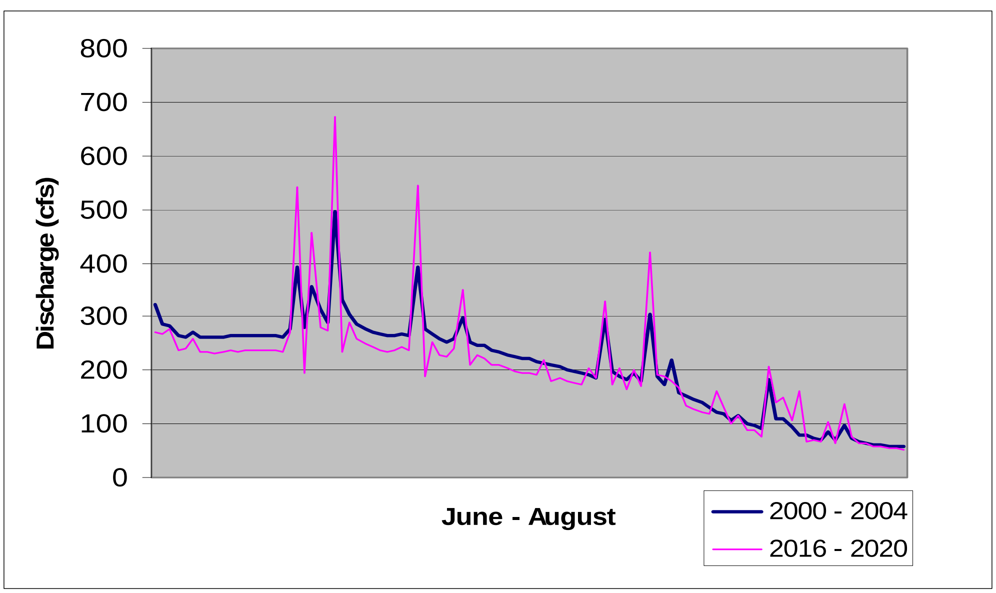


Figure 4.5 Daily Maximum Stream Discharge for the Study Area for Two Five-Year Periods.

An increase in sediment pollution is predicted to coincide with future development. To a lesser extent, nutrient pollution is also predicted to increase. Sediment yield is predicted to more than double by 2020 in the Little White Oak Creek and White Oak Creek FAUs, and there will likely also be large increases in the Kenneth Creek and Utley Creek FAUs (Table 4.3) Portions of Neills Creek area are predicted to see smaller but significant sediment yield increases under anticipated future land use conditions. Relatively large increases in nutrients, particularly phosphorus, are predicted in the Little White Oak Creek and Utley Creek FAUs (Table 4.3).

The predicted changes in pollutant yield and associated changes in instream concentrations under the anticipated development are relevant to the functional status of study area streams. Water quality and aquatic habitat in seven of the FAUs (Little White Oak Creek, White Oak Creek, Utley Creek, Middle/Lower Neills Creek, Kenneth Creek - Suburban, Upper Neills Creek and Kenneth Creek-Rural) are threatened by these large changes in pollutant loading. Harris Lake is also threatened by the predicted increase of delivered nutrients. Only the relatively undisturbed portions of the study area and the presently build out area around Kenneth Creek are unlikely to see major changes in water quality and habitat function. If development continues at its current rate, 65% of the study area will face new threats to functional qualities.

Table 4.3 Predicted Changes in Pollutant Yields by FAU, 2004 – 2020.

FAU	Sediment	Nitrogen	Phosphorus
Little White Oak Creek	105%	19%	28%
White Oak Creek	288%	20%	13%
Utley Creek	86%	15%	61%
Buckhorn Creek	-1%	-2%	4%
Parkers Creek	-4%	9%	-2%
Avents Creek	0%	-4%	-5%
Hector Creek	3%	11%	16%
Middle/Lower Neills	-8%	37%	39%
Kenneth Creek - Suburban	69%	31%	8%
Kenneth Creek - Urban	6%	6%	-4%
Upper Neills Creek - Urban	22%	17%	11%
Kenneth Creek - Rural	32%	16%	9%

4.2 Land Use Controls to Minimize Development Impacts

4.2.1 Low Impact Development

One possible solution to the impacts from new development is the implementation of low impact development (LID) design practices. LID is a suite of design practices to conserve natural systems and reduce infrastructure footprints and costs. Goals may include preserving open space, minimizing land disturbance, protecting natural features, and implementing processes that provide "green" infrastructure. LID is best suited for new suburban development. Relevant practices for the protection of functional processes within the study area include stormwater management designed to approach or achieve pre-development hydrologic conditions for the post-development period, and the preservation of riparian buffers as greenways.

LID may be implemented at different intensities and over different areas depending on need, economic feasibility, and political will. In order to evaluate the potential of LID to address functional deficits resulting from future development in the study area, two possible LID development scenarios were developed. A modest implementation of LID practices for the study area was used to represent development configurations that reduced new impervious surfaces and limited new stormwater collection systems. Under this moderate LID implementation scenario, new development would involve only 75% of the impervious surface area and only 70% of the curb length expected under standard development. Existing high value riparian buffers protected would also be protected throughout the watershed.

Aggressive implementation of LID practices would aim to protect existing hydrographs throughout the study area. Hydrographs would be maintained by the common and widespread installation of onsite infiltration devices. In addition, essentially all existing riparian buffers would be protected.

Both the moderate and aggressive LID scenarios were parameterized and used to drive SWAT model runs to determine the general potential of LID to mitigate the impacts from anticipated land use change in the study area. Results of this analysis are presented in Table 4.4.

Table 4.4 Predicted Sediment Load Reductions under LID Development Scenarios.

FAU	Standard Development	Moderate LID	Aggressive LID
Little White Oak Creek	105%	95%	28%
White Oak Creek	288%	213%	13%
Utley Creek	86%	81%	15%
Buckhorn Creek	0%	0%	0%
Parkers Creek	0%	0%	0%
Avents Creek	0%	0%	0%
Hector Creek	3%	3%	3%
Middle/Lower Neills	0%	0%	0%
Kenneth Creek - Suburban	69%	50%	8%
Kenneth Creek - Urban	6%	6%	6%
Upper Neills Creek - Urban	22%	17%	11%
Kenneth Creek - Rural	32%	16%	9%

In general, moderate LID practices, even if widespread, are not by themselves sufficient to significantly reduce the threat of future development to functional processes within the study area. However, aggressive application of LID does address the majority of impacts from future development. Given the broad range of functional conditions of the 12 FAUs, one possible solution is to consider watershed-wide implementation of moderate LID practices with aggressive LID practices prescribed in key areas.

4.2.2 Stormwater Ordinances

By implementing stormwater ordinances in advance of new development, watershed functions can be protected and expensive retrofit BMPs can be avoided. A sample ordinance can be found in the stormwater requirements of the Neuse River regulations (NCDENR, 2003). The requirements of this policy are applicable in the study area, with the possible exception of the nutrient loading cap. The Neuse River stormwater requirements include the following:

- Requirements for no net increase in the peak flow leaving the site from predevelopment conditions for the 1-year, 24-hour storm,
- Implementation of public education programs,
- Identification and removal of illegal discharges, and
- Identification of suitable sites for retrofit stormwater BMPs.

5 Conclusions and Action Items

This report identifies a number of opportunities to restore and protect watershed function throughout the middle Cape Fear local watershed plan study area. Prioritized project information sheets are included in Appendices 1 through 4.

Given the vulnerable condition of the natural resources in this area, it is vital to expedite implementation of the efforts recommended in this report. Many watershed functions are already degraded or threatened by current development, and future development is likely to continue at the same or, potentially, an accelerated pace. Failure to act will likely put municipalities and agencies in a reactive, rather than a proactive, position. This is a more costly and less effective approach to management, similar to the difference between retrofit stormwater BMPs and new development stormwater BMPs (Section 2.4). Additionally, it is more difficult to restore **non-functioning** habitat, hydrology, or water quality than it is to restore areas that are **at risk**.

Many of the opportunities presented in this report can be undertaken by the EEP, while others will need the involvement of local governments and other watershed stakeholders. Outlined below are a number of steps that can be taken to begin the process of implementing the recommendations in this report.

- EEP can capitalize on mitigation opportunities to fund stream and wetland restoration projects, and possibly stormwater and agriculture BMPs. EEP is in a good position to implement projects, having funded the development of the local watershed plan and formed relationships with watershed stakeholders. Initiating implementation can provide on-the-ground examples that contribute to community education and encourage additional restoration efforts.

- Local governments should undertake efforts to implement LID requirements. Since it will be necessary to obtain buy-in from town council members and county commissioners, meetings should be held to present the findings from the local watershed plan. If it is not possible to achieve community buy-in to implement aggressive LID practices throughout the towns and county, it may be feasible to adopt moderate LID practices with aggressive LID practices prescribed in key areas (e.g., headwaters).

- In addition to adoption of LID practices, local governments should adopt stormwater ordinances to alleviate the effects of development. The Neuse River stormwater requirements are a good example of a sample policy.

- Local governments should seek funding sources to implement additional watershed efforts. Funding sources include the US Environmental Protection Agency's Section 319 funds for nonpoint source management; the NC Clean Water Management Trust Fund; institution of a stormwater utility; and municipal bonds, as well as others. The former two measures may be more politically feasible because they provide outright grants, though a cost share is required. Inkind services and land donations could be used to provide cost share equivalents. The utility or bonds are both essentially taxes, but are guaranteed to provide funds.

- Local governments should decide how to allocate limited resources and choose which opportunities to pursue. For instance, they may want to focus on a particular type of opportunity - preservation, restoration, or BMPs. Such decisions are value judgments that may vary between different local governments. Limited resources may be spread between opportunity categories and locations (e.g., FAUs), or they may be combined for more targeted results.

- It will be important for all involved stakeholders to monitor before and after opportunity implementation. Documenting results validates the investment. It also allows adjustments to be made if the practice is not performing as expected. For example, maintenance or changes to vegetation types may be required.

- Efforts should be made to contact Progress Energy and other large landowners regarding preservation opportunities. These opportunities would ensure future watershed function in a number of areas. This practice is a much more cost-effective than funding restoration efforts after development has occurred.

6 References

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