UPPER NEUSE WATERSHED MANAGEMENT PLAN

DEVELOPED BY THE

UPPER NEUSE RIVER BASIN ASSOCIATION

PRODUCED BY

TETRA TECH, INC.
RESEARCH TRIANGLE PARK, NC

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Executive Summary

The Upper Neuse River Basin Association (UNRBA) has developed an *Upper Neuse Watershed Management Plan* (referred to hereafter as the Plan). The North Carolina General Assembly provided funding support, and policy leaders from the North Carolina Department of the Environment and Natural Resources (NCDENR), the North Carolina Environmental Management Commission, and the North Carolina Department of Transportation provided guidance toward the development of a watershed management approach. If adopted, the Plan will provide a guide for protecting the quality of public drinking water supplies, surface water quality, and aquatic habitats in the many streams and rivers within the Upper Neuse Basin. The Plan will be revisited and revised on a five-year basis to reflect new information about watershed conditions and changing management strategies.

What Is the Upper Neuse River Basin Association?

The UNRBA was formed in 1996 to provide an ongoing forum for cooperation on water quality protection and water resource planning and management within the 770-square mile watershed referred to as the Upper Neuse River Basin. The eight municipalities, six counties, and local Soil and Water Conservation Districts in the watershed voluntarily formed the Association. Each of the participating jurisdictions appoints local representatives to the UNRBA Board of Directors, which is responsible for establishing the organization's work plan and activities

The Upper Neuse River Basin is home to a diverse variety of wildlife, many important natural areas, and nine public drinking water supply reservoirs that together serve about 500,000 people. Clearly, the watershed's water resources are essential to the health, safety and vitality of the region's people, economy, and environment. The UNRBA's member governments agree that as additional growth, and associated land conversion, occur throughout the watershed, the region must take proactive efforts to assure that water resources are protected for the long-term.

What Are the Priority Issues in the Watershed?

During the watershed management planning process, local governments, partner agencies, and the UNRBA Board identified the most important water resource issues of concern in the watershed. Part 1 of this Plan identifies and ranks these issues:

- Level 1- Most Important: Protection of Public Drinking Water Resources
- Level 2- Very Important: Protection of Aquatic and Riparian Habitat, Support of Recreational Use
- Level 3- Important: Maintenance of Adequate Water Supply, Protection of Aesthetics

In developing the strategies recommended in Part 4 of the Plan, the UNRBA used these priority issues as guidance.

What Are the Current Conditions in the Watershed?

Part 1, Description of the Upper Neuse Watershed, provides a general description of the Upper Neuse River Basin, including its geographic location, the encompassed local government jurisdictions, current and projected population estimates, existing and future land uses, and existing water quality conditions. The following are general findings:

- Population: The total population of the watershed is approximately 190,000 people. Projections show that the Upper Neuse will experience almost 50 percent growth in households between 2000 and 2025 (from 79,910 to 119,855 households). Most of this growth is expected to occur in Wake County (9,195 new households) and the City of Durham (20,180 new households).
- Land Use: The Plan reports that about 61 percent of the watershed is forested, 16 percent is in agriculture, and 17 percent is suburban and urban development. About 60,040 acres of land (about 12.2 percent) in the watershed is protected open space.
- Water Quality Conditions: Although the Upper Neuse exhibits generally good water quality, several streams have poor habitat, severe bank erosion, and a high proportion of siltation. The most threatening water quality issues are aquatic habitat degradation, urban and agricultural runoff, low levels of dissolved oxygen, accelerated lake eutrophication, potential for toxic spills, and eutrophication in the Neuse Estuary. In the Neuse River Basinwide Water Quality Management Plan (North Carolina Division of Water Quality, 1998), the state reports that our collective activities are having an adverse impact in several areas of the watershed. Of the 562 stream miles evaluated in the watershed, 19.2 stream miles (3.4 percent) are "not supporting" their intended uses. Another 37.6 miles (6.7 percent) are only "partially supporting" their uses. During the period from 1993 to 1998, the combined total miles of non-supporting and partially supporting streams in the watershed increased by 42 percent.

What Key Factors Contribute to Water Resource Degradation in the Watershed?

In addition to topography, soils, climate, and other natural factors, the way we have developed, the activities we conduct on the land, and the way we have modified natural stream and river corridors affect water quality and environmental conditions within the Upper Neuse Basin. The following "stressors" result from our activities and can degrade the water resources:

- Increased levels of nutrients, algae, and total organic carbon;
- Increased erosion and sedimentation;
- Changes in the amount and rate of surface water runoff (hydro-modification);
- Increased levels of biochemical oxygen demand/decreased dissolved oxygen; and
- Increased incidences of toxins and pathogens.

The Plan recommends that watershed management efforts be targeted to address those stressors relating to the highest priority issues. Those stressors are nutrients/algae/total organic carbon; sedimentation and erosion; and hydro-modification. Using existing data, indicators have been selected for assessing the top three stressors. Impervious surface area is the indicator of hydro-

modification and potential sedimentation and erosion, while chlorophyll *a* is the indicator of nutrient levels. Chlorophyll *a* and impervious cover management targets were also chosen based on the potential of each indicator to affect water supply and recreation/habitat.

How Much Additional Growth and Development Is Expected in the Watershed?

The Planning Approach (Part 2) includes population growth and land conversion projections for three different scenarios: 1) Year 2025; 2) Buildout Low; and 3) Buildout High. These scenarios are explained below.

The first scenario involves a projection of conditions for the Year 2025. It is anticipated that by that time, the population of Upper Neuse Watershed will increase by 53 percent – to a total of about 280,000 people. There will be a corresponding 50 percent increase in the number of households (from 79,910 to 119,855 households). Most of the projected growth would be in Wake County (9,195 new households) and the City of Durham (20,180 new households). Currently, almost 400,000 acres of land (81 percent of the watershed) are undeveloped (forest and agriculture). It is projected that by 2025, about 50,000 acres (13 percent) of the remaining undeveloped land will convert to developed land, bringing the total developed land to 140,000 acres (28 percent of the watershed).

The Buildout Low and High scenarios evaluate projected conditions at an undetermined time in the future when: (a) land is developed as currently zoned and allowed under the Water Supply Watershed "low density" option regulations, and (b) land is developed as currently zoned assuming the "high density" option allowed under local Water Supply Watershed regulations. Under the buildout scenarios, new development will consume 76 percent of the remaining undeveloped land in the watershed.

How Will Projected Growth Affect Watershed Conditions?

For each of the future growth scenarios, the Plan includes an assessment of projected water resource conditions. The results are summarized in Part 3. With respect to water supply reservoir conditions, the assessment predicts:

- Existing regulations are expected to be adequate to meet drinking water targets for all lakes through 2025.
- In the longer term (at buildout), assuming current state and local regulations, the chlorophyll *a* targets are projected to be exceeded for all public drinking water supply reservoir intake areas except Falls Lake.
- Under the Buildout – High Density option, water supply targets will be significantly exceeded.

For habitat and recreational area protection, the assessment finds:

- Existing regulations are adequate to meet the chlorophyll *a* target for protecting habitat and recreation for all future scenarios analyzed in all lakes except the uppermost segment of Falls

Lake. This portion of Falls Lake is already experiencing habitat impairment and will worsen without additional management measures.

- The management threshold of 10 percent total impervious area is currently exceeded in 6 of the 32 subwatersheds. By 2025, 12 subwatersheds will exceed this threshold. Under the buildout scenarios, a range of 19 to 27 of the subwatersheds would likely exceed the threshold. Within these areas, existing regulations pertaining to impervious surfaces and stormwater runoff from developed areas are not considered adequate to protect habitat and water-based recreation objectives.

Part 3 of the Plan also addresses risks for other key stressors not assessed under the future scenarios. These stressors have the potential to cause future degradation to water resources and merit future analysis:

- **Dissolved Oxygen (DO)** – Several streams consistently exhibit DO concentrations below the state standard. The low levels are due primarily to wastewater treatment plants and agricultural practices. The DO standard can be protected with adequate wastewater treatment and agricultural best management practices.
- **Urban Stormwater Runoff** – Urban stormwater runoff is considered the source of impairment for seven of the nine Upper Neuse Watershed stream segments included on the state's 303(d) list. For these areas where impervious cover levels are already higher than the management target, additional measures are needed to require and/or encourage lower levels of imperviousness and to decrease the peak and average volume of stormwater discharged.
- **Construction Activities** – Three of the nine impaired stream segments were impaired by construction. Sedimentation and erosion control programs governing construction and logging activities need to be enhanced to reduce the risk of degradation due to sediment and runoff from land-disturbing activities. Equally important, there is a need to educate the construction industry about improved construction practices through programs such as the national Clean Water Contractor Training Program.
- **Agricultural Runoff** – Only 1 of the 13 impaired stream segments were impaired by agricultural activities. Agricultural runoff is not seen as a major future source of impairment.
- **Fecal Coliform Bacteria** – Enhanced inspection and maintenance programs will be needed for public and private sewage treatment and conveyance systems.
- **Wetlands and Riparian Areas** – It is estimated that more than 34 percent of the Upper Neuse Watershed's total "baseline" wetlands have been disturbed or destroyed. In twelve of the subwatersheds, more than 50 percent have been disturbed or destroyed. The UNRBA and NC Wetlands Restoration Program have targeted two of the more impacted watersheds, the Lake Rogers and Ellerbe Creek watersheds, for detailed watershed assessment and restoration projects.

What Are the Water Quality Goals or "Targets" for the Watershed?

The Plan proposes a non-degradation target for the nine water supply reservoirs within the watershed, using chlorophyll *a* as the primary indicator. This non-degradation target is stricter than the state's standard, which is linked to protection of aquatic habitat. However, for six of the nine

lakes, the targets are less stringent than the U.S. EPA's nutrient guidance for water supply reservoirs in the Southeastern U.S. (15 µg/l for chlorophyll *a*).

Recreation and habitat targets are linked to two key indicators: chlorophyll *a* and impervious area. Key thresholds of concern are watershed imperviousness exceeding 10 percent, and chlorophyll *a* levels greater than 25 µg/l.

What Management Strategies does the Plan Recommend?

Part 4, Proposed Management Strategies, describes an overarching strategy for managing new development. This strategy is based on four core values: 1) maintaining a "community of communities"; 2) sustaining economic success; 3) protecting greenspace and environmental quality; and 4) improving mobility. The Plan organizes the recommended management strategies into five general watershed management techniques consistent with the core values. These techniques, and the watershed management strategies, are listed below.

1. **New Development Site Management Strategies** to control the quality and amount of water running off future development sites.
    - Development ordinance revisions for density limits and/or water quality performance, riparian buffers, and low impact development design
    - Development performance review for nitrogen performance standard, phosphorous performance standard, and enhanced peak flow management
2. **Monitoring and Enforcement Strategies** to ensure proper systems performance and gauge how well the management techniques are working.
    - Long-term monitoring programs
    - Enhanced construction, site inspection, and enforcement action
    - Requirements for management and inspection of individual septic systems (for counties only)
    - Sanitary sewer overflow inspections (for cities only)
    - Inspection and maintenance program to identify and correct leaking sewer pipes and illegal connections to storm drainage systems (for cities only)
    - Inspection and cleaning of storm drainage systems (for cities only)
    - Routine inspection and maintenance of drainage channels and creeks (for cities only)
3. **Education and Citizen Stewardship** programs to increase awareness of and participation in watershed management efforts.
    - Low-impact design education
    - Adopt-a-stream programs and general watershed education
    - Agricultural and forestry best management practices (for counties only)
    - Targeted land acquisitions and conservation easements (for counties only)

4. **Management and Control of Point Sources** to upgrade existing wastewater treatment facilities and to phase out older facilities.
    - NPDES Program (Federal) Requirements (for cities only)
    - DENR Policy of upgrading regional wastewater treatment plants to advanced tertiary treatment (for cities only)
5. **Restoration Projects** to restore the natural functions and characteristics of impaired water bodies.
    - Riparian Area Restoration
    - Streambank Stabilization
    - Streambank and Wetland Restoration
    - Stormwater Retrofits

Finally, Part 4 discusses the estimated costs of implementing the Plan. The detailed cost descriptions are presented in Appendix C of the Plan.

What's Next?

Part 5, Recommended Actions and Next Steps, discusses the two phases of plan endorsement and implementation. Under Phase 1, the UNRBA Board of Directors will present the Plan for consideration by the participating member governments. Once the member local governments and partner organizations have reviewed, commented on, and endorsed the Plan, the UNRBA will make appropriate revisions. Under Phase 2, the UNRBA will prepare a detailed Implementation Plan, describing the roles and responsibilities of the partner agencies, and a timetable for action.

Why is this plan needed?

The Upper Neuse Watershed (Figure 1) includes nine public water supply reservoirs, which currently provide high-quality drinking water for an estimated 450,000 people. In addition, lakes and streams in the watershed provide important recreational opportunities and abundant fish and wildlife for the region. With some water resources currently stressed and with the watershed's population projected to increase by 100,000 in the next 25 years, protecting water quality and stream habitat will be increasingly complex, expensive, and challenging.

What will water quality be in 25 years if we have the projected level of growth while implementing existing land use regulations? Looking beyond 25 years, what will water quality be if all property owners build as allowed in local zoning and development ordinances? Will we meet water quality regulations and targets? If not, then what additional protection measures should we adopt to ensure

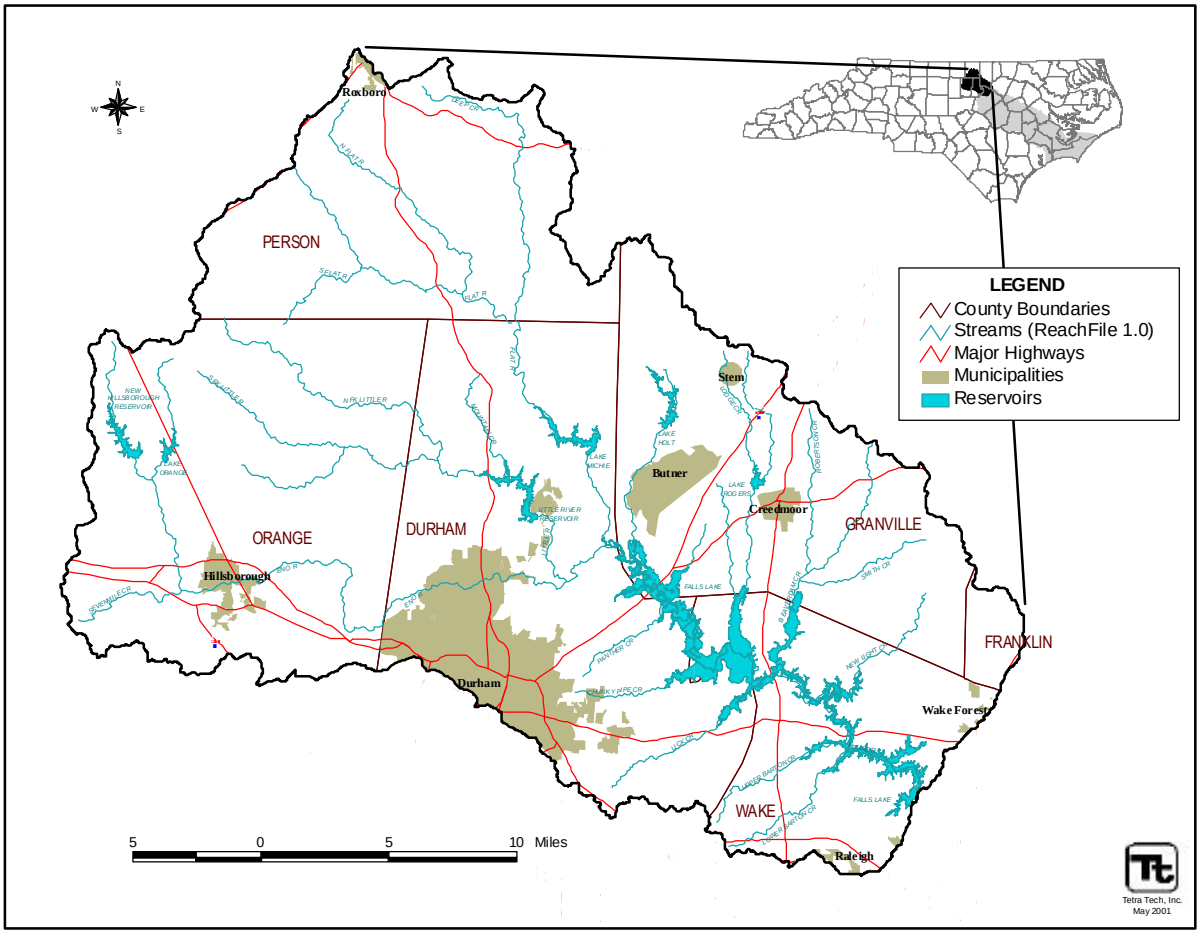


Figure 1. Location Map of Upper Neuse Watershed

that we can continue to have good quality water supplies and stream habitat? The Upper Neuse Watershed Management Plan was developed to answer these questions and to serve as a springboard for collaborative efforts among the local governments within the watershed.

How was the plan developed?

The Upper Neuse River Basin Association (voluntarily formed by the 14 local governments with land use planning and zoning jurisdiction in the 770-square mile watershed plus the Soil and Water Conservation Districts) and policy leaders from the North Carolina Department of the Environment and Natural Resources (NCDENR), the North Carolina Environmental Management Commission, and the North Carolina Department of Transportation, jointly undertook the Upper Neuse Watershed Management Plan. It was intended to initiate a formal, ongoing state-local partnership for planning in the Upper Neuse Basin as outlined in the Upper Neuse Watershed Management Approach (October, 1998).

The Upper Neuse River Basin Board of Directors, comprised of representatives from each local governing board, established a Policy Coordinating Council and Technical Advisory Committee to guide development of the management plan. The Policy Coordinating Council had representatives from the state partners as well as officers from the UNRBA Board. The Technical Advisory Committee had staff representatives from each state water quality program participating as well and local government planners and engineers. These Committees provided input at key milestones along the road to developing this plan (Figure 2).

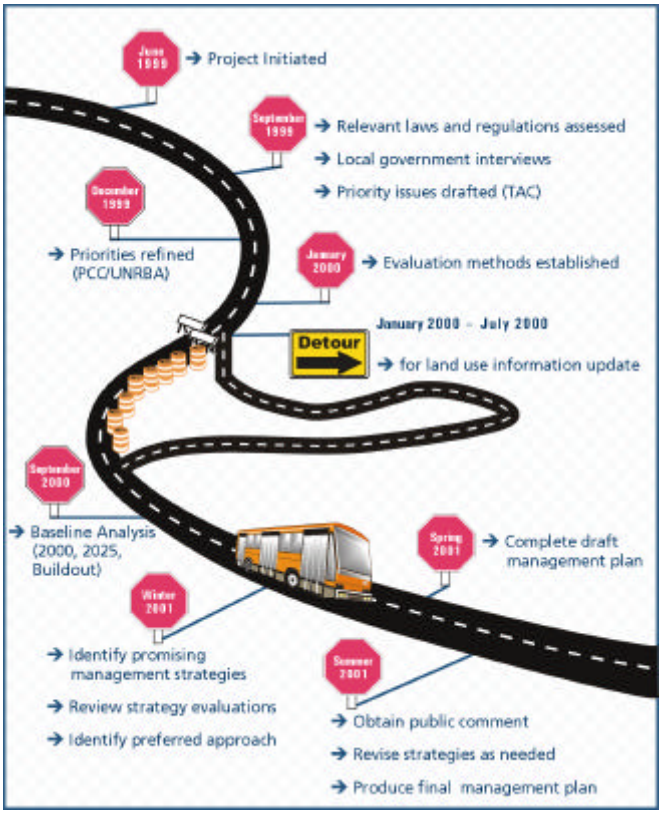


Figure 2. Road Map to Developing the Upper Neuse Watershed Management Plan

The Board contracted with Tetra Tech, Inc. (hereafter referred to as the Project Team) to provide professional consulting services to develop the plan, including:

- gathering and analyzing existing data
- identifying priority management issues
- developing water quality indicators and targets for priority issues
- developing and applying watershed modeling tools that could be used to evaluate the water quality impacts of existing regulations and different management strategies
- comparing water quality impacts of different management strategies to the water quality targets
- evaluating costs of the strategies or protection measures
- identifying the preferred approach
- preparing a watershed management plan document.

The analysis was conducted and a plan developed for each drinking water supply watershed in the Upper Neuse River Basin (Figure 3).

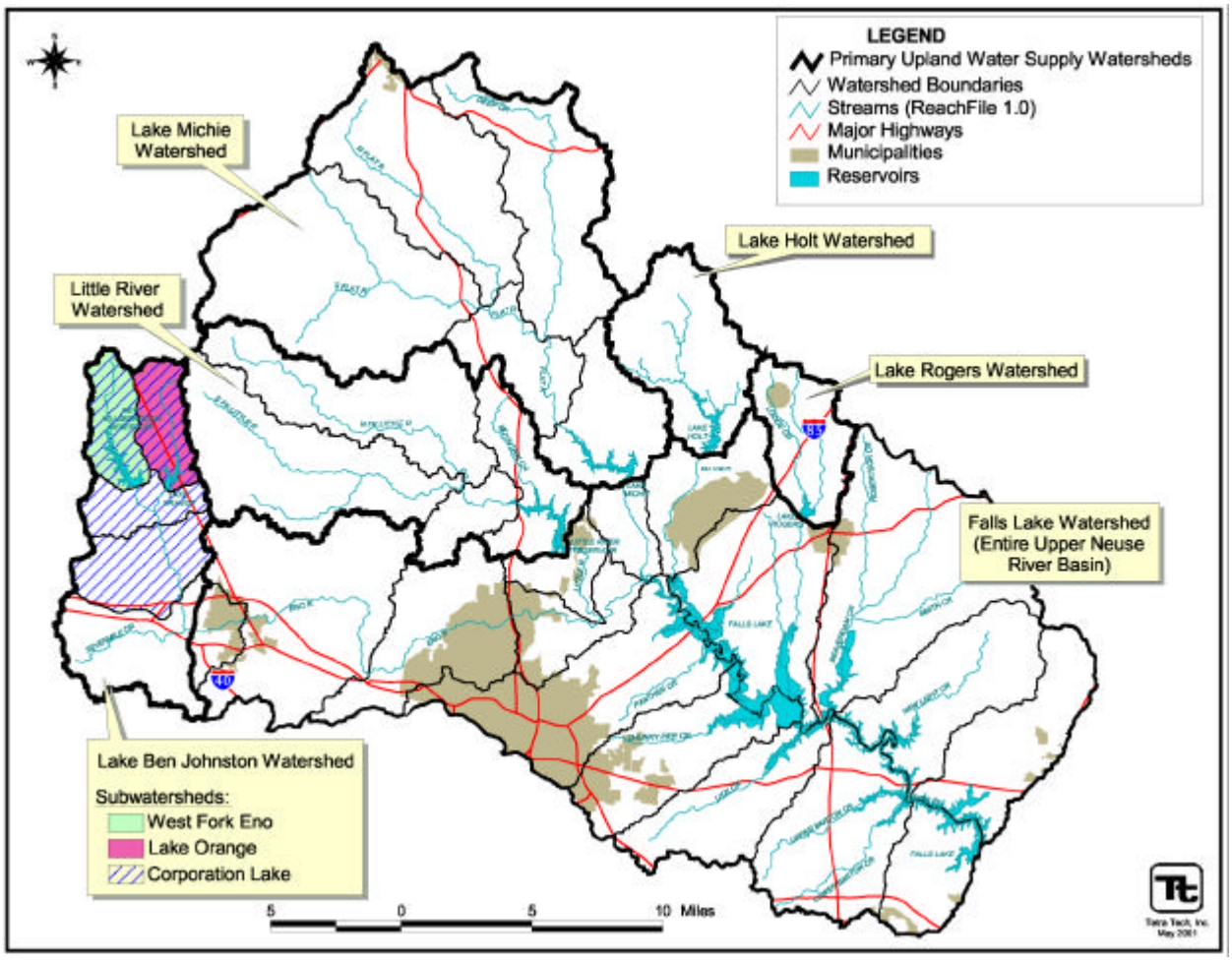


Figure 3. Upper Neuse Water Supply Watersheds

What are the benefits and challenges?

Given that local governments are already doing a lot to meet federal and state environmental requirements, why should they consider doing more? A key finding in the Upper Neuse analysis is that each local government needs to employ new and long-term water resource protection measures if it wants to meet the water quality and habitat protection targets established for the watershed by the UNRBA. But what are the benefits of adopting this plan and meeting those targets? And what are the real challenges of implementing this plan?

Benefits

Locally Driven Goals and Management Strategies

Many local environmental regulations are driven by USEPA and NCDENR requirements. For example, the state's Neuse Nutrient Sensitive Waters regulations are based on the state's goal to reduce by 30 percent the nitrogen loading to the Neuse Estuary. As another example, the state's water supply watershed protection rules are minimum statewide requirements. This plan, however, developed by representatives from each local government, is based on *local* water quality and stream habitat goals and on locally crafted management options to meet local needs.

Better Information—Better Decisions

Never before have we taken such a long-term and comprehensive view of the implications of our local watershed management strategies and efforts. This plan improves local awareness about what's needed – long-term – to be a good neighbor to other jurisdictions and to protect your own jurisdiction's local streams and lakes. Each jurisdiction now has the information regarding what it needs to do to protect local water supplies from being degraded over the long-term—this is especially important because it takes at least 15 to 20 years and millions of dollars to build a new drinking water supply reservoir. Importantly, the plan provides the basis to protect local drinking water supplies beyond the state Watershed Protection Act's minimum requirements. Better information leads to better long-term decisions.

Helping to Shape Growth Wisely

The plan supports the local and regional strategy to better shape where and how growth occurs. By having more clearly defined urban growth and conservation areas, it is consistent with the Triangle Regional Development Choices Project's four core values to serve as a basis for shaping growth:

1. **maintaining a "community of communities"** – shaping growth can enable communities to develop unique and distinctive places, preserving their character as development occurs.
2. **sustaining economic success** – shaping growth can influence both the success of economic centers and the "quality of place" important to a mobile, skilled workforce.
3. **protecting greenspace and environmental quality** – shaping growth can steer development away from sensitive natural areas such as watersheds, wetlands, and wildlife corridors, maintain the form and function of important agricultural areas and preserve land for parks and open space.
4. **improving mobility** – shaping growth can increase mobility choices by making transit or pedestrian and bicycle travel possible for more residents and can maximize the effectiveness of transportation infrastructure investments.

Coordinated Approach

This plan highlights ways that local governments can work together on watershed management programs to achieve cost savings and prevent duplication of effort. It also provides a coordinated approach to design and performance standards.

Flexibility in Managing New Development

For each **county** government, this plan offers at least two options for managing new development in the conservation areas in ways that meet water quality targets:

1. Large lot zoning /density limit of 1 unit per 3 to 5 acres and 5 percent impervious maximum (the limit depends on the characteristics of the watershed and the target) **or**
2. Nitrogen loading performance standard of 1.7 lbs/ac/yr. (surface loading) and phosphorous loading performance standard of 0.3 lbs/ac/yr. (surface loading).

Similar to the existing requirements in Orange and Durham Counties, the plan recommends a minimum 100 ft. stream buffer throughout the conservation areas, rather than the 50 ft. buffer required by the state NSW regulations.

For existing and planned **municipal (urban growth) areas**, the plan recommends use of the existing Nutrient Sensitive Waters nitrogen loading performance standard of 3.6 lbs/ac/yr. for new development. The plan also provides for a new phosphorus loading performance standard of 0.6 lbs/ac/yr. for new development. However, the plan would eliminate the requirement for a 50 ft. stream buffer in the urban areas, and instead, treat buffers as one of many best management practices that can help achieve the nitrogen and phosphorus loading targets. This provides maximum flexibility in urban site design.

Limiting the Need for Costly Restoration

By preventing degradation, actions recommended in this plan would reduce the potential number of streams that may be rated as impaired due to water quality or aquatic habitat degradation. Therefore, it reduces the potential need for Total Maximum Daily Load (TMDL) requirements and costly restoration in the future.

Targeting and Leveraging Grants

This plan provides local governments with a technical basis to support future grant requests to state and federal agencies for high priority local projects.

Launching Win-Win Solutions

Different management actions can pose different benefits and burdens of water quality protection. By outlining different management options for each local government to consider, the plan can facilitate negotiations for win-win solutions.

This document also discusses the potential cost of watershed management actions that are required for all local governments to meet existing state or federal requirements, or are recommended to meet the watershed protection objectives agreed to by the UNRBA. This provides a basis for wisely phasing and sharing in the financial burden of implementing the plan, thus maximizing cost effective management.

Challenges

Agreeing on Protection Goals

Representatives of the Upper Neuse River Basin Association established a goal of non-degradation of the region's water supplies. Since the management strategies are driven by this goal, all local governments that are members of the association will need to agree to this basic goal before considering the changes recommended. In other words, are the benefits of non-degradation listed above worth the cost?

Paying for New Costs

This plan poses new costs to local communities. The challenge before each local government is how to phase in the plan, what combination of existing or new revenue sources to use (e.g., new user fees, impact fees, utility fees, or general tax revenues), and how to coordinate efforts with other governments so that it is affordable.

Balancing Burdens and Benefits

Perhaps the greatest challenge in the plan is creating win-win solutions for the protection of the region's water supply. For example, where protection of the water supply depends on land use controls by upstream jurisdictions that do not benefit from the supply, the implementation plan may need to find ways to share the burden or find alternative solutions that shift the balance of burden and benefit while being equally protective. As noted in Chapter 4, Recommended Strategies, many of the recommended actions would be most effective, and cost effective, if administered at the regional level. Such programs pose additional opportunities for balancing benefits and burdens and creating win-win approaches.

Thinking Long-Term

Another key challenge is thinking and planning beyond a 10 or 20-year horizon; after all, uncertainty increases as the horizon expands. Why not just wait and see what really happens as existing regulations and requirements are implemented? The risks are the flip side of the benefits coin:

1. If local governments allow their drinking water supply sources—which are already eutrophic—to further degrade, there will be increased risk of taste and odor problems, operational problems, and health problems associated with disinfection by-products.

2. The prospect of building new water supplies is limited: there are few remaining feasible locations; regulations are prohibitive, time-consuming and costly to meet; and federal and state funding support has diminished. Even when successful, building new water supplies takes decades and millions of local dollars. Thus, protecting existing supplies is critical.

3. By not taking proactive measures now, substantial resources could be required to restore impaired waters in the future. Federal Total Maximum Daily Load regulations to remediate impairment will likely have a higher local price tag than proactive protection efforts and will not be driven or crafted by local governments.

4. Not acting means *missed opportunities* to coordinate with other local governments, leverage state and federal technical and funding resources, and provide more flexibility for development.

5. Finally, if we do not act soon, in the future decades we may have very little effect in wisely shaping where growth occurs.

Who should read this plan?

Because the Upper Neuse Watershed Management Plan defines existing and future problems that need to be addressed, any group that influences or is affected by water quality and habitat management and land use decisions should read this report. Counties, municipalities, and local groups in the Upper Neuse Basin should use this plan as a foundation for local action, from stream restoration projects to development ordinance changes. State and federal agencies can use this plan to enhance understanding of local watershed conditions and as a basis for coordinating basin planning, permitting, and regulatory decisions.

How is this plan organized?

This plan is written for a diverse audience and divided into five parts:

Part 1: Description of the Upper Neuse Watershed

- Location, local government jurisdictions, current and projected population
- Existing and future land use
- Existing water quality conditions
- Priority issues: watershed stressors of greatest interest, and where management efforts should be focused

Part 2: Planning Approach

- Key indicators and targets for the Upper Neuse Basin (linked to watershed stressors or issues of greatest importance)

Part 3: Baseline Assessment

- An assessment of what conditions are projected to be in 25 years and at buildout if existing state and local regulations are fully implemented

Part 4: Proposed Management Strategies

- The overarching strategy for meeting targets in the Upper Neuse Basin
- Five watershed management techniques recommended (this includes new development site management, monitoring and enforcement, education, point source controls, and stream restoration projects
- Management strategies recommended for all local governments
- Management strategies recommended for counties only
- Management strategies recommended for urban areas only
- Discussion of estimated cost of implementing the management plan

Part 5: Recommended Actions and Next Steps

Appendix A: Development Ordinance Changes Recommended for Local Governments

- Ordinance changes needed for each local government to meet targets

Appendix B: Waivers and Variances for Stream Buffers

Appendix C: Cost Estimate for Upper Neuse Management Plan

- Estimated cost for each local government (this includes estimated initial cost and estimated cost in 25 years)

Glossary

1. General Description of the Watershed

1.1 Location and Population

The Upper Neuse watershed covers 770 square miles in north-central North Carolina. The watershed includes parts of Durham, Franklin, Granville, Orange, Person, and Wake Counties and eight municipalities (Table 1). The largest urban areas are Durham, Hillsborough, and Camp Butner. The population of the watershed grew by 21 percent over the last decade (from 157,000 in 1990 to 190,000 in 2000). Approximately 40 percent of the households are in the City of Durham and 22 percent in Durham County (outside of the City's jurisdiction) (Table 2).

Over the next 25 years, the watershed is projected to grow by 53 percent (from 190,000 to approximately 280,000 people). In the longer term, the population could ultimately triple or quadruple if land is built upon as allowed in existing local zoning and development regulations (Figure 4).

Table 1. Upper Neuse River Watershed Jurisdictional Areas

Jurisdiction	Total Area within Upper Neuse River Watershed (acres)		County Area within Upper Neuse River Watershed (excluding municipal area) (acres)	
Durham County	130,898	(26.5%)	105,985	(21.5%)
Franklin County	5,327	(1.1%)	5,327	(1.1%)
Granville County	84,726	(17.2%)	78,477	(15.9%)
Orange County	125,559	(25.4%)	123,077	(24.9%)
Person County	83,089	(16.8%)	82,584	(16.7%)
Wake County	64,088	(13.0%)	63,187	(12.8%)
Creedmoor	1,358	(0.3%)	N/A	
Durham	24,913	(5.0%)	N/A	
Hillsborough	2,482	(0.5%)	N/A	
Raleigh	559	(0.1%)	N/A	
Roxboro	504	(0.1%)	N/A	
Stem	506	(0.1%)	N/A	
Wake Forest	700	(0.1%)	N/A	
Butner	4,384	(0.9%)	N/A	

Table 2. Projected Number of Households in Upper Neuse River Basin Communities

Jurisdiction	Year 2000 Number of Households		Year 2025 Number of Households	
Durham County	16,820	(21.6%)	19,330	(16.1%)
Franklin County	460	(0.6%)	1,150	(1.0%)
Granville County	3,475	(4.5%)	5,900	(4.9%)
Orange County	10,330	(13.3%)	13,850	(11.6%)
Person County	3,120	(4.0%)	4,210	(3.5%)
Wake County	8,620	(11.1%)	17,815	(14.9%)
Creedmoor	370	(0.5%)	690	(0.6%)
Durham	30,620	(39.3%)	50,800	(42.4%)
Hillsborough	2,000	(2.6%)	2,860	(2.4%)
Raleigh	1,170	(1.5%)	1,680	(1.4%)
Roxboro	200	(0.3%)	330	(0.3%)
Stem	65	(0.1%)	90	(0.1%)
Wake Forest	150	(0.2%)	450	(0.4%)
Butner	510	(0.7 %)	700	(0.6%)
Total	***79,910***	***(100%)***	***119,855***	***(100%)***

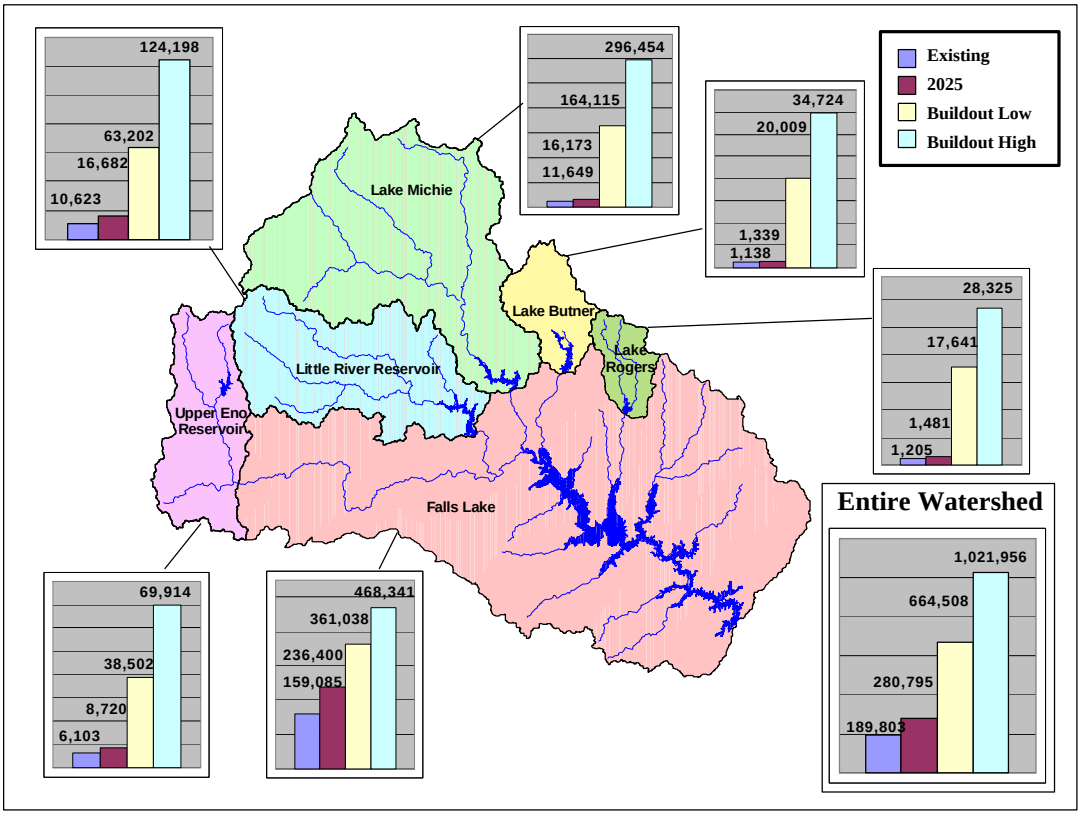


Figure 4. Existing and Projected Population in the Upper Neuse Basin

1.2 Land Use and Land Cover (Existing and Future)

Currently, 61 percent of the Upper Neuse Basin is forested and 16 percent is agricultural. Suburban and rural residential development covers 15 percent of the watershed and urban development (high density residential, commercial, and industrial areas) 2 percent (Figure 5). It has been estimated that approximately 60,040 acres—12.2 percent of the watershed—is currently protected open space.

How will the projected population and job growth change land use in the coming years? It is anticipated that with the 53 percent increase in population growth over the next 25 years, 70,000 acres of forest and agricultural land will be converted to residential and urban development (Figure 6). Under the buildout scenario, no farmland is projected to remain and the only remaining forest land will be public land, primarily the Army Corps of Engineers land around Falls Lake.

Another way to think about the change in land is undeveloped land (parks, forest, farmland) vs. developed land (subdivisions, commercial areas, etc.). As shown in Figure 7, it is projected that over the next 25 years we will lose 80 square miles of undeveloped land in the watershed, while developed land will increase by 50 percent. (The watershed's existing developed land was developed more gradually over 200+ years.) Under the projected buildout conditions, we will have lost 448 square miles, or 76 percent, of our undeveloped land.

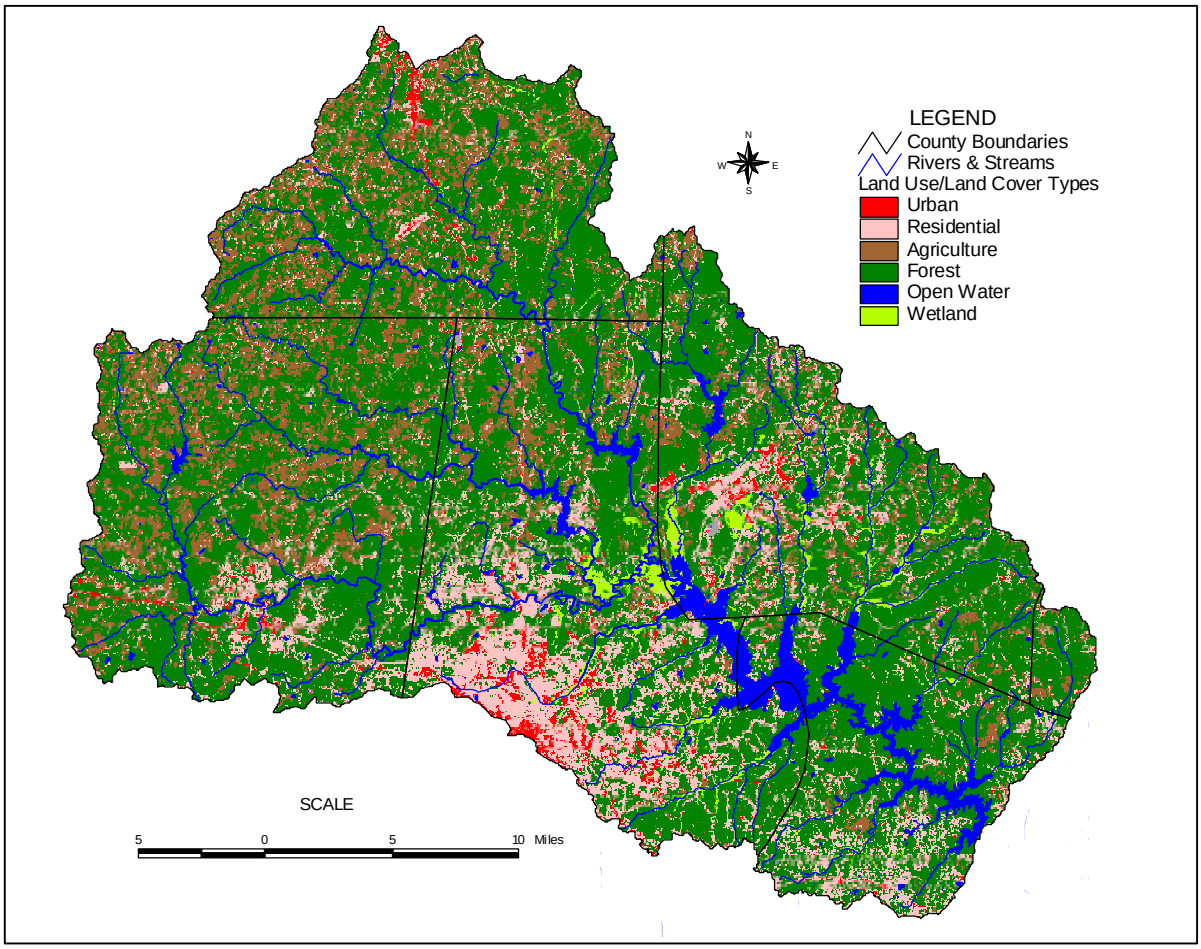


Figure 5. Upper Neuse Watershed Current Land Use / Land Cover

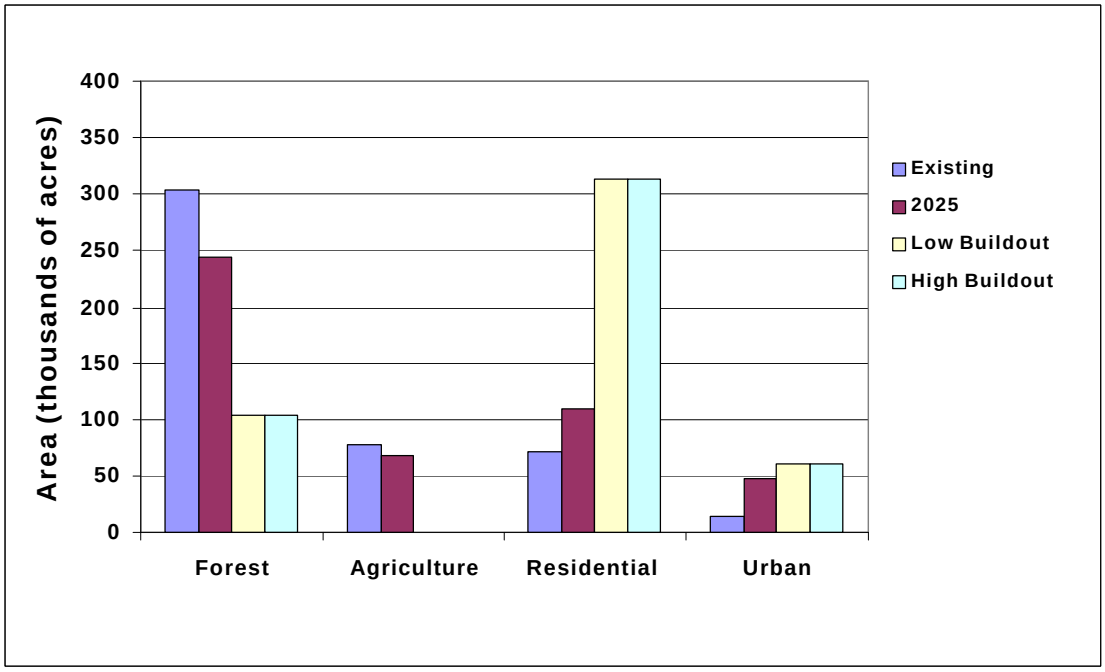


Figure 6. Upper Neuse Land Use

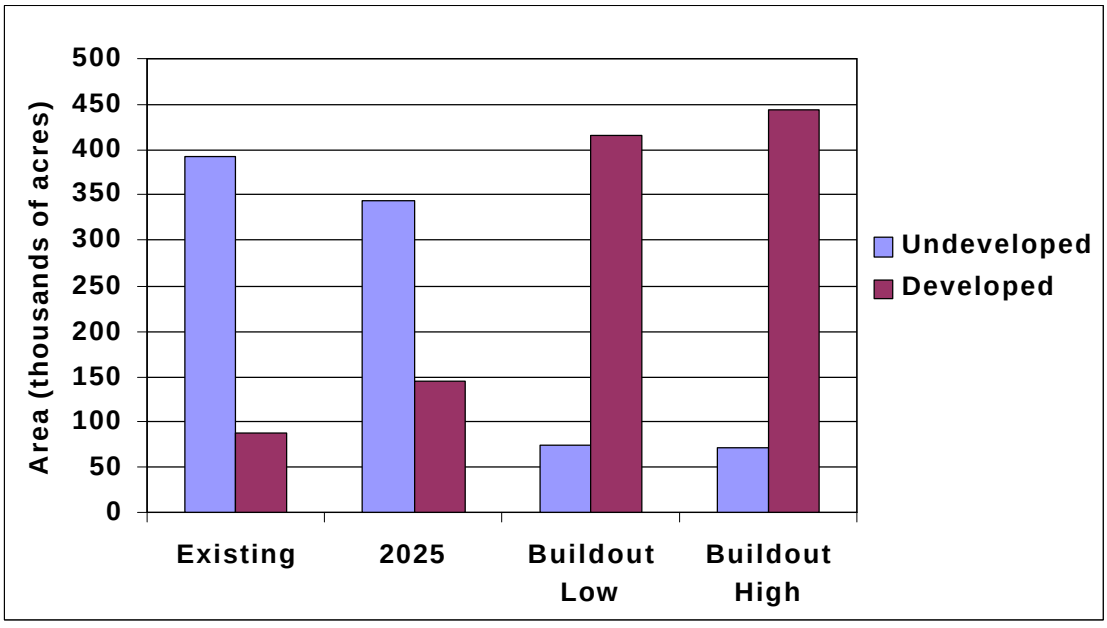


Figure 7. Upper Neuse Future Conditions Undeveloped vs. Developed

1.3 Watersheds

As shown in Figure 8 and Table 3, 32 subwatersheds are nested within the Upper Neuse's 770 square mile area, and form the headwaters of the large Neuse River Basin. These 32 watersheds (averaging 24 sq. mi.) combine to form 9 drinking water supply watersheds, with the smallest being Lake Orange (9.1 sq. mi.) and the largest being Falls Lake (which drains the entire 770 sq. mi. area).

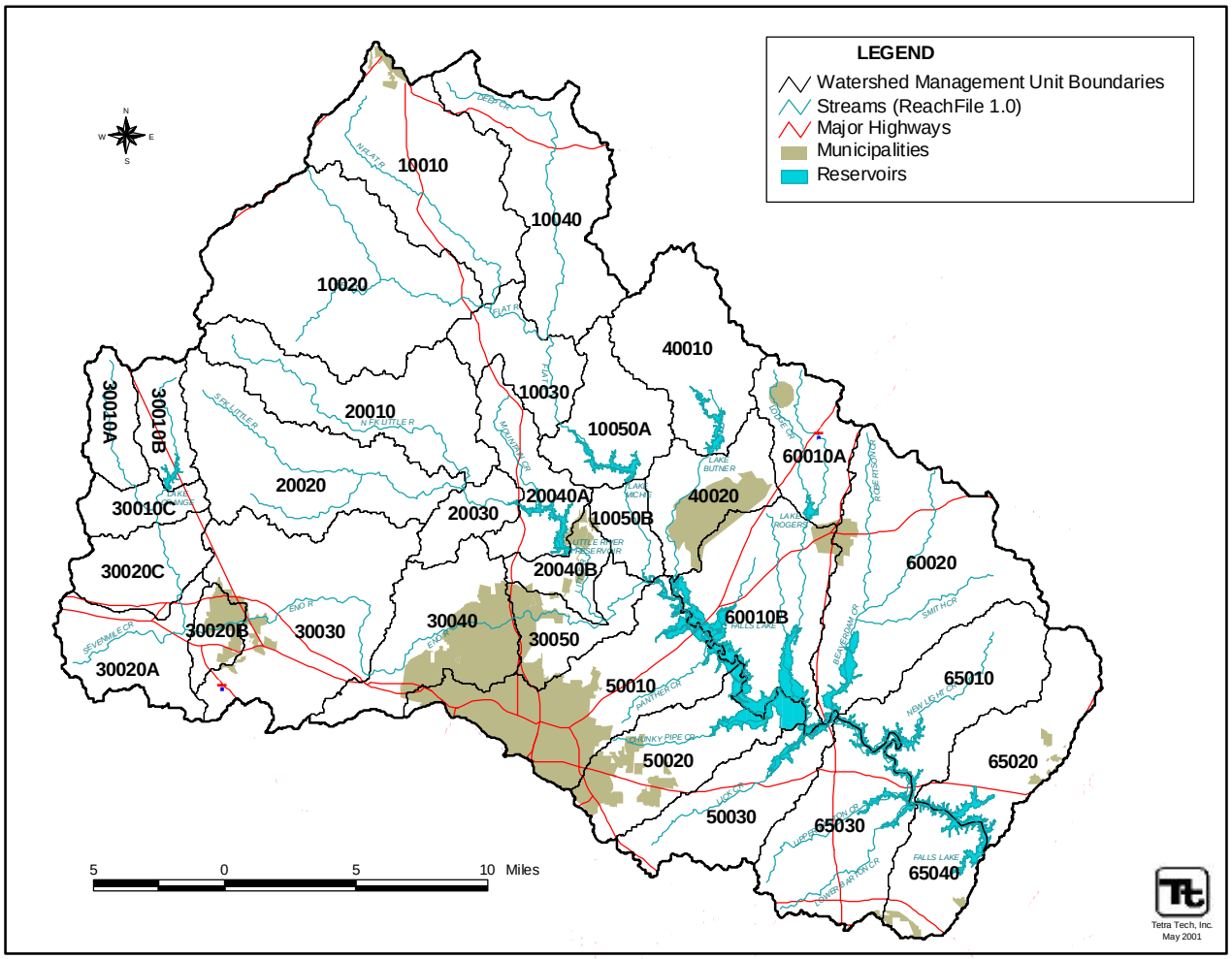


Figure 8. Upper Neuse Watershed Management Units

The project team used the small subwatershed boundaries to assess and report existing and future conditions. This more precisely reflects existing and potential future stresses to the subwatersheds, which range in size from 5 to 55 square miles. Using subwatersheds allows for a more tailored approach to management recommendations.

1.4 Scoping of Water Quality Conditions

A scoping analysis was performed to provide a snapshot of current water quality conditions and trends throughout the Upper Neuse River Basin, and to determine existing water quality problems that need to be addressed in the management plan. This analysis was based on six primary information sources: "North Carolina's 2002 303(d) List," "Draft Basinwide Assessment Report Support Document – Neuse River Basin," "Water-Quality Trends for Streams and Reservoirs in the Research Triangle Area of North Carolina, 1983-95," "Water and Bed Material Quality of Selected Streams and Reservoirs in the Research Triangle Area of North Carolina, 1988-94," the "Falls Lake Watershed Study – Final Report," and NCDWQ's benthic macroinvertebrate sampling data results for the year 2000.

Table 3. Upper Neuse Watershed Management Units

	Watershed Code	Land Area		Primary Surface Waters
		Acres	Square Miles	
1	10010	25,799	40.31	North Flat River, Chappels Creek
2	10020	36,159	56.50	South Flat River, Alderidge Creek, Bushy Fork Creek
3	10030	9,681	15.13	Flat River
4	10040	23,660	36.97	Deep Creek, Rock Fork Branch
5	10050A	12,142	18.97	Lake Michie, Flat River, Dry Creek, Dial Creek
6	10050B	4,706	7.35	Flat River Below Lake Michie
7	20010	21,120	33.00	North Fork Little River, Buffalo Creek
8	20020	25,026	39.10	South Fork Little River, Forrest Creek
9	20030	5,316	8.31	South Fork Little River
10	20040A	10,539	16.47	Little River Reservoir
11	20040B	5,145	8.04	Little River Below Little River Reservoir
12	30010A	6,069	9.48	West Fork Eno River
13	30010B	5,818	9.09	East Fork Eno River, Lake Orange
14	30010C	5,235	8.18	West Fork Eno River, East Fork Eno River Below Lake Orange
15	30020A	12,020	18.78	McGowans Creek, Sevenmile Creek, Lake Ben Johnson
16	30020B	3,759	5.87	Eno River Below Lake Ben Johnston
17	30020C	9,398	14.68	Corporation Lake
18	30030	30,652	47.89	Eno River, Strouds Creek, Stoney Creek
19	30040	18,062	28.22	Eno River, Crooked Creek
20	30050	8,327	13.01	Eno River
21	40010	18,302	28.60	Lake Holt, Knap of Reeds Creek, Camp Creek
22	40020	11,490	17.95	Knap of Reeds Creek
23	50010	24,445	38.20	Ellerbee Creek, Panther Creek
24	50020	16,150	25.23	Little Lick Creek
25	50030	14,635	22.87	Lick Creek
26	60010A	11,232	17.55	Lake Rogers, Ledge Creek, Holman Creek
27	60010B	21,921	34.25	Ledge Creek Below Lake Rogers
28	60020	34,091	53.27	Beaverdam Creek, Smith Creek, Robertson Creek
29	65010	17,980	28.09	New Light Creek
30	65020	15,829	24.73	Horse Creek
31	65030	19,810	30.95	Upper Barton Creek
32	65040	9,164	14.32	Cedar Creek
	TOTAL:	**493,685**	**771.36**	
	AVERAGE:	**15,428 acres**	**24.11 mi^2**	

Current Water Quality Conditions and Trends

General Conclusions

- Water chemistry data from ambient monitoring sites showed few serious water quality problems.
- Good water quality is found in the Eno, Flat and Little River systems. Based on macroinvertebrate and fish monitoring, most sites on these rivers are rated as being Good or Excellent.
- Poor habitat, severe bank erosion, and a high proportion of sand and silt characterized all evaluated sites in the Durham urban area, the most developed area of the watershed.

Positive Trends

- Significant reductions in total phosphorus concentrations have been achieved during the period 1983 to present. This improvement has resulted from both the implementation of phosphorus removal measures at several of the region's wastewater treatment facilities and a statewide ban on the use of phosphate detergents.
- A decreasing trend in total nitrogen has been observed at the Eno River near Hillsborough, Little River near Orange Factory, Little River Reservoir and Lake Michie. Total nitrogen concentrations at most other sites studied were stable from 1983 through 1995.
- Organic nitrogen concentrations were either stable or declining from 1983 through 1995. Decreasing organic nitrogen trends occurred at Eno River near Weaver, Knap of Reeds Creek, and Little River Reservoir.
- Nitrate concentrations at most sites were stable from 1983 through 1995. (Increasing nitrate trends were observed at the Eno River near Durham, Knap of Reeds Creek, and Falls Lake at NC Highway 98.)
- Decreasing trends in nitrate occurred at Lake Michie and Falls Lake near the dam.
- Wastewater treatment facility upgrades improve surface water quality.
  - ⇒ The results of some biological monitoring suggest that upgrades in wastewater facility operations have resulted in some corresponding improvements in water quality conditions.
  - ⇒ Comparisons of data from 1987-1991 (upon which the first Neuse River Basinwide Plan was based) with more recent data show that improvements in wastewater treatment have resulted in higher dissolved oxygen values and lower nutrient concentrations, especially in streams draining into Falls Lake.
  - ⇒ The Durham Northside Water Reclamation Facility, Butner Wastewater Treatment Plant, and Town of Hillsborough Wastewater Treatment Plant all experienced similar improvements in toxicity testing results for the period 1992-1996 as compared to the period 1988-1991.
- Nine sites in the Upper Neuse River Basin were sampled for fish in 1995. Based on this work, ecological health ratings for fish ranged from Fair in Ellerbe Creek, to Good-Excellent for the Eno River. At least four sites showed improvement in fisheries since the last evaluation.
- Benthic macroinvertebrate sampling was conducted at 23 locations in the year 2000. Eighteen of those sites were also sampled in 1995. Of those 18 sites, 7 sites showed improvement, while 4 showed some slight decline. Seventeen sites were rated as either "Good" or "Excellent" while only one site was rated as "Fair."

- Watershed nutrient loading is declining
  - ⇒ In the Falls Lake watershed, estimated nitrogen yields during the period 1989-1994 were 0.58 tons per square mile. This is nearly 50 percent less than the yield estimated for the period 1983-1986 (1.1 tons per square mile).
  - ⇒ Estimated nitrogen yields in the Little River watershed during the period 1989-1994 were nearly 30 percent less than yields for the period 1983-1986.
  - ⇒ In the Falls Lake watershed, estimated phosphorus yields during the period 1989-1994 were 0.04 tons per square mile. This is about 20 percent less than the yield estimated for the period 1983-1986 (0.05 tons per square mile).

Water Quality Issues

1. Aquatic habitat is being impacted by alterations to hydrology, stream bank erosion, and sedimentation from urban runoff and construction. Disturbance of vegetated land cover and associated increases in impervious surface areas are causing increased stormwater volume and increased water velocity that erodes soil, undercuts streambanks, and deposits the sediments instream. The changes in hydrology patterns impact stream channel physical characteristics and ecology.

   Estimated Extent: Widespread throughout the watershed. Impacts expected to increase as population grows if not managed effectively. For significant portions of the watershed, projected population and economic growth could generate 24-30 percent imperviousness in residential development and up to 70 percent imperviousness for nonresidential development. This could lead to degradation of streams currently characterized as having good or excellent water quality.

   Severity:

   A. *Regarding restoration needs*: Eight of nine stream segments listed by DWQ as impaired in 2002 were attributed to urban stormwater runoff and construction. Little Lick Creek has been targeted by NCDWQ for a TMDL (See Figure 9 and Table 4).

   B. *Regarding protection needs*: Good water quality is found in sections of the Eno, Flat, and Little River subwatersheds as evidenced by biological assessment ratings of Good or Excellent.

2. Historically, agricultural runoff has been a source of impairment to aquatic habitat, particularly in northern parts of the watershed. This source may be declining, and the NCDENR continues to monitor certain stream segments for these effects.

   Estimated Extent: Flat River is listed as impaired, partially due to agricultural runoff.

   Severity: Only the Flat River is listed as impaired by agriculture on the 2002 303(d) list. The South Flat, North Fork Little, and New Light Creek subwatersheds are not currently listed as impaired in the 2002 303(d) list. However, NCDENR will continue to monitor these streams because they were listed as impaired in 2000 (see Figure 9 and Table 4).

3. Dissolved oxygen standard violations pose a threat to aquatic life in several locations in the upper portion of the watershed.

   Estimated Extent: Historical data indicate violations in Ellerbe Creek, Flat River below Lake Michie, Knap of Reeds Creek, Little Lick Creek, and Lick Creek.

   Severity: Flat River from dam at Lake Michie to 1.6 miles downstream is targeted by DWQ for development of a management strategy. In the state's 2002 303(d) List, Little Lick, Ellerbe, Knap

of Reeds, and Lick Creek are slated for additional monitoring to determine whether a TMDL is necessary (see Figure 9).

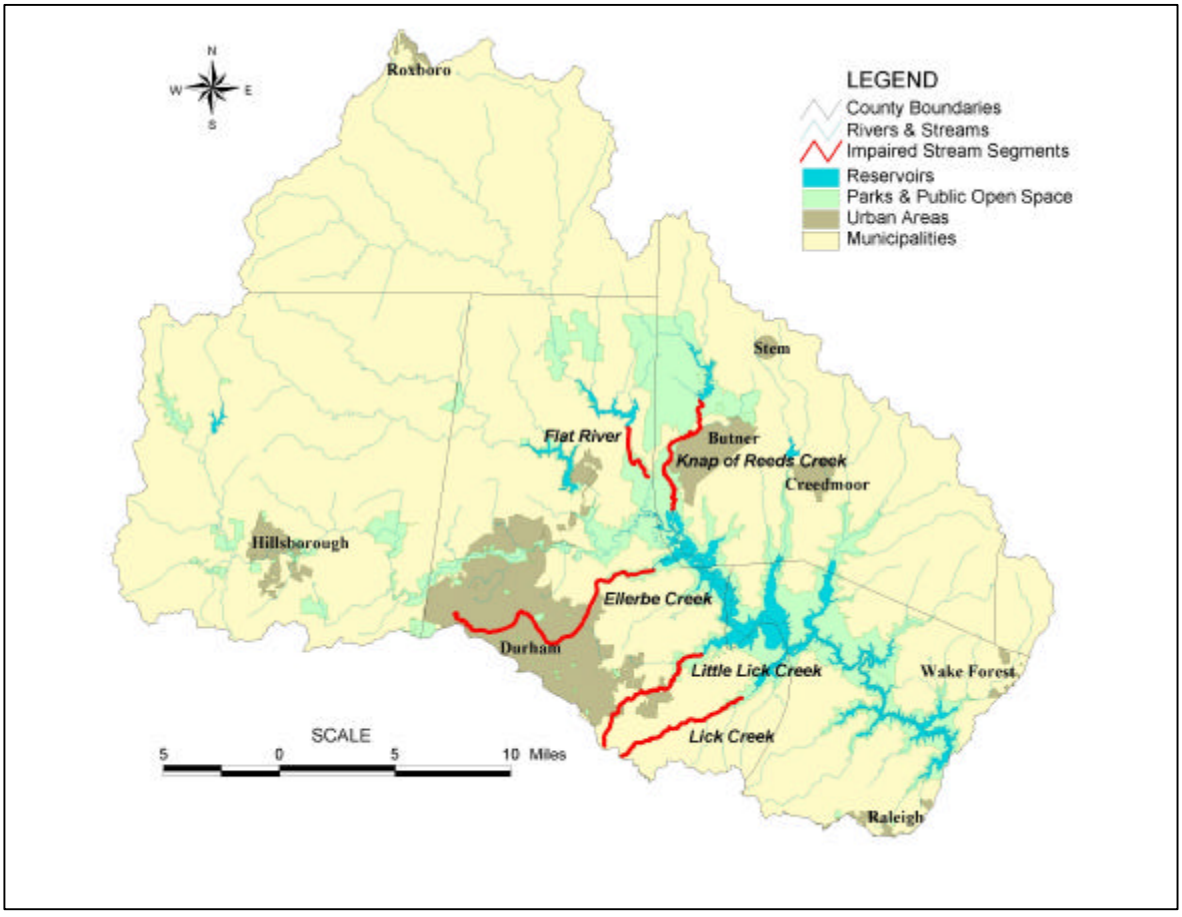


Figure 9. Location of Impaired Streams on NCDENR's 303 (d) List

4. Lake eutrophication threatens drinking water aesthetics, recreation use, and aquatic life. Potential drinking water impacts from lake eutrophication include taste and odor problems, water treatment plant difficulties due to clogging of filters, increased risk of disinfection byproducts which can be carcinogenic, and increased risk of blue-green algae blooms which can produce algal toxins. Algal blooms can limit boating and fishing in recreation areas, and deplete dissolved oxygen in the water needed to support aquatic life. Although in general, phosphorus loading appears to be going down, chlorophyll *a* concentrations appear to be rising. Sources of nutrients to our lakes include nonpoint source runoff from urban areas, agricultural use, and failing septic tanks. Falls Lake also receives contributions from municipal wastewater treatment facility discharges.

   Estimated Extent: Of the eight lakes monitored in the Upper Neuse, chlorophyll *a* is reportedly increasing in all but Lake Michie. All lakes are experiencing some level of eutrophication problems.

   Severity: Three lakes are considered mesotrophic-eutrophic (Lake Holt, Lake Michie, Lake Orange), four are considered eutrophic (Corporation Lake, Lake Ben Johnston, Little River Reservoir, and Falls Lake), and one is considered hypereutrophic (Lake Rogers).

Table 4. Impaired Waters and Sources of Impairment

Segment Description	Cause	Source of Impairment
Waters Requiring a Total Maximum Daily Load		
Little Lick Creek (1 segment) •From source to 0.4 miles upstream from SR 1811	Low Dissolved Oxygen	Construction Urban Runoff / Storm Sewers
Waters Impaired by Pollution (TMDL not appropriate)		
Flat River (1 segment) •From dam to SR 1004	Low Dissolved Oxygen	Agriculture Flow Modification
Biologically Impaired Waters – Monitoring Needed to Detect Cause		
Lick Creek (1 segment) •From source to SR 1809	Sediment	Construction Urban Runoff / Storm Sewers
Knap of Reeds (2 segments) •From Lake Holt to point 1.9 miles downstream of Granville C. SR 1120 •From point 1.9 miles below SR 1120 to Falls Lake	Monitoring Needed	Urban Runoff / Storm Sewers
Ellerbe Creek (3 segments) •From source to I-85 bridge •From I-85 bridge to a point .2 miles upstream of Durham C. SR 1636 •From point .2 miles upstream SR 1636 to Falls Lake	Monitoring Needed	Urban Runoff / Storm Sewers Minor Non-municipal Discharge
Little Lick Creek (1 segment)	Monitoring Needed	Construction

Source: North Carolina's 2002 303(d) List, NCDENR DWQ, March 31, 2003.

5. The potential for episodic spills of hazardous/toxic materials poses a threat to drinking water quality.

   Estimated Extent: Numerous road and rail crossings of streams and lakes exist in the watershed upstream of water supply intakes.

   Severity: Potential threat to human health and/or disruption of water supply during episodes.

6. Eutrophication in the Neuse Estuary, located a considerable distance downstream of the Upper Neuse watershed, is impairing aquatic life and recreational and commercial uses in the estuary.

   Estimated Extent: Numerous episodic events involving algae blooms, fish kills, and low dissolved oxygen have been documented by government agencies and academic researchers. DWQ has attributed the problem to nutrient loading from the entire Neuse Basin including the Upper Neuse watershed. However, nutrient loading from the watershed is only a small part of the total load to the estuary.

   Severity: DWQ has adopted a TMDL for total nitrogen delivered to the Neuse River estuary, targeting 30 percent reductions from point and nonpoint sources from 1991-1995 baseline loads. Preliminary results from recent modeling efforts indicate that the nitrogen load reduction may need to be increased, perhaps to 40 to 45 percent from the baseline load.

Water Quantity Issues

1. Recurring drought conditions, inadequate infrastructure, regulatory requirements regarding interbasin transfer, and increasing water demands pose a challenge to ensuring adequate water supply in some portions of the basin.

   Estimated Extent: Distribution system upgrades are needed in Butner and Creedmoor. Granville County is looking to Butner for a regional water supply to meet future demands in the area; however, Butner does not think it has the capacity to assume that role. Wake Forest is concerned that regulatory delays in obtaining approval for interbasin transfer are an obstacle to meeting future water supply demands. Durham and Hillsborough both plan to increase the capacity of their raw water supplies within the watershed, but the cost for such expansions are significant. The NC Division of Water Resources (NCDWR) and local governments throughout the region have begun implementing conservation and drought management techniques.

1.5 Priority Water Resource Issues

After reviewing available water quality data, the Project Team interviewed local government representatives (planning and engineering staff, managers, and elected officials) from each jurisdiction in the Upper Neuse Basin to determine what was viewed as the most important water resource issues they face.

The review of available information and interviews with local governments generated a draft issues list. North Carolina State University then assisted the UNRBA Technical Advisory Committee in a formal prioritization process. The Technical Advisory Committee developed a hierarchic structure that described and organized the watershed management decision-making problem in a complete, logical way, including the interrelationships between issues. First, the hierarchy outlined water resource issues from the draft issues list. Then it identified the stressors affecting the issues, and the main criteria the Committee thought were important in prioritizing the issues. The Committee then assigned weights to each element to show the relative importance of each element in the decision-making process. Figure 10 shows the Decision Hierarchy used for Prioritizing Water Resource Issues in the Upper Neuse River Basin.

A key question in the prioritization process was, "Are there adequate, existing local or state programs in place to address this issue? And where are there management gaps or areas that need to be strengthened?" Based on the information about existing and potential threats and existing management efforts, the UNRBA Board, Policy Coordinating Council, and the Technical Advisory Committee reached consensus on the top management priorities and the level of effort to spend in addressing different water quality and habitat stressors (see Tables 5 and 6).

Table 5. Upper Neuse Management Priorities

Level 1 – Most Important	• Drinking Water Safety
Level 2 – Very Important	• Limits on Recreational Use • Threat to Aquatic and Riparian Habitat
Level 3 – Important	• Inadequate Water Supply • Threat to Aesthetics

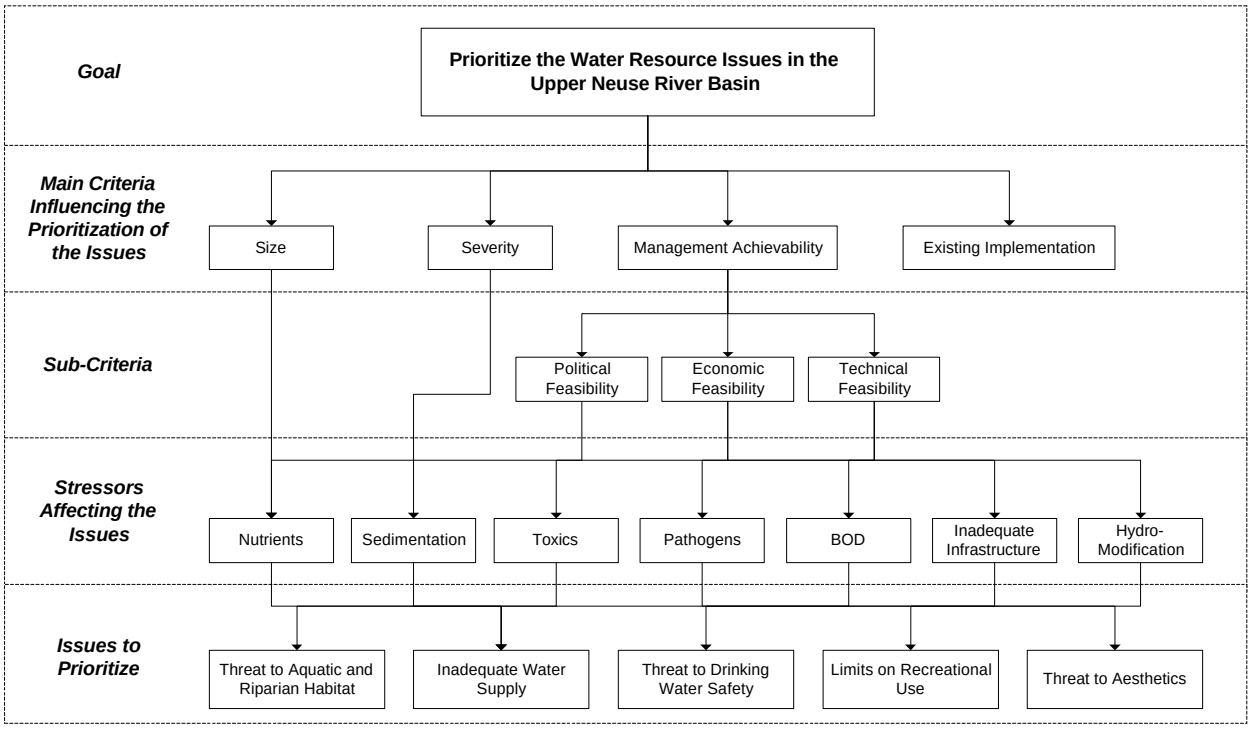


Figure 10. Decision Hierarchy

As shown in Table 5, the most important issue was drinking water safety, followed by threats to recreation (such as fishing and swimming) and stream habitat. To address these issues, the UNRBA Board of Directors instructed that the management plan place the largest level of effort in studying and developing management strategies for two issues:

1. Nutrients /Algae/Total Organic Carbon: All drinking water supply lakes in the Upper Neuse watershed are experiencing eutrophication problems. The objective of the management plan is to minimize additional problems and potential risks associated with increased levels of eutrophication. Drinking water problems can include increased taste and odor problems, water treatment plant difficulties due to clogging of filters, risk from disinfection byproducts, which can be carcinogenic, and risk of blue-green algae blooms that can produce algal toxins. Recreation and habitat problems include increased algal blooms which can limit boating and fishing in recreation areas and deplete dissolved oxygen in the water needed to support aquatic life.

2. Sedimentation and Erosion: Throughout the watershed, disturbance of vegetated land cover and associated increases in impervious surface areas are causing increased stormwater volume and increased water velocity that erodes soil, undercuts streambanks, and deposits the sediments instream. The objective of the management plan is to minimize the changes in hydrology patterns that impact stream channel physical characteristics and ecology.

The UNRBA instructed that for its initial watershed planning cycle, a moderate level of effort be spent on hydrologic modification (changing the stream channel and volume is related to issue #2 above) and inadequate infrastructure. Based on these priority issues, the key causes of impairment to address in the management plan include construction activities, agricultural runoff, urban stormwater runoff (both volume and quality), and wastewater plant/septic tank discharges.

Table 6. Management Plan Focus

Type of Stressor	Level of Effort	Priorities				
		Drinking Water Safety	Recreational Use	Aquatic & Riparian Habitat	Inadequate Water Supply	Aesthetics
Nutrients/ Algae/ TOC	Largest	4	4	4		4
Sedimentation and Erosion	Largest	4	4	4		4
Hydro-modification	Moderate		4	4		4
Inadequate Infrastructure	Moderate	4		4	4	
Toxics	Some	4		4		
Pathogens	Some	4	4			
BOD	Some			4		

2. Planning Approach

This chapter discusses the approach for developing the Upper Neuse Watershed Management Plan. It explains how the water quality and quantity objectives were assessed.

2.1 Overall Approach

The UNRBA developed its watershed management plan in three phases. The first phase primarily entailed compiling and analyzing existing data and establishing watershed management priorities and targets. The second phase of the watershed plan involved a baseline analysis. The purpose of this analysis was to predict (1) what the watershed conditions will be in the year 2020 if the local governments' existing regulations and practices remain the same, and (2) what conditions will be when the watershed builds to the capacity allowed under existing regulations (Note: Full buildout of the watershed will not occur until well after the year 2020. This plan does not attempt to predict when buildout conditions will occur, but rather it predicts the impacts of the additional development). The baseline analysis identified water bodies which would not achieve targets unless additional management measures are adopted. The third phase of the plan evaluated how different management strategies compare in meeting the UNRBA's water quality and habitat targets.

Central to evaluation of data for the watershed characterization is an understanding of the UNRBA's watershed management objectives. These objectives provide the context for answering the questions, "How do we define acceptable or unacceptable conditions in our rivers, lakes, and streams? What are important characteristics to measure that reflect things the cities and counties care about? What do we want our counties and cities to be like in 2020, particularly with respect to the natural environment? Do our current policies protect the things we want to protect?"

As described in Part 1, the UNRBA Board, TAC, and PCC adopted priority issues and related stressors to address in development of the watershed management plan (Table 7). Many of the priority issues and stressors are difficult to measure directly. Therefore, for the purposes of water quality and habitat modeling, measurable quantities or **indicators** were developed to assess the top three stressors: nutrients; sedimentation and erosion; and hydromodification (Table 7).

The TAC members developed and adopted targets (the value of the indicator that the City or County wishes to achieve) for each of the indicators discussed above (Table 8). The **water supply targets** were based on:

- TAC members' knowledge of existing water quality conditions in their water supply lakes and treatment plant operational experiences, and
- USEPA guidelines for growing season average chlorophyll *a* levels in water supply lakes in the Southeast.

Tetra Tech recommended using chlorophyll *a* as an indicator for the stressors nutrients and algae because it could be used in the linked watershed/lake models as a predictor of the potential for bloom conditions on a seasonal basis. The modeling results could then be compared to established U.S. Environmental Protection Agency (EPA) guidelines for chlorophyll *a* and current, problematic bloom conditions.

Table 7. Stressors Used in Modeling

Indicators	Stressor	Priority
Chlorophyll *a*	Nutrients / algae	Drinking water, Habitat
Impervious Area	Sedimentation and erosion	Habitat, Recreation
Impervious Area	Hydromodification	Habitat, Recreation

Table 8. Management Targets

Waterbody	Indicator(s)	Management Target[1]
Lake Butner	Chlorophyll *a*	15 µg/L[2] (2000 model average = 14.7µg/L)
Little River Reservoir	Chlorophyll *a*	15 µg/L[2] (2000 model average = 14.8 µg/L)
Lake Orange	Chlorophyll *a*	No significant increase (2000 model average = 23.0 µg/L)
New Hillsborough Lake	Chlorophyll *a*	No significant increase (2000 model average = 19.9 µg/L)
Corporation Lake	Chlorophyll *a*	No significant increase (2000 model average = 24.2 µg/L)
Lake Ben Johnston	Chlorophyll *a*	No significant increase (2000 model average = 18.8 µg/L)
Lake Michie	Nutrient Load [3]	No significant increase in existing annual load (P average = 46,790 lbs/yr; N average = 271,550 lbs/yr)
	or	
	Chlorophyll *a*	No significant increase in existing levels at intake (2000 model average = 25.2 µg/L)
Lake Rogers	Nutrient Load	Interim[4] - No significant increase in existing annual load (P average = 3,460 lbs/yr; N average = 35,480 lbs/yr)
Falls Lake		
Raleigh Intake (segment 6)	Chlorophyll *a*	15 µg/L[2] (2000 model average = 9 µg/L)
Upper Segments	Chlorophyll *a*	No significant increase in existing levels Segment #1 2000 model average = 49 µg/L Segment #2 2000 model average = 16 µg/L Segment #3 2000 model average = 16 µg/L

[1] Targets for Chlorophyll *a* represent growing season averages (May - Sept.) as predicted by the applicable lake model. The phosphorus load targets are based on estimated watershed conditions for the year 2000 using GWLF models.

[2] The U.S.EPA Office of Research and Development Athens GA Laboratory recommends 15 µg/L for chlorophyll *a* as a target for water supply intake areas in Southeastern Lakes, and a growing season average of 25 µg/L for lakewide protection of other uses. (Source: Raschke, R. Guidelines for Assessing and Predicting Eutrophication Status of Small Southeastern Piedmont Impoundments. USEPA Region IV, 1993.)

[3] Phosphorus load is recommended as the indicator under existing lake and watershed conditions. If Lake Michie is expanded in the future, or if another reservoir is constructed upstream, the assimilative capacity for phosphorus loading within the watershed would increase and chlorophyll *a* levels at the intake would become the optimum indicator.

[4] Existing water quality in Lake Rogers is highly degraded. Watershed management alone will not achieve substantial water quality improvements. A Clean Lakes Assessment is highly recommended.

The operational experiences and EPA guidelines led the TAC members to recommend a target of non-degradation (avoid worsening the existing nutrient and chlorophyll *a* problems) in the lakes (see Table 8 for detailed water supply targets). The target of non-degradation for chlorophyll *a* is stricter than the state's standard, which is linked to protection of aquatic habitat. However, for six of the nine lakes, the targets are less stringent than U.S. EPA's nutrient guidance for Southeastern lake water supplies: 15 µg/l for chlorophyll *a*.

The **recreation and habitat targets** are linked to two indicators:

- A threshold of imperviousness: watershed-wide average imperviousness not to exceed 10 percent. The Center for Watershed Protection reports that watersheds averaging 10 percent or greater imperviousness begin to show signs of habitat impairment. This 10 percent threshold is a general indicator that is also used as a target in the Wake County Watershed Management Plan (2003). Some habitat indicators begin to shown signs of impairment with 6 percent watershed imperviousness and others only begin to degrade after exceeding 15 percent watershed imperviousness.
- Chlorophyll *a*: a maximum of 25 µg/l for chlorophyll *a*. This is based on a U.S. EPA guideline for protecting designated habitat and recreational uses of southeastern lakes.

The Project Team used these targets, along with projected types of development in the local land use plan and zoning ordinances, to evaluate baseline conditions (i.e., what will happen in the future with no change in regulations and policies) and to identify which water bodies would not meet management objectives in the future without additional protection measures. The targets were also used to evaluate alternative draft management scenarios. The UNRBA Board and TAC were involved in developing scenarios and in selecting the preferred management strategies.

3. Baseline and Future Conditions Assessment

This chapter summarizes the assessment of water quality and habitat for future conditions in the Upper Neuse River Basin. Additional assessment details can be found on the UNRBA website (www.unrba.org). The results are presented in three major sections corresponding to the watershed management objectives:

- Protecting drinking water supplies;
- Protecting stream habitat and recreation areas and minimizing hydromodification; and
- Addressing other key water quality stressors.

Each section provides a summary of the targets, findings, and conclusions relating to the baseline assessment.

3.1 Protect Drinking Water Supplies

All drinking water supply lakes in the Upper Neuse watershed are experiencing eutrophication problems associated with nutrient loads, including phosphorus and nitrogen. The objective of the management plan is to minimize additional problems and potential risks associated with increased levels of eutrophication, including taste and odor problems, water treatment plant difficulties due to clogging of filters, increased risk from disinfection byproducts which can be carcinogenic, and increased risk of blue-green algae blooms which can produce algal toxins.

The UNRBA's targets for protecting drinking water are:

- Chlorophyll *a* < 15 μg/l for Lake Holt, Little River Reservoir, and Falls Lake intake (U.S. EPA guideline for drinking water supply lakes in the Southeast). This is essentially a non-degradation target.
- For Lake Orange, New Hillsborough Reservoir (on the West Fork of the Eno River), Corporation Lake, Lake Ben Johnston, and Lake Michie: no significant increase from existing conditions (based on operational experiences with existing levels of eutrophication).
- Lake Rogers: no significant increase in existing annual nutrient loads (as an interim target until a Clean Lakes Assessment and restoration plan are completed).

Findings

If the Upper Neuse watershed develops as projected over the next 25 years and existing state and local regulations are fully implemented and enforced (including land use regulations and NPDES requirements), existing regulations are adequate to meet the drinking water targets for all lakes through 2025 (i.e., eutrophication, as predicted through chlorophyll *a*, will not worsen from existing conditions).

In the longer term, if land in the watershed is developed to its potential as allowed in the local governments' existing low density option regulations, the drinking water supply source targets are

exceeded for all water supply reservoirs except Falls Lake. If land is developed as allowed in the high density options, targets for all water supply reservoirs are *significantly* exceeded, with the exception of Falls Lake (Figure 11).

Conclusions

If the local governments wish to meet the UNRBA's water supply protection targets over the long term, additional management measures are needed to reduce mass loadings of *both* phosphorus and nitrogen for all water supply watersheds except Falls Lake.

3.2 Protect Habitat and Recreational Areas

The targets for protecting habitat are:

- For lake areas that are not around water supply intakes, 25 µg/l chlorophyll *a* as a lakewide average during the growing season (U.S. EPA guideline) (Note: 40 µg/l chlorophyll *a* is the NCDENR standard).
- For stream habitat, minimize increase in watershed impervious area. For watersheds with ≥10 percent impervious area, require peak flow control and encourage low-impact design and development.

Findings

Chlorophyll a

Existing regulations are adequate to meet the chlorophyll *a* target for protecting habitat and recreation for all lakes for all future scenarios analyzed, including the buildout scenario. Although

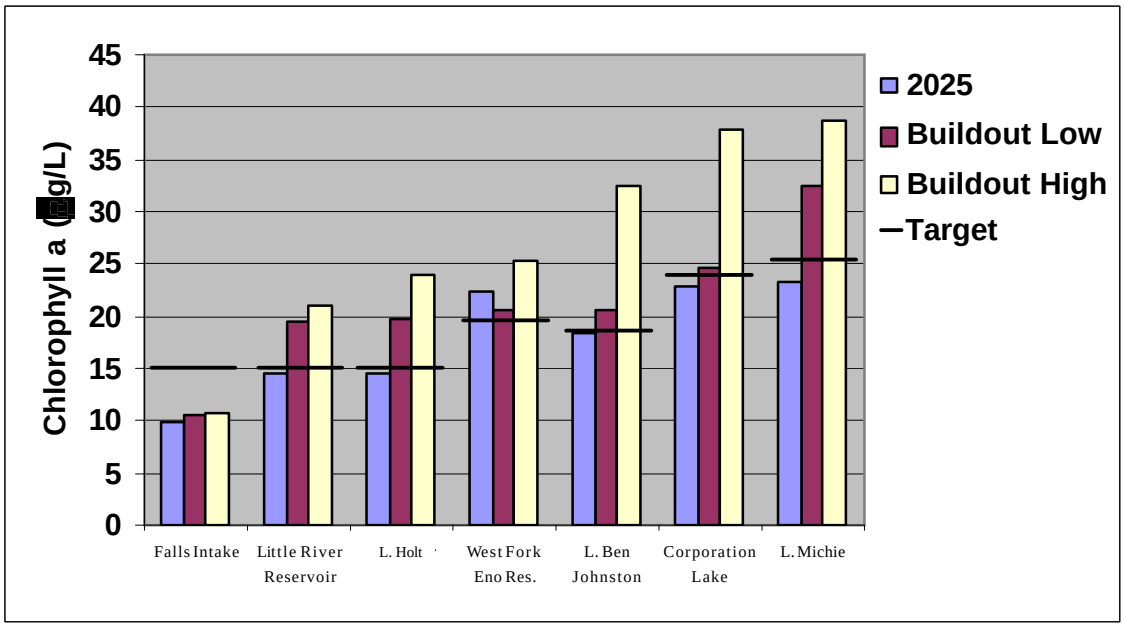


Figure 11. Evaluation of Water Supply Source Impairment Assuming Full Implementation of Existing Regulations: Estimated Chlorophyll *a* vs. Target

Falls Lake meets the 25 µg/l lakewide average (and meets this level in five of its six segments), the upper segment of Falls Lake currently exceeds the state standard of 40 µg/l. Given projected development and existing regulations, habitat impairment is expected to worsen in this upper segment of Falls Lake without additional management measures (Figure 12).

Impervious Area

Another indicator of potential habitat and recreation impairment is impervious area. Impervious area can increase the volume of water running off a site (causing sedimentation and erosion, alteration of channels and banks, and increased pollutant loading downstream). Based on studies of the relationship between extent of watershed imperviousness and habitat and water quality impairment, water quality, aquatic habitat, and stream channel impairment can be expected within watersheds with more than 10 percent imperviousness.

Already, 6 of the 32 subwatersheds exceed the 10 percent imperviousness threshold. Under full implementation of existing regulations and projected growth, this threshold would be exceeded in 12 subwatersheds by 2025. Under buildout conditions with developers using the low-density option provisions in the local ordinances, 19 of the 32 watersheds would ultimately exceed 10 percent imperviousness. Under the high-density options, 27 of the watersheds would likely exceed the threshold target (Figure 13).

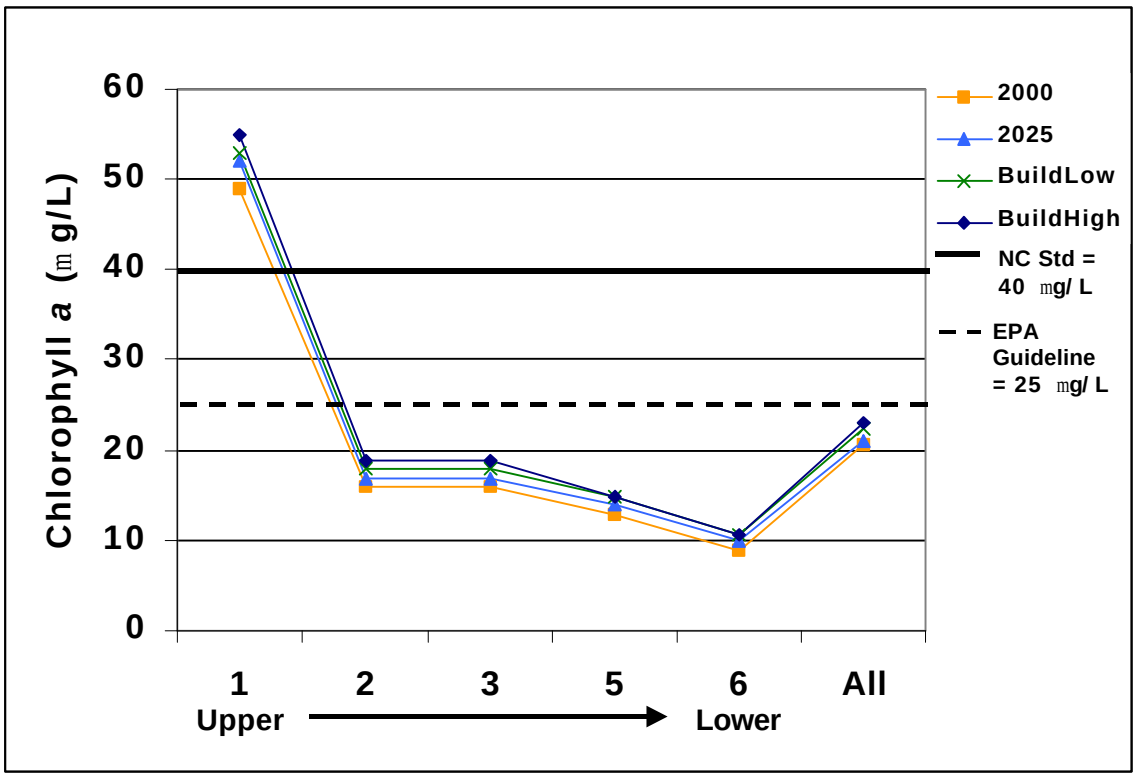


Figure 12. Habitat Impairment: Falls Lake Chlorophyll *a* by Segment

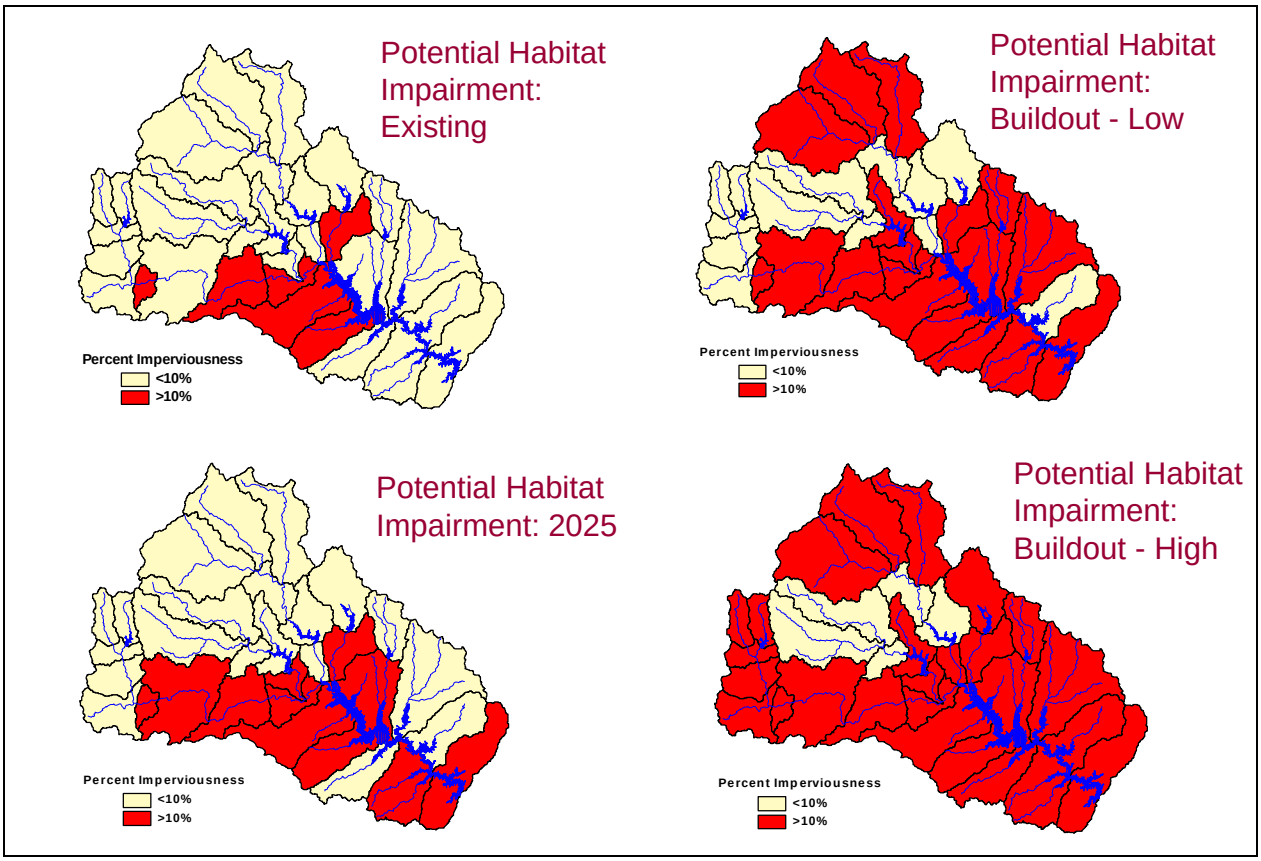


Figure 13. Potential Habitat and Recreation Impairment Existing, 2025, Buildout Low and Buildout High

Conclusions

Existing regulations pertaining to impervious surfaces and stormwater runoff from developed areas are not considered adequate to protect aquatic habitat and water-based recreation objectives. Therefore, additional measures are needed to require and/or encourage lower levels of imperviousness and to decrease the peak and average volume of stormwater discharged.

Predicted levels of eutrophication (as indicated by chlorophyll *a*) should not pose a threat to recreational and habitat uses of our lakes. Chlorophyll *a* concentrations in the upper segment of Falls Lake are expected to remain above the state standard of 40 µg/l, and could worsen if additional management measures are not implemented in the subwatersheds draining to the segment.

3.3 Address Risks for Other Key Stressors

Other key stressors were identified based on past monitoring, the state's 303(d) list of impaired waters, and discussions with the UNRBA Board, Technical Advisory Committee, and Policy Coordinating Council. NCDENR lists a waterbody as "impaired" (defined as partially supporting or not supporting its designated use(s)) in the state's Clean Water Act Section 303(d) report, issued biennially. Waters that are identified as impaired and for which there are no management strategies in place to ensure that the water quality standards will be met are also placed on the state's Section

303(d) list of waters that require development of Total Maximum Daily Loads (TMDLs). Nine stream and river segments in the Upper Neuse River Basin are included on North Carolina's 2002 303(d) list (Figure 9 identifies these segments).

A numeric target was assigned for one parameter:

- Biochemical Oxygen Demand /Dissolved Oxygen (listed by DENR as major source of existing impairment)

  ⇒ (Target: North Carolina water quality standards of 5.0 µg/l for dissolved oxygen.)

The following stressors have a non-numeric objective: to reduce existing and future risks:

- Construction activities (listed by DENR as major source of existing impairment)
- Urban stormwater runoff volume and quality (listed by DENR as major source of existing impairment)
- Fecal coliform bacteria/pathogens (listed by the UNRBA TAC and PCC as a potential threat that needs to be addressed)
- Toxics (listed by the UNRBA TAC and PCC as a potential threat that needs to be addressed)

Biochemical Oxygen Demand and Dissolved Oxygen

Findings

Monitoring data indicate that DO concentrations have been consistently below the standard in recent decades in Ellerbe Creek, Flat River below Lake Michie, Knap of Reeds, Little Lick Creek, and Lick Creek. Little Lick Creek is targeted by DENR for a TMDL for dissolved oxygen.

The primary area of concern for DO in the Upper Neuse waters is below wastewater treatment facilities (WWTPs), which discharge oxygen-consuming material in their effluents. The wasteload allocations contained in the NPDES discharge permits issued by DENR are designed to prevent excursions of the DO standard. In addition, the state's most recent Neuse River Basin Plan has a policy of eliminating old, small WWTPs and encouraging regional WWTPs with tertiary treatment.

Another potential source of DO violations is farming operations. With the state's Nutrient Sensitive Waters Management Strategy Rule requirements for farm BMPs, and the expected reductions in farm operations in the coming decades, risks from this source are projected to be reduced.

Conclusions

The DO standard can be protected with adequate wastewater treatment and agricultural BMPs. Future risk is lower due to the state's policy to encourage regional WWTPs and improved treatment.

Urban Stormwater Runoff

Findings

Urban stormwater runoff is considered the source of impairment for seven of the nine Upper Neuse watershed stream segments included on the state's 303(d) list. As described in the section on habitat impairment, 6 of the 32 subwatersheds already exceed 10 percent imperviousness, an indicator of potential problems from stormwater runoff. In the future, the majority of the subwatersheds will exceed 10 percent imperviousness, given existing regulations.

Conclusions

Additional measures are needed to require and/or encourage lower levels of imperviousness and to decrease the peak and average volume of stormwater discharged (this is the same as the measures needed to protect habitat and recreation areas).

Construction Activities

Findings

Three of the watershed's nine impaired stream segments are reportedly impaired by construction activities. Each of these segments is in the Little Lick and Lick Creek subwatersheds. Sediment loads from construction sites damage aquatic habitat and life in the streams. Most UNRBA Board and TAC members indicated that more frequent sediment and erosion control inspections are needed to better ensure compliance with applicable sedimentation and erosion control requirements. Logging practices prior to construction were also seen as a source of sedimentation and erosion that needs to be better managed.

As the Upper Neuse watershed becomes more urbanized– with a 53 percent increase in population growth projected over the next 20 years and significant increases in impervious area projected throughout the basin– problems associated with logging and construction activities will likely be more widespread.

Conclusions

Sedimentation and erosion control programs governing construction and logging activities need to be enhanced to reduce existing and potential risk of degradation due to sediment and runoff from land-disturbing activities. Equally important, there is a need to educate the construction industry about improved construction practices through programs such as the national Clean Water Contractor Training Program.

Agricultural Runoff

Findings

In the 2000 303(d) list, five of the watershed's impaired stream segments were impaired by agricultural activities. At this time, only a segment of the Flat River is listed as impaired. As noted in the DO/BOD section above, the state's Nutrient Sensitive Waters Management Strategy Rule requirements for farm BMPs and the expected reductions in farm operations in the coming decades are projected to continue reducing risks from this source.

Conclusions

To address existing impacts, several stream segments should be targeted for stream restoration. Future impacts should be mitigated by the NSW Rule requirements, if the requirements are fully implemented.

Fecal Coliform Bacteria

Findings

The limited monitoring data that are available do not indicate existing pathogen problems. However, as central wastewater collection systems and community and individual on-site wastewater systems increase in age and extent, the potential for pathogen problems may increase.

Conclusions

To reduce existing and future potential problems associated with sewer system overflows and failing septic systems, enhanced inspection and maintenance programs will be needed for public and private sewage treatment and conveyance systems.

Toxics

Findings

Monitoring data do not indicate any existing problems relating to toxics.

Conclusions

Existing and potential risks due to toxics are, in general, adequately addressed through the state's NPDES program, BMPs for urban runoff, U.S. EPA Safe Drinking Water Act Provisions, and spill prevention and containment programs. Additional protection is needed at bridge crossings over or near drinking water supply lakes, but may be cost-prohibitive.

Wetlands and Riparian Area Protection and Restoration

The protection and restoration of wetlands and riparian corridors is an essential component of the Upper Neuse Watershed Management Plan. The UNRBA analyzed spatial data from two studies: the *Falls Lake Wetlands Assessment* (North Carolina Wetlands Restoration Program (NCWRP) and Division of Coastal Management) and the *Buffer Preservation and Streambank Restoration in the Upper Neuse River Basin: A Blueprint for the Future* (Triangle J Council of Governments (TJCOG)) to identify:

- Potential wetland restoration sites
- Potential wetlands for protection
- Potential riparian and stream restoration sites
- Potential riparian areas for protection

A detailed analysis is available in the technical brief titled Upper Neuse Wetlands and Riparian Protection and Restoration Analysis.

Findings – Wetlands

The Wetlands Assessment is the NCWRP's comprehensive assessment of wetlands adapted from the NC Division of Coastal Management's NC-CREWS model, which identifies and classifies the functions of wetlands. The NCWRP data estimate that 18,700 acres (29.2 square miles) of wetlands have existed in the Upper Neuse Watershed. These "baseline" wetlands include both existing and former (or "historic") wetlands. Of the baseline wetlands, about 66 percent remain. The sections below describe two analyses based on the wetlands assessment data: potential wetland restoration and protection sites.

Potential Wetlands Restoration Sites

It is estimated that nearly 6,400 acres, over 34 percent of the baseline wetlands, have been disturbed or destroyed. Forty-two percent of these disturbed wetlands were drained and cleared, and 34 percent were converted to pine forest. Few of these wetlands are still potentially restorable because of economic and ecological considerations.

The analysis reveals potential restoration sites which, once restored, could protect water quality. The hydrologic units with the greatest area of potential wetland restoration sites are: Beaver Dam Creek (HU 60020), North Flat River (HU 10010), Knapp of Reeds Creek (HU 40010), Ellerbe Creek (HU 50010), Little Lick Creek (HU 50020), and Ledge Rock Creek/Lake Rogers (HU 60010).

Potential Wetlands Protection Sites

The *Falls Lake Wetlands Assessment* procedure rates each wetland in the Upper Neuse watershed for its various functions, including water quality improvement, floodwater retention, and habitat functions. The UNRBA used the resulting Wetland Functional Significance data to identify currently unprotected wetlands with high water quality functions. Figure 14 shows the acreage of wetlands with high water quality function.

The hydrologic units with the greatest area of potential wetland protection sites are: Beaver Dam Creek (HU 60020), Knapp of Reeds Creek (HU 40010), Ellerbe Creek (HU 50010), Lick Creek (HU 50030), and Deep Creek (HU10040).

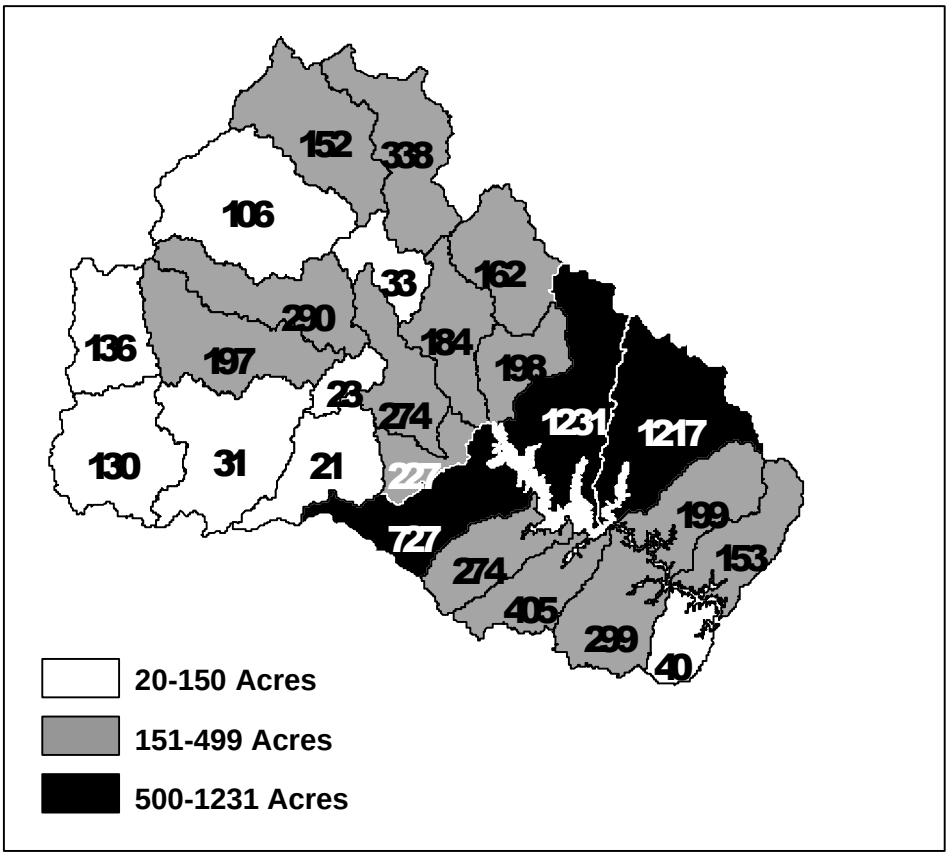


Figure 14. Potential Wetland Protections Area by Hydrologic Unit

Findings – Streams and Riparian Areas

In June 2000, the Triangle J Council of Governments presented to the NC Clean Water Management Trust Fund its Buffer Preservation and Streambank Restoration in the Upper Neuse River Basin: A Blueprint for the Future ("Riparian Blueprint"). This report addresses the extent of riparian buffer corridors, analyzes general riparian buffer conditions in the watershed, and prioritizes certain riparian buffer areas for protection. The Riparian Blueprint estimates that as of 1998, nearly 73 percent of the total riparian land area (defined as the area within a 330-foot buffer of water bodies) is either forested, herbaceous, or woody wetlands.

The analysis of potential restoration sites is based on a similar analysis in the Riparian Blueprint. The second analysis of potential protection sites relies entirely on the Riparian Blueprint.

Potential Riparian and Stream Restoration Sites

The UNRBA has identified non-forested riparian areas of at least 3,000 feet in length and 100 feet in width. The 3,000-linear-foot distance is based on NC Wetlands Restoration Program criteria for identifying "restorable" sites. Figure 15 shows the general percentage of total stream length in each HU that is non-forested.

Of the mapped 2,614 miles of streams in the Upper Neuse, it is estimated that 6.7 percent (177 miles) are areas with significant (300,000 square feet) non-forested riparian zones. The hydrologic units with the highest percentage of non-forested riparian corridors are: Ellerbe Creek (50010);

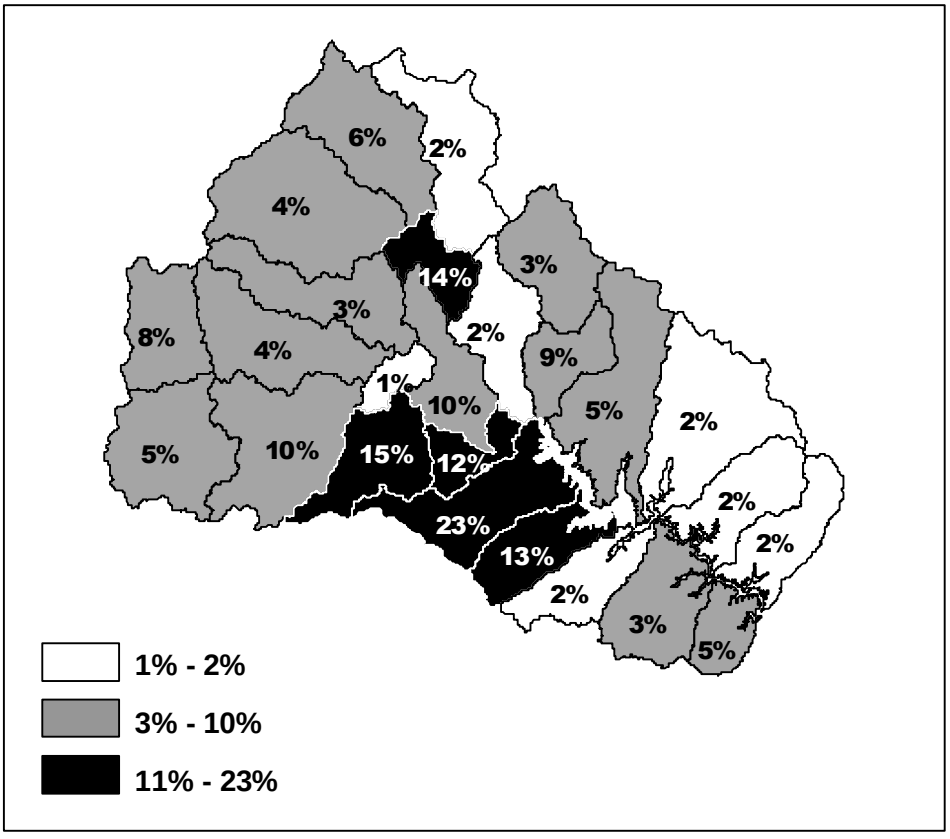


Figure 15. Potential Riparian and Stream Restoration Sites as a Percentage of Total Stream Length by Hydrologic Unit

Lower Eno River (30040); Lower Flat River (10030); Little Lick Creek (50030); and Lower Little River (30050). All of these HU except the Lower Flat River are located in urban and urbanizing areas.

Potential Riparian Areas for Protection

The *Upper Neuse Riparian Blueprint* ranks riparian areas in the watershed based on several functional criteria including water quality protection, ecosystem integrity, recreational and educational use, and flood protection. The UNRBA used this assessment to identify several riparian areas in the watershed for protection. This analysis does not consider existing riparian protection regulations. The analysis excluded riparian areas in publicly owned lands. Figure 16 shows the percentage of total riparian area identified as potential riparian protection sites.

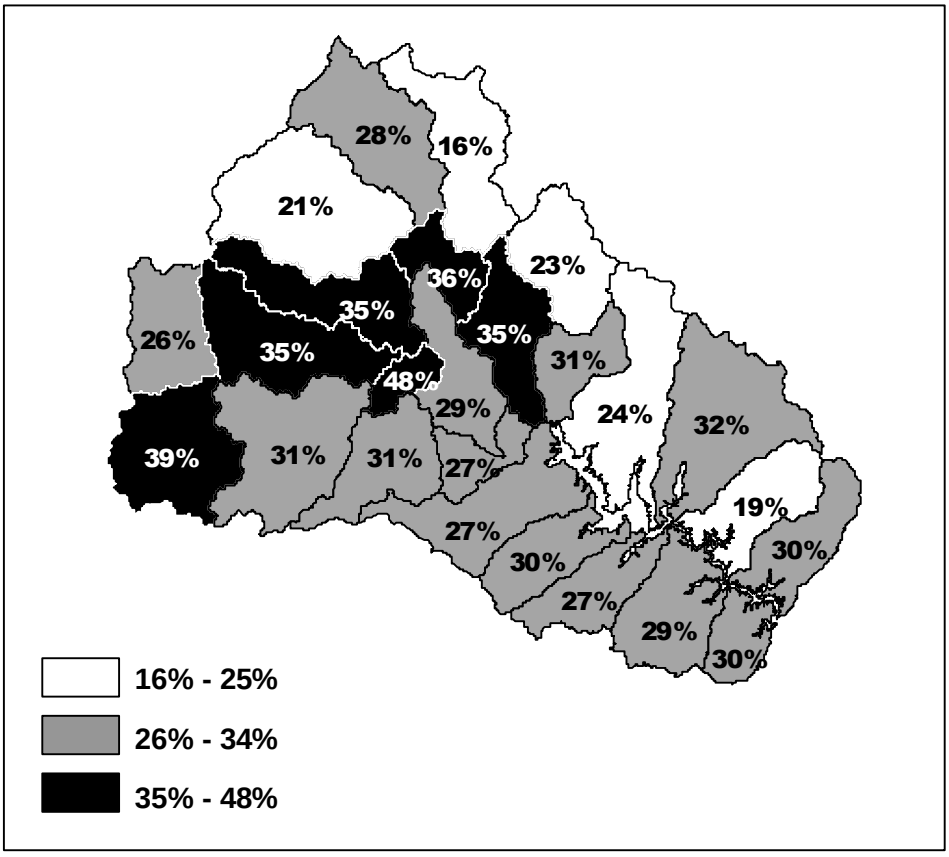


Figure 16. Potential Riparian Protection Sites as a Percentage of Total Stream Length by Hydrologic Unit

The hydrologic units with the highest percentage of potential riparian protection sites are: Little River (20030); Eno River/Sevenmile Creek (30020); South Fork Little River (20020); North Fork Little River (20010); Flat River (10030); and Lower Flat River/Lake Michie (10050).

Conclusions

The restoration analyses offer general guidance to local governments and the NCWRP for identifying sites with the potential for restoration and/or protection. This analysis provides several important results, including:

- General guidance for NCWRP on where to pursue restoration opportunities;
- General guidance for local governments on restoration, protection, and monitoring opportunities;
- A communication tool for member governments and agencies;
- A reference for regional analysis; and
- A potential tool for local governments as they pursue funding for protection and restoration projects.

This is a general GIS analysis, and field verification of results by professional biologists from the appropriate agencies is recommended. Table 9 offers overall and analysis-specific rankings for each subwatershed.

Table 9. Wetland and Riparian Restoration Rankings by Subwatershed

Hydrologic Unit (last 5 digits)	Potential Wetland Restoration	Potential Wetlands Protection	Potential Str./Rip. Restoration	Potential Riparian Protection	Restor-ation Rank	Overall HU Rank
North Flat River (10010)	**2**	17	8	16	**3**	8
South Flat River (10020)	16	20	8	23	13	22
Flat R. (10030)	15	22	10	**3**	14	15
Deep Creek (10040)	13	**5**	20	25	19	20
Lake Michie (10050)	9	14	21	**4**	17	11
North Fork Little (20010)	13	7	17	**4**	17	7
South Fork Little (20020)	10	13	13	**4**	11	6
South Fork Little (20030)	16	24	25	**1**	25	21
L.R. Reservoir (20040)	7	8	6	14	6	**5**
Upper Eno (30010)	16	18	7	20	11	19
Eno/Sevenmile Cr. (30020)	16	19	12	**2**	16	12
Eno/Stoney Cr. (30030)	16	23	**2**	8	8	12
Eno/Crooked Cr. (30040)	8	25	**4**	8	**5**	9
Eno River (30050)	11	10	11	17	10	12
Lake Holt (40010)	**3**	15	16	22	9	17
Knap of Reeds (40020)	12	12	13	8	14	9
Ellerbe Creek (50010)	**4**	**3**	**1**	17	**1**	**1**
Little Lick Cr. (50020)	**5**	8	**3**	11	**2**	**3**
Lick Creek (50030)	16	**4**	22	17	22	18
Ledge Creek (60010)	6	**1**	**5**	21	**4**	**4**
Beaverdam Creek (60020)	**1**	**2**	15	7	7	**1**
New Light Creek (65010)	16	11	23	24	23	25
Horse Creek (65020)	16	16	24	11	24	22
Upper Barton Cr. (65030)	16	6	18	15	20	16
Cedar Creek (65040)	16	21	19	11	21	22

The NCWRP has been an active partner throughout the Upper Neuse watershed management planning process. After evaluating the results of the watershed assessment, the NCWRP and UNRBA have begun more detailed local watershed assessments in two priority 14-digit hydrologic units within the watershed. The NCWRP uses local watershed assessments to identify restoration opportunities. These hydrologic units are:

1. Hydrologic Unit #03020201060010 that contains the Lake Rogers watershed in Granville County. Lake Rogers is the Town of Creedmoor's water supply reservoir. The Lake Rogers watershed was identified because it includes a water supply reservoir that is currently experiencing an increased level of degradation relative to other water supply sources within the Upper Neuse.
2. Hydrologic Unit #03020201050010 that contains Ellerbe Creek in northern Durham. Ellerbe Creek drains a highly urbanized watershed and is included in the state's 303(d) list of impaired waters. Ellerbe Creek is currently rated as impaired from the source to Falls Lake (11.0 miles) due to fair bio-classification ratings. In addition, elevated lead and zinc levels, low dissolved oxygen levels, and high fecal coliform levels are major concerns. This process has already identified one restoration site.

The analyses offer a useful planning tool for the UNRBA and the NCWRP as they identify future watersheds for the local watershed planning process. In addition, these analyses will begin the process of identifying areas of focus for land protection efforts.

4. Proposed Strategies

Using the water quality models developed for this study, the Project Team worked with the UNRBA TAC and Board of Directors to develop a list of promising management strategies. The Project Team evaluated these strategies and developed a combination of actions that could best meet our future water quality targets. The UNRBA TAC and Board considered the modeling results and subsequently recommended a package of management strategies for meeting the established watershed goals and objectives. The UNRBA will present this package to each local government in the Upper Neuse Basin for consideration and potential adoption.

This chapter describes the proposed strategies. They include an overarching strategy for managing new development in the watershed, five recommended management techniques, and specific required actions (including those actions recommended for all jurisdictions, for County jurisdictions only, and for municipal jurisdictions only). This section and Appendix C summarize the estimated costs of the actions for each jurisdiction. Appendix A details development ordinance changes required to meet water quality targets by jurisdiction and drinking water supply subwatersheds.

4.1 Overarching Strategy for Protecting Water Resources

Early in the screening of potentially feasible management strategies, the UNRBA Board concluded its number one strategy should be to shape WHERE growth occurs in the Upper Neuse Basin through more distinct urban areas and planned conservation areas. A number of local governments are already studying this approach. For the entire Research Triangle Region, the *Regional Development Choices Project,* has identified four core values and eight regional principles to serve as a basis for shaping growth.

The four core values illustrate why shaping growth can be an important strategy:

1. **maintaining a "community of communities"** – shaping growth can enable communities to develop as unique and distinctive places, preserving their character as development occurs.
2. **sustaining economic success** – shaping growth can influence both the success of economic centers and the "quality of place" important to a mobile, skilled workforce.
3. **protecting greenspace and environmental quality** – shaping growth can steer development away from sensitive natural areas such as watersheds, wetlands, and wildlife corridors, maintain the form and function of important agricultural areas and preserve land for parks and open space.
4. **improving mobility** – shaping growth can increase mobility choices by making transit or pedestrian and bicycle travel possible for more residents and can maximize the effectiveness of transportation infrastructure investments.

One of the key regional principles describes how the region's growth should be shaped:

> **"Smart Pattern of Development"** Clearly define land areas that are appropriate for development, as well as environmentally sensitive, historic, natural or recreational

land areas that need protection. Pursue policies and strategies that are both equitable and consistent with these identifications."

(Other regional principles involve walkable communities; affordable living; green space; integrated transportation; enhanced civic realm; mixed use activity centers; and shared benefits.)

Consistent with the principle of "smart development," the recommended Upper Neuse Watershed Plan has three distinct zones: urban development zones; suburban zones; and conservation zones (upland drinking water supply watersheds). These zones are shown on Figure 17. The overarching strategy is to hold the requirements for new development constant in the existing and future urban development and suburban zones and to increase requirements in the conservation zones to the level needed to meet water quality targets. This creates an incentive to concentrate future development in the planned urban areas and maintain or enhance their economic vitality, while protecting the environmental quality of our important conservation areas.

The UNRBA TAC and Board directed the Project Team to evaluate two different approaches to shaping growth: zoning and on-site performance standards for new development. These approaches are described below in "Recommended Watershed Management Actions."

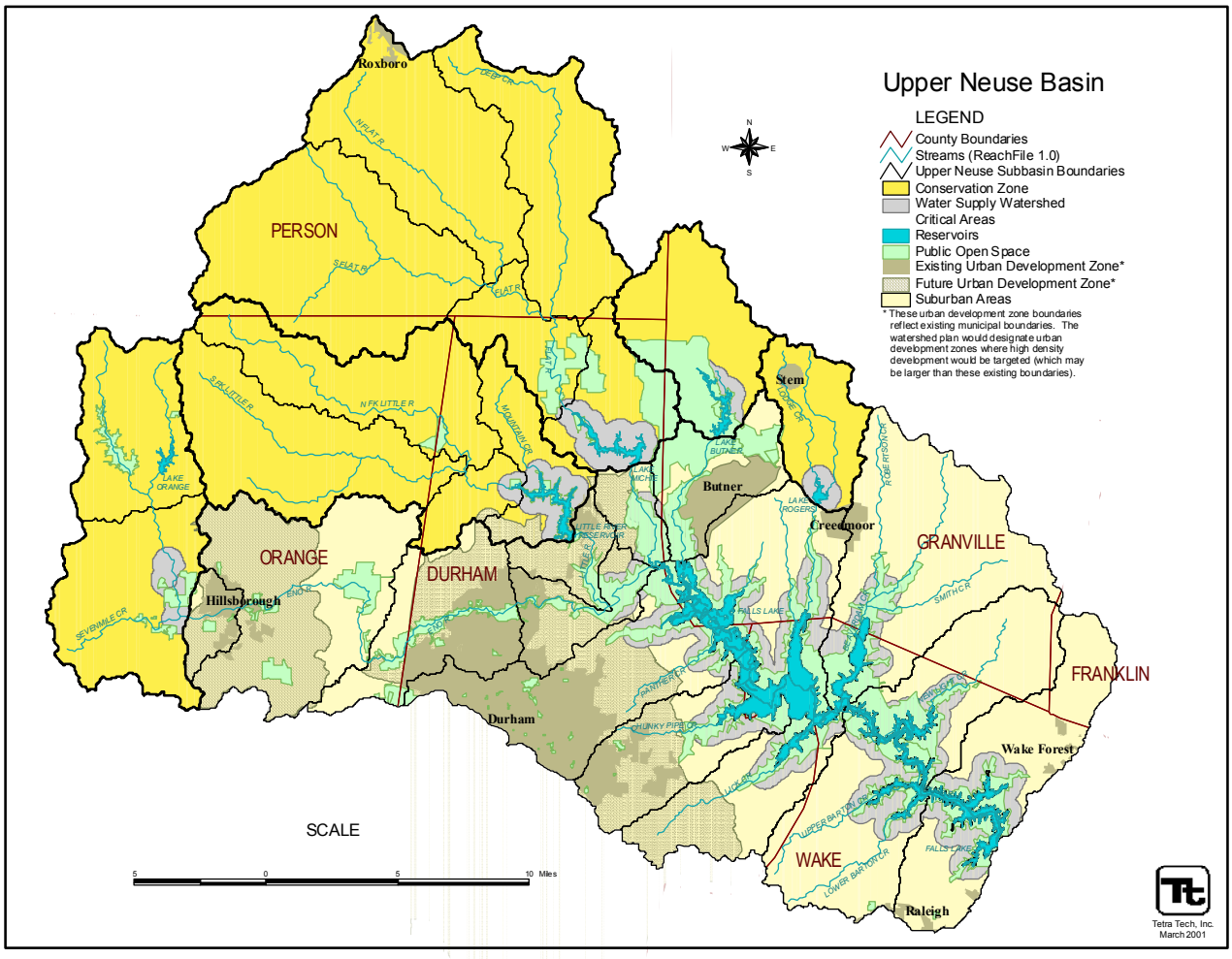


Figure 17. Watershed Management Zones

4.2 Five Watershed Management Techniques

The Upper Neuse Watershed Management Plan is a package of techniques: some designed to address existing problems, others to address new, future problems. Some techniques address both. Five general watershed management techniques are recommended for the Upper Neuse Watershed:

New Development Site Management: controlling the quality and quantity of water running off future development sites through density and impervious area limits and enhanced peak flow requirements or through on-site performance standards for nitrogen, phosphorus, and peak flow.

Monitoring and Enforcement: enhanced monitoring and enforcement programs to ensure the proper performance and maintenance of wastewater/stormwater/septic systems as well as compliance with local laws, and to measure the effectiveness of our actions in protecting and restoring our streams and lakes. (How well are the management techniques working?)

Education/Citizen Stewardship: programs to increase citizens' and developers' awareness of and participation in watershed management efforts.

Point Source Controls: efforts to upgrade existing wastewater treatment facilities and to phase out older facilities.

Stream and Wetland Restoration Projects: efforts to restore some of the natural functions and characteristics of impaired water bodies.

Each of these techniques helps mitigate or prevent pollution. To be most effective, all five must be employed together. Table 10 provides an overview of the Upper Neuse Watershed Management Plan Components. It outlines which components address existing problems and which are being employed to proactively minimize future problems. Many of the management plan actions address multiple parameters of concern. The table shows each action's degree of importance, either essential to mitigating risks or helping to reduce risk.

The following sections provide more details about actions that are recommended under each technique. They are categorized by actions required of all jurisdictions, by county jurisdictions only, and by municipal jurisdictions only. For each action, it is noted whether it is most appropriate to be implemented at the local level only, or whether it is appropriate for the action to be implemented through a collaborative inter-local approach initiated by the Upper Neuse River Basin Association.

Existing Impacts	Future Impacts	Management Plan Component	Degree of Importance for Parameters Addressed				
			Nutrients	Sediment/ Habitat	Fecal Coliform	BOD	Flooding
		New Development Site Management					
	✔	Nitrogen and Phosphorus Performance Standards (3.6 and .6 lb/ac/yr, respectively, in urban/suburban area; 1.7 and .3 lb/ac/yr, respectively, in rural areas) or	essential				
	✔	Density limits (1 unit per 3-5 acres) in rural areas; existing regulations for urban growth areas	essential			essentia l	
	✔	100 ft stream buffer on all streams for all new development in rural/conservation areas	essential	essential			reduces risk
	✔	Peak flow management (24 hr, 1 yr. storm) for all new development above 10% imperviousness		essential			essential
		Monitoring and Enforcement					
✔	✔	Long term monitoring program	essential	essential	essential	essential	essential
✔	✔	Septic tank recommendations	reduces risk		reduces risk		
✔	✔	Inspections and maintenance of storm drain age and sanitary sewer systems	reduces risk		reduces risk		reduces risk
	✔	Enhanced construction site inspection and enforcement action for erosion and sedimentation		reduces risk			
✔	✔	Enhanced animal operations inspections			reduces risk		
	✔	Stormwa ter water quality BMP inspection and enforcement	essential	essential	reduces risk	reduces risk	
		Education/Citizen Stewardship					
	✔	Education for low -impact design	reduces risk	reduces risk	reduces risk	reduces risk	reduces risk
✔	✔	Education of homeowners regarding buffer maintenance	reduces risk	essential			
✔		Agricultural BMPs	reduces risk	reduces risk	reduces risk		reduces risk
✔	✔	Targeted land acquisition/conservation easements	reduces risk	reduces risk			reduces risk
✔	✔	Adopt -a-Stream Program	reduces risk	reduces risk			reduces risk
		Point Source Controls					
✔	✔	NPDES program requirements	essential			essential	
✔		DEHNR Policy: regional WWTPs' w/advanced tertiary treatment	essential			essential	
		Stream and Wetland Restoration Projects					
✔		Riparian Area Reforestation	reduces risk	essential			
✔		Streambank Stabilization		essential			
✔		Streambed and Wetland Restoration		essential			reduces risk

Table 10. Upper Neuse Management Plan Components

4.3 Recommended Watershed Management Actions

The UNRBA TAC and Board directed the Project Team to evaluate two different approaches to shaping growth: zoning and on-site performance standards for new development. Table 11 provides a summary of these recommendations, and the sections below describe them in more detail. Figure 17 shows the urban, suburban, and conservation zones.

Table 11. Performance Standards vs. Zoning Density Approach to New Development Site Management

	Urban/Suburban Zone	Conservation Zone
Performance Standards		
Surface Loading Nitrogen (lbs/ac/yr)	3.6 (existing*)	1.7
Surface Loading Phosphorus (lbs/ac/yr)**	0.6	0.3
Stream Buffer	50 feet (existing)	100 feet
Enhanced Peak Flow Control	For new development with greater than or equal to 10% total impervious cover	For new development with greater than or equal to 10% total impervious cover
-OR-		
Zoning Density		
Density Limits	Existing zoning	1 unit per 3-5 acres
Impervious Limits	Existing zoning	3.5% - 5% impervious area
Stream Buffer	50 feet (existing)	100 feet
Enhance Peak Flow Control	For new development with greater than or equal to 10% total impervious cover	For new development with greater than or equal to 10% total impervious cover

*Refers to the existing standards established in the Neuse River Nutrient Sensitive Water Management Strategy rules.
**There are currently no existing standards for phosphorus.

A recommended alternative for jurisdictions in the Upper Neuse River Basin is to choose a zoning density approach to watershed management. Under this approach, zoning and development ordinance requirements could be held constant in the urban and suburban areas and made more stringent in the conservation area. Modeling results show that, using this approach, the conservation area should have a housing density limit of 1 unit per 3 acres or 1 unit per 5 acres (depending on the target) and an impervious area maximum of 3.5 percent to 6 percent (again depending on the water quality target). Mandatory stream buffer protection areas should be at least 50 feet from the stream's ordinary high water mark in urban and suburban areas and at least 100 feet from the ordinary high water mark in the conservation area. All jurisdictions in the Upper Neuse River Basin should set a 10 percent impervious cover threshold that would trigger requirements for enhanced peak flow control.

Alternatively, if local governments choose to use the performance standard approach, the urban and suburban areas would implement the existing nitrogen performance standard for new development in the NC NSW rules (3.6 lbs/ac/yr for new developments). New developments in conservation areas would need to meet a much higher standard of 1.7 lbs/ac/yr. Since phosphorus is the primary nutrient of limiting concern in the Upper Neuse watershed, urban and suburban areas would need to implement a new phosphorus loading standard of 0.6 lbs/ac/yr for new development, while new developments in the conservation area would need to meet a more stringent phosphorus loading standard of 0.3 lbs/ac/yr. This strategy meets water quality targets and wisely shapes where growth will occur in the watersheds. This approach uses the same recommendations for mandatory stream buffers and enhanced peak flow control as the zoning density approach described above.

Recommendations by Jurisdiction

The following recommendations are provided for jurisdictions in the Upper Neuse Watershed. To find out what is recommended for a particular jurisdiction, use the following as a guide:

Counties: read the sections below titled "Actions Recommended for All Jurisdictions," "Actions Recommended for County Jurisdictions Only," the "Estimated Cost of Implementing the Management Plan," and the section in Appendix A related to ordinance changes recommended for the jurisdiction of interest.

Municipal/Urban Areas: read the sections below titled "Actions Recommended for All Jurisdictions," "Actions Recommended for Municipal Jurisdictions Only," the "Estimated Cost of Implementing the Management Plan," and the section in Appendix A related to ordinances changes recommended for the jurisdiction of interest.

Each recommendation is recommended for implementation at a local scale, regional scale, or both. Local implementation means administered individually by each local government. Regional implementation means administered jointly by two or more local governments through a local or regional government or through a non-profit agency.

Actions Recommended for All Jurisdictions

Development Ordinance Revisions for Density Limits and/or Water Quality Performance Standards: Modify the zoning and development ordinance requirements to meet the density limit, stream buffer, and enhanced peak flow requirements for each subwatershed. Alternatively, modify development ordinances to include the performance requirements for total nitrogen and total phosphorus, enhanced peak flow management, and stream buffers. Incorporate use of presumptive site designs which developers can use to meet the standards. Use the Development Performance Review Model to evaluate innovative/alternative designs. (See the recommended development ordinance changes for each jurisdiction later in this section.)

- ***Recommended Implementation:*** Local

Development Ordinance Revisions for Riparian Buffers: For future development in the conservation areas, revise the development ordinance to establish a 100 ft. buffer setback from each edge of the waterbody (unless existing local requirements are equal to or more stringent than the 100 ft. buffer). For future development in the urban and suburban areas, the existing requirements remain the same in the zoning and performance approach. In urban areas, it is recommended that state and local laws be amended to allow for more flexible waivers and variances of the buffer requirement.

Appendix B provides example waivers and variances. In addition, these waivers and variances should be obtained through local rather than state approval process.

- ***Recommended Implementation:*** Local

Development Ordinance Revisions for Low Impact Development Design: Evaluate components of the county's and city's development ordinance requirements, including zoning provisions, stormwater engineering controls design, road and parking design, floodplain and tree protection provisions. Modify ordinance requirements as needed to allow and promote low impact design and development techniques (see also Low Impact Design Education recommendation).

- ***Recommended Implementation:*** Local

Development Performance Reviews for Nitrogen Performance Standard: Implemented by all municipal/urban areas (which already must meet a nitrogen performance standard of 3.6 lbs/ac/yr for new development) and all counties which choose to use the performance standard approach (would need to meet a 1.7 lbs/ac/yr limit for all new developments in the conservation or upland drinking water supply areas). For all proposed developments greater than or equal to 10 percent imperviousness, the staff reviews a site plan spreadsheet analysis for compliance with the nitrogen performance standard. All or some of the jurisdictions may choose to implement the performance standard approach.

- ***Recommended Implementation:*** Local

Development Performance Review for Phosphorus Performance Standard: Implemented by all municipal/urban areas and all counties which choose to use the performance standard approach. Municipal/urban areas would meet a phosphorus performance standard of 0.6 lbs/ac/yr for all new developments. Counties would need to meet a 0.3 lb/ac/yr total phosphorus loading limit for all new developments in the conservation (or upland drinking water supply) areas. All or some of the jurisdictions may choose to implement the performance standard approach.

- ***Recommended Implementation:*** Local

Development Performance Reviews for Enhanced Peak Flow Management: Implemented by all jurisdictions. For all proposed developments greater than or equal to 10 percent imperviousness, the local staff reviews stormwater management plans to ensure enhanced peak flow management. (See also Low Impact Design Education under the Education section.

- ***Recommended Implementation:*** Local

Stormwater Control Inspections: Annually inspect stormwater control ponds and other structural devices to certify their proper functioning and to require repair of failing systems.

- ***Recommended Implementation:*** Regional

Enhanced Construction, Site Inspection, and Enforcement Action: Inspect construction sites more frequently to determine compliance with applicable sedimentation and erosion control requirements. All sites currently should be inspected at least three times: before construction, during construction, and after construction. Enhanced site inspections should add an average of two additional visits to a site. Routine inspections will occur during dry weather. Enhanced inspections should observe a site during a variety of weather conditions. Enforce sedimentation and erosion control requirements more vigorously through required repairs, stop work orders, and fines.

- ***Recommended Implementation:*** Local

Low Impact Design Education: For all proposed developments greater than 5 acres and having at least 10 percent impervious area, educate applicants about opportunities for using low impact development design techniques. These techniques maximize preservation of undisturbed land and preservation/creation of green space area, minimize impervious area, micromanage the stormwater generated on site to maximize infiltration of rainwater, and use a combination of other stormwater management techniques to mimic the hydrology of and stormwater runoff from the site prior to development.

- ***Recommended Implementation:*** Regional

Long-Term Monitoring Program: Implement monitoring program to support water quality condition assessment and trends analysis, evaluation of best management practices, and the reporting of water quality indicators.

- ***Recommended Implementation:*** Regional

Adopt-A-Stream Program and General Watershed Education: Enhance support of adopt-a-stream groups. These are group of citizens taking care of a stream through various activities including visual inspections and water quality monitoring to detect problems, trash pickups, conducting restoration projects, helping develop small watershed plans, and holding festivals. General watershed education includes educating citizens and homeowners about the importance of the watershed plan efforts, including:

- buffer maintenance (once channels have eroded the buffer area, sediments and other pollutants have an outlet to the stream or lake; maintaining native vegetation in the riparian buffer and reforesting the area retains and enhances the integrity of the buffer system);
- septic tank maintenance (educating homeowners about the importance of having septic tanks pumped regularly, drainage fields maintained, and proper disposal of household products);.
- nonpoint source pollution control, including proper use and disposal of residuals;
- and other related topics.

- ***Recommended Implementation:*** Regional and Local

Stream and Wetland Restoration Projects: This includes a broad range of practices (including reforestation, streambank stabilization, streambed restoration, wetland restoration) that enable stream corridors and wetlands to recover ecological function at a self-sustaining level. It is assumed that stream and wetland restoration projects will be dependent upon the availability of state and federal grant funding for such activities.

- ***Recommended Implementation:*** Regional and Local

Stormwater Retrofit Projects: Install new best management practices (BMP) or improve existing BMP in previously developed areas. BMP can include a broad range of practices. Communities complying with NPDES Phase I regulations are required to identify and undertake stormwater retrofit projects.

- ***Recommended Implementation:*** Regional and Local

Targeted Land Acquisition/Conservation Easements: Inventory critical land (i.e., land critical for water quality and habitat protection) within the Upper Neuse River Basin for areas already under

protection, areas planned for protection by local, state, or federal bodies, and those areas not yet under protection but worthy of protection. Submit grant proposals or other funding applications to purchase land and/or conservation easements in environmentally sensitive areas.

- ***Recommended Implementation:*** Regional and Local

Actions Recommended for County Jurisdictions Only

Requirements for Individual Septic Systems: Adopt some or all of the following recommendations:

1. Establish an inspections and maintenance program. Three alternatives are offered:
   a) Inspect septic systems every five years to ensure that they are functioning properly. On average, this would mean inspecting 20 percent of all septic systems in the county annually. Require that homeowners repair or replace failing systems. (Local Health Code may need to be revised to require this inspection and maintenance program).
   b) Alternatively, use the results of Wake County's pilot onsite wastewater conditions assessment to develop risk-based management strategies for septic systems. Risk-based strategies could be based on any of the following: system type, system location, system age, or system maintenance history.
   c) Alternatively, inspect septic systems at the time of new home sale or home resale (new system inspections could be delayed by 6-9 months).
2. Implement a GIS database of existing septic tank and well owners.
3. Develop a certification program for people who install and inspect septic systems, and require that a licensed person install all septic systems. (Note: the General Assembly is now considering the adoption of a state-wide certification program.)
4. Provide operation and maintenance information packages to all homeowners who have septic systems by mail or at time of property purchase.

- ***Recommended Implementation:*** Local

Agricultural Best Management Practices: Assist in cost-sharing with farmers to implement practices to reduce the amount of sediment, nutrients, herbicides, and pesticides running off the land into nearby streams and lakes. These efforts include conservation cropping, contour farming, planting schemes, chemical application plans, grazing systems, development of ponds, tree planting, and vegetated stream buffer maintenance. At minimum, work with Soil and Water Conservation Districts, NRCS, Cooperative Extension Service, and the state to target areas for needed agricultural BMPs.

- ***Recommended Implementation:*** Regional Inspections, Planning and Technical Assistance

Enhanced Animal Operations: Work with the state to target potential problem areas.

- ***Recommended Implementation:*** Regional and Local

Forestry Best Management Practices: Educate landowners and timber harvesters about practices to reduce the amount of sediment, nutrients, herbicides, and pesticides running off the land into nearby streams and lakes. These efforts include development of logging plans and road and access plans, reforestation activities, and adequate protection of streamside management zones.

- ***Recommended Implementation:*** Regional

Actions Recommended for Municipal Jurisdictions Only

Point Source Controls: Implement the NPDES requirements in the state's Neuse River Basin NSW rules, and other regulations controlling point sources of pollution. Where practical, implement the state's Neuse River Basinwide Water Quality Management Plan guidance for eliminating old WWTPs and consolidating capacity of the older plants into regional WWTPs with tertiary treatment. (Although this watershed management plan focuses on controlling nonpoint source pollution, the modeling and evaluation of strategies to meet targets addressed point and nonpoint sources, and assumed that the point source controls would meet the existing regulatory requirements noted above.)

- ***Recommended Implementation:*** State, Regional and Local

Sanitary Sewer Overflow Inspections: Inspect sewage conveyance systems (e.g., pipes, pump stations, manholes, etc.) to ensure their proper functioning. When sanitary sewer systems overflow, untreated or partially treated sewage may flow into streams, rivers and lakes within the watershed. Repairs to overflowing systems may include detecting and disconnecting storm drain connections, replacing conveyance pipes to allow larger volumes of flow or to replace older pipes, and upgrading or repairing pump stations, including installation of automatically-actuated standby power generators.

- ***Recommended Implementation:*** Local

Inspection and Maintenance Program for Leaking Sewer Pipes and Illegal Connections to Storm Drainage System: Inspect sewage conveyance systems to detect and repair leaks of untreated sewage. When sanitary sewer systems leak, untreated or partially treated sewage may flow into streams, rivers and lakes in the watershed. Also, when water that should be conveyed through the sanitary sewer system to the treatment plant is instead connected to the stormwater drainage system, untreated sewage may flow into rivers and lakes. It is important to detect and remove these illegal connections.

- ***Recommended Implementation:*** Local

Inspection and Cleaning of Storm Drainage System: Where necessary, periodically flush problem storm drains with water to suspend and remove deposited materials. Flushing is especially needed for storm drain pipes with grades too flat to be self-cleansing and it helps pipes convey the flow for which they were designed. Also, pollutants need to be flushed and captured so they do not accumulate and wash into streams during storm events.

- ***Recommended Implementation:*** Local

4.4 Estimated Cost of Implementing the Management Plan

With assistance from the UNRBA TAC, the Project Team has developed general planning-level estimates of the costs for implementing the various strategies recommended in the Upper Neuse Watershed Management Plan. In estimating the cost of the management plan components, the estimates reflect the cost of managing major development sites only and the marginal cost associated with implementing the new activities; it is understood that all applicable state and local regulations now in effect will continue to be enforced by the local governments in the Upper Neuse Watershed.

The cost estimate for many of the activities is derived from a unit cost based on the projected number of developments in each jurisdiction. The development projections do not include minor

subdivisions and commercial sites; as a result, the cost estimate likely underestimates the total cost of implementation, especially for activities such as construction site inspection and BMP inspections.

To implement the plan, local governments must generate additional revenues to cover the costs of the recommended program components. It is very important to recognize that additional costs of implementing the Watershed Management Plan may be recovered using a number of different fee-for-service revenue strategies, such as: development plan review fees; stormwater management fees; and septic system management program fees charged to septic system owners.

Appendix C presents the estimated program costs for each applicable component. It also shows the total cost for each component and for each jurisdiction. Costs are given for Year 1 and Year 25 of component implementation. Costs for Year 25 are based on an assumed rate of inflation of 3 percent per year. Hourly rates shown include overhead (equipment, transportation, etc.).

The total cost is presented in two ways: a total cost, and a marginal cost. Total cost includes existing programs and requirements in each jurisdiction, as well as additional protection measures. The marginal cost highlights only the additional protection measures (i.e., activities that would be required *only* because of the Upper Neuse Watershed Management Plan).

Program costs are those capital and ongoing costs to each jurisdiction to implement the management plan component. These costs do not include indirect costs, such as increasing or decreasing land values, design fees, or construction costs to build structural BMPs that may also be associated with implementation of the components. Estimates also do not account for one-time program start-up costs, such as the cost of revising development ordinances.

While costs are presented for each jurisdiction, many of the programs could be implemented through a collaborative approach, such as through the Upper Neuse River Basin Association, thereby providing potential cost savings.

The septic systems management program strategy has by far the greatest estimated cost of any of the components included in the proposed Upper Neuse Watershed Management Plan. The septic systems management program represents more than 95 percent of the total "new program" costs associated with the plan. Even when considering the total costs of all program components (including those requirements associated with implementation of the Neuse River Basin nutrient rules), the cost of the septic system management program component is more than 62 percent of the Year 1 costs associated with the entire plan. It represents more than 66 percent of the total costs in Year 25.

This cost consideration is significant to the jurisdictions—particularly the counties—within the Upper Neuse Watershed. However, septic system management programs similar to that proposed by this plan have been implemented in several other parts of the country in order to protect public and environmental health. Based on information from those programs, the program cost per single family dwelling unit covered is typically in the range of $20 to $150 per year, depending on the level of program services included. Those costs are usually recovered through an annual or monthly fee charged to the property owner, rather than through property tax revenues. This plan assumes a cost of $65 per year per dwelling unit with septic tank, or a cost of $325 every five years.

For more information about the cost estimates above as well as assumed unit costs for Structural BMP and stream restoration activities, please see the Technical Memorandum titled "Management Options Cost Estimate" at www.unrba.org.

5. Recommended Actions and Next Steps

The Upper Neuse River Basin Association recommends a phased approach to the consideration of this Watershed Management Plan:

- Phase I: Discussion and Endorsement of the Plan by UNRBA member governments, and
- Phase II: Development and Adoption of the Detailed Implementation Plan.

5.1 Phase 1: Discussion and Endorsement of the Plan

A key finding in the watershed analysis is that each local government in the Upper Neuse watershed needs to employ new protection measures if it wants to meet the water quality and habitat protection targets. Representatives from the 14 local governments, both staff and elected officials, have been involved in developing this Plan. The UNRBA Board of Directors has formally accepted the Plan and forwarded it to local staff and boards for their comment and consideration. In accepting the Plan, the Board made the following points. The UNRBA:

- Believes the Plan is a valid analysis of water quality change;
- Believes the recommended management strategies can achieve the UNRBA's management goals;
- Agrees to work within our respective local jurisdictions to implement all or portions of the Plan's management strategies, or equally protective strategies; and
- Understands that endorsement does not commit any individual partner to implementing all of the Plan's specific recommendations.

Now each member local government needs to discuss the recommendations and determine if it supports the Plan. Key to determining a local government's level of support—and its willingness to move to implementation (Phase II)—is its discussion of challenges to implementing the plan, including:

Agreeing on Protection Goals

Representatives of the Upper Neuse River Basin Association established a goal of nondegradation of the region's water supplies. Since the management strategies are driven by this goal, all local governments that are members of the Association will need to agree to this basic goal before considering the changes recommended. In other words, are the benefits of nondegradation worth the cost?

Paying for New Costs

This plan poses new costs to local communities in a time of shrinking resources. The challenge before each local government is how to phase in the plan, what combination of existing or new revenue sources to use (e.g., new user fees, impact fees, utility fees, or general tax revenues), and how to coordinate efforts with other governments so that implementing the plan is affordable. Although the strategies for paying for new costs would be finalized in Phase II, adopting the plan in concept would signal a local government's commitment to implementation.

Balancing Burdens and Benefits

Different management actions can pose different burdens and benefits of water quality protection. By outlining different management options for each local government to consider, the plan can launch negotiations for win-win solutions.

Perhaps the greatest challenge in the plan is creating a win-win solution for the protection of the region's water supply. For example, where protection of the water supply depends on land use controls by upstream jurisdictions that do not benefit from the supply, the implementation plan may need to find ways to share the burden or find alternative solutions that shift the balance of burden and benefit while being equally protective. As noted in Chapter 4, Recommended Strategies, many of the recommended actions would be most effective, and cost effective, if administered at the regional level. Such programs pose additional opportunities for balancing benefits and burdens and creating win-win approaches.

Several possible solutions to the problem could exist. For example, adopting performance standards could allow the planned development while protecting the resource from degradation. Creating funding and management mechanisms for watershed protection efforts can go a long way in balancing benefits and burdens. Allowing for targeted lands acquisition, conservation easements, purchases of development rights, or even transferring of development rights (TDR is not currently allowed under state regulations), could come from the users who benefit from clean drinking water. These and other potential solutions need to be explored in the implementation plan before the state increases protection requirements for any or all of these lakes.

Recommended Next Steps

- UNRBA presentation of the Plan to each member local government for comment and consideration.
- UNRBA presentation of the Plan to the Policy Coordinating Council comprised of the officers of the UNRBA, the executive management of the NC Department of Natural Resources, the NC Environmental Management Commission, the NC Department of Transportation, and the NC Department of Commerce.
- UNRBA begins detailed implementation planning process (described below).
- UNRBA presentation of Plan to the general public.
- Discussion and negotiation of revisions needed. Each local government board determines its level of support for the Plan, and if supported, formally endorses the Plan.
- Local Boards begin implementing all or portions of the Plan's recommended management strategies.

5.2 Phase II: Development and Adoption of the Detailed Implementation Plan

The purpose of Phase II is to move the recommended actions from paper to reality. The detailed Implementation Plan will outline actions that local and state agencies commit to take to address existing and future impacts. For each action, the Plan will document the group responsible for implementation, the timeline, the cost, and the funding source. While local and state agencies could initiate some actions within 5 years, other actions—particularly restoration projects—should be viewed as longer-term ventures spanning 10 to 20 years.

Appendix A

Development Ordinance Changes Recommended for Local Jurisdictions

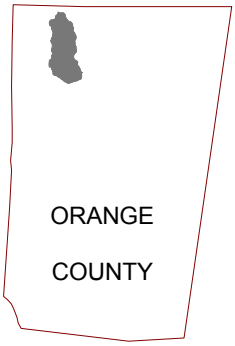
Development Ordinance Changes Recommended for County Areas (excluding existing and future urban development area)

Development Ordinance Changes Recommended for Orange County's Subwatersheds

Orange County's jurisdiction within the Upper Neuse Watershed covers portions of six upland drinking water supply watersheds; this land area constitutes approximately 25 percent of the Upper Neuse Watershed. For each drinking water supply watershed, you will find a brief description of the land area, existing regulations, and recommended changes to the development ordinance. First, there are two important notes:

1. The TAC recommended testing two alternative management scenarios: 5-acre lot zoning and 3-acre lot zoning with a small village allowed per township. A village was defined as a 50-acre area developing under a high density option (up to 70 percent imperviousness). Although the 5-acre lot zoning was the only scenario that absolutely met the non-degradation target (except for the Lake Orange subwatershed where existing zoning is sufficient), for two subwatersheds (West Fork Eno Corporation Lake, and Little River) the 3-acre lot zoning with village exceeded the water quality target by only 1 to 2 μg/l of chlorophyll *a* which was deemed adequate to address the target. Therefore, both are listed as meeting the target for these two subwatersheds.
2. Modeling demonstrated that Lake Ben Johnston is more sensitive to alternative management options. The Lake Ben Johnston subwatershed includes the West Fork Eno, Lake Orange, and Corporation Lake subwatersheds and can therefore potentially be impacted by activities that increase loading in those drainages. The West Fork Eno and Lake Orange reservoirs have more storage than Corporation Lake and thus provide more nutrient trapping than Corporation Lake. The trapping allows for different options to be selected for the West Fork Eno and Lake Orange subwatersheds, while still protecting the downstream waters. However, if Orange County wishes to meet the non-degradation target for the Lake Ben Johnston drinking water supply, the remaining drainage in the Corporation Lake subwatershed (i.e., the area below the West Fork Eno and Lake Orange subwatersheds) and the direct drainage to Lake Ben Johnston should be zoned at 1 unit per 5 acres and 5 percent maximum impervious area for new development, or should meet the nitrogen loading performance standard of 1.7 lbs/ac/yr and phosphorus loading performance standard of 0.3 lbs/ac/yr, rather than zoning for 1 unit per 3 acres with villages.

Northwest Upper Eno



Area in Orange County: 9.5 sq. mi.
2.4 percent of land area of Orange County

Existing development regulations:

- 1 unit per 2 acres in Critical Area
- 1 unit per acre and 12 percent impervious surface area maximum in Protected Area
- Stream buffer approximately 100 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

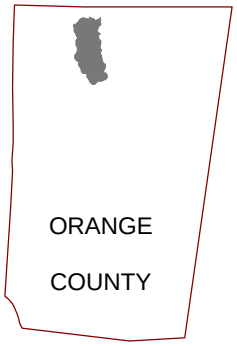
Enhanced peak flow management for any new developments >10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 5 percent impervious surface area maximum or
2. 1 unit per 3 acres plus 1 village per township or
3. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Northeast Upper Eno (Lake Orange)



Area in Orange County: 9.1 sq. mi.

2.3 percent of land area of Orange County

Existing development regulations:

- 1 unit per 2 acres in Critical Area
- 1 unit per acre and 12 percent impervious surface area maximum in Protected Area
- Stream buffer approximately 100 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

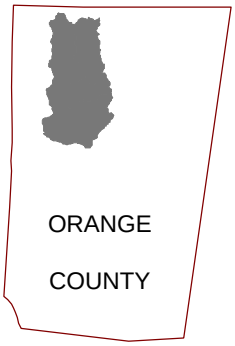
Enhanced peak flow management for any new developments ≥10 percent imperviousness

Options for Managing Water Quality

Existing regulations meet targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Upper Eno (Corporation Lake)



Area in Orange County: 41.4 sq. mi.

10.3 percent of land area of Orange County

Existing development regulations:

- 1 unit per 2 acres in Critical Area
- 1 unit per acre and 12 percent impervious surface area maximum in Protected Area
- Stream buffer approximately 100 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

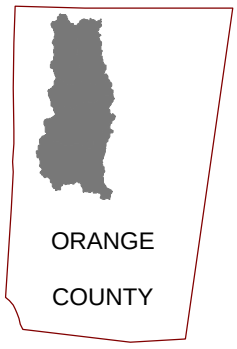
Enhanced peak flow management for any new developments ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 5 percent impervious surface area maximum or
2. 1 unit per 3 acres plus 1 village per township or
3. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Upper Eno and Sevenmile Creek (Lake Ben Johnston)



Area in Orange County: 60.2 sq. mi.

15.0 percent of land area of Orange County

Existing development regulations:

- 1 unit per 2 acres in Critical Area
- 1 unit per acre and 12 percent impervious surface area maximum in Protected Area
- Stream buffer approximately 100 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

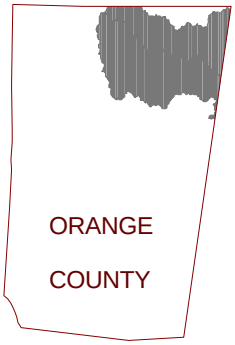
Enhanced peak flow management for any new developments ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 5 percent impervious surface area maximum or
2. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Little River Reservoir



Area in Orange County: 62.2 sq. mi.

15.5 percent of land area of Orange County

Existing development regulations

- 1 unit per 2 acres and 6 percent impervious surface area maximum
- Stream buffer approximately 100 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

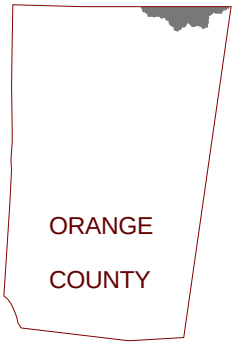
Enhanced peak flow management for any new developments ≥10 percent imperviousness 1 unit per

Options for Managing Water Quality

1. 5 acres and 3.5 percent impervious surface area maximum or
2. 1 unit per 3 acres plus 1 village per township or
3. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Flat River (Lake Michie)



Area in Orange County: 7.1 sq. mi.

1.8 percent of land area of Orange County

Existing development regulations:

- 1 unit per acre
- 12 percent impervious surface area maximum
- Stream buffer approximately 100 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Enhanced peak flow management for any new developments ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 5 percent impervious surface area maximum (for all County jurisdictions) or
2. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively, or
3. Durham builds upland lake and Orange County regulations are unchanged.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Durham County's Subwatersheds

Little River Reservoir

Area in Durham County: 32.9 sq. mi.

11.0 percent of land area of Durham County

Existing development regulations:

- 1 unit per 2 acres and 6 percent impervious surface area maximum
- Stream buffer: perennial 150 feet and intermittent 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

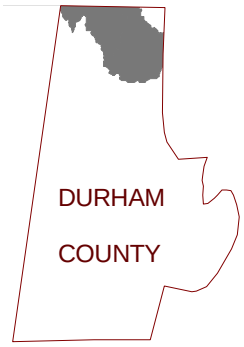
Enhanced peak flow management for any new developments ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 3.5 percent impervious surface area maximum or
2. 1 unit per 3 acres plus 1 village per township or
3. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Lake Michie



Area in Durham County: 28.2 sq. mi.

9.5 percent of land area of Durham County

Existing development regulations:

- 1 unit per 2 acres and 6 percent impervious surface area maximum
- Stream buffer: perennial 150 feet and intermittent 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Enhanced peak flow management for any new developments ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 5 percent impervious surface area maximum (for all county jurisdictions) or
2. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively, or
3. Durham builds upland lake in Person County.

Option not tested in model for water quality benefits: Durham expands Lake Michie.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Falls Lake Critical and Protected Areas

Area in Durham County: 103.9 sq. mi.

34.9 percent of land area of Durham County

Existing development regulations:

- 3.6 lb/ac/yr nitrogen loading limit for new development
- Critical Area
  - Low Density Option
    - Within ½ mile: 6 percent impervious surface area maximum; 1 unit per 2 acres
    - ½ to 1 mile: 9 percent impervious surface area maximum; 1 unit per 1 to 2 acres
  - High Density Option
    - Outside urban growth area: 40 percent impervious surface area maximum; control first 1 inch of rainfall
- Protected Area
  - Low Density Option
    - Inside urban growth area: 24 percent impervious surface area maximum; 20,000 sq.ft. minimum lot
    - Outside urban growth area: 12 percent impervious surface area maximum; 80,000 sq.ft. minimum lot
  - High Density Option
    - Inside urban growth area: 70 percent impervious surface area maximum

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development ≥10 percent imperviousness

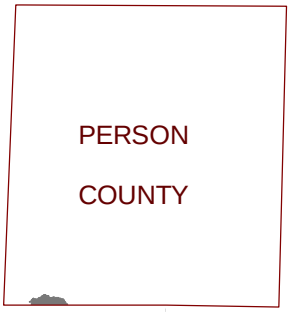
Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Person County's Subwatersheds

Little River Reservoir



Area in Person County: 0.15 sq. mi.

0.04 percent of land area of Person County

Existing development regulations:

- 1 unit per 1 acre and 12 percent impervious surface area maximum
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

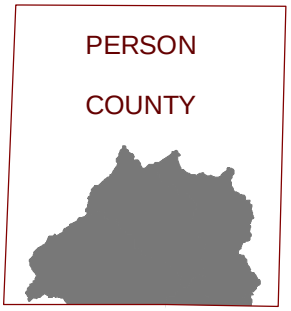
Require enhanced peak flow control for any development ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 3.5 percent impervious surface area maximum or
2. 1 unit per 3 acres or
3. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Lake Michie



Area in Person County: 125.8 sq. mi.

31.1 percent of land area of Person County

Existing development regulations:

- 1 unit per .5 acres and 24 percent impervious surface area maximum
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 5 acres and 5 percent impervious surface area maximum (for all jurisdictions) and 100 ft stream buffers or
2. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively or
3. Durham builds upland lake in Person County

Option not tested in model for water quality benefits: Durham expands Lake Michie.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Lake Holt

Area in Person County: 3.9 sq. mi.

0.97 percent of land area of Person County

Existing development regulations:

- 1 unit per 1 acre and 12 percent impervious surface area maximum
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development ≥ 10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 3 acres plus 10 percent of the watershed allowed at 50 percent imperviousness with stormwater controls and 75-foot stream buffers or
2. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively; and 75-foot stream buffers.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Granville County's Subwatersheds

Lake Holt

Area in Granville County: 20.8 sq. mi.

3.9 percent of land area of Granville County

Existing development regulations:

- 1 unit per 1 acre and 12 percent impervious surface area maximum
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development ≥10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 3 acres plus 10 percent of the watershed allowed at 50 percent imperviousness with stormwater controls and 75-foot stream buffers or
2. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively; and 75-foot stream buffers.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Lake Rogers

Area in Granville County: 17.6 sq. mi.

3.3 percent of land area of Granville County

Existing development regulations:

- 1 unit per 1 acre and 12 percent impervious surface area maximum
- Stream buffer: 50 feet

Development regulation changes required to meet interim target*:

Habitat Requirement

Require enhanced peak flow control for any development >10 percent imperviousness

Options for Managing Water Quality

1. 1 unit per 3 acres plus 10 percent of the watershed allowed at 50 percent imperviousness with stormwater controls and 75-foot stream buffers or
2. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 1.7 lbs/ac/yr and 0.3 lbs/ac/yr, respectively; and 75-foot stream buffers.

*Existing water quality in Lake Rogers is highly degraded. Watershed management alone will not achieve substantial water quality improvements. A Clean Lakes Assessment is highly recommended.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Falls Lake Critical and Protected Areas

Area in Granville County: 84.3 sq. mi.

15.7 percent of land area of Granville County

Existing development regulations:

- 24 percent impervious surface area maximum
- 20,000 sq. ft. minimum lot size
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development > 10 percent imperviousness

Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Franklin County's Subwatersheds

Falls Lake Critical and Protected Areas

Area in Franklin County: 5.0 sq. mi.

0.94 percent of land area of Franklin County

Existing development regulations:

- 24 percent impervious area maximum
- 40,000 sq. ft. minimum lot size without water & sewer (15,000 sq. ft. with water & sewer within a Cluster Subdivision—maximum density 1 dwelling unit per 40,000 sq. ft. with 20 percent open space)
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development > 10 percent imperviousness

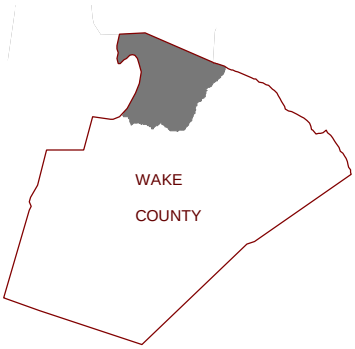
Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Wake County's Subwatersheds

Falls Lake Critical and Protected Areas



Area in Wake County: 100.1 sq. mi.

11.7 percent of land area of Wake County

Existing development regulations:

- 3.6 lb/ac/yr nitrogen loading limit for new development
- Critical Area: 6 percent impervious surface area maximum for commercial; 1 unit per 2 acres for residential
- Protected Area:
  - 12 percent impervious surface maximum without stormwater controls for commercial; 24 percent impervious surface area maximum with stormwater controls for commercial; 1 unit per acre for residential
- Stream buffer: 50 feet undisturbed

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development >10 percent imperviousness

Options for Managing Water Quality

Existing regulations meet water quality targets

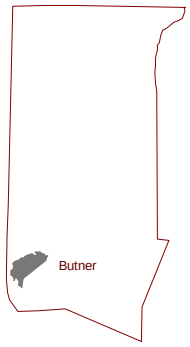
Wake County has developed a countywide watershed management plan. As a first phase, the county is committed to implementing existing regulations, including fully complying with the state's Nutrient Sensitive Water regulations. Wake County jurisdictions may strengthen these requirements as recommendations made in the county's Watershed Management Plan are implemented.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Urban Areas

Development Ordinance Changes Recommended for Butner's Subwatersheds

Falls Lake Critical and Protected Areas



Area in Butner: 6.8 sq. mi.

100 percent of land area of Butner

Existing development regulations:

- Critical Area: 50 percent impervious surface area maximum
- Protected Area: 70 percent impervious surface area maximum
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirements

Require enhanced peak flow control for any development ≥10 percent imperviousness

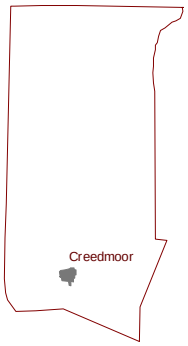
Options for Managing Water Quality

Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 3.6 lbs/ac/yr and 0.6 lbs/ac/yr, respectively.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Creedmoor's Subwatersheds

Falls Lake Critical and Protected Areas



Area in Creedmoor: 2.0 sq. mi.

93.4 percent of land area of Creedmoor

Existing development regulations:

- 24 percent impervious surface area maximum on a case-by-case basis
- 36 percent impervious surface area maximum without curb and gutter
- 14,000 to 20,000 sq.ft. minimum lot size depending on zoning district
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development >10 percent imperviousness

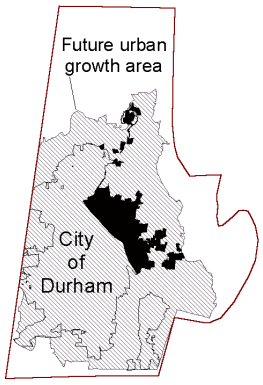
Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for City of Durham's Subwatershed

Falls Lake Critical and Protected Areas



Area in existing municipal zone: 16.5 sq. mi.; 18 percent of land area of City of Durham

Area in future urban growth area: 60.1 sq. mi.; future: 33.6 percent of land area of City of Durham

Existing development regulations:

- 3.6 lb/ac/yr nitrogen loading limit for new development
- Critical Area
  - Low Density Option
    - Within ½ mile: 6 percent impervious surface area maximum; 1 unit per 2 acres
    - ½ to 1 mile: 9 percent impervious surface area maximum; 1 unit per 1 to 2 acres
  - High Density Option
    - Outside urban growth area: 40 percent impervious surface area maximum; control first 1 inch of rainfall
- Protected Area
  - Low Density Option
    - Inside urban growth area: 24 percent impervious surface area maximum; 20,000 sq. ft. minimum lot
    - Outside urban growth area: 12 percent impervious surface area maximum; 80,000 sq. ft. minimum lot
  - High Density Option
    - Inside urban growth area: 70 percent impervious surface area maximum

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development >10 percent imperviousness

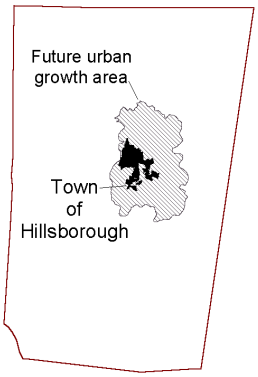
Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Town of Hillsborough's Subwatershed

Upper Neuse Watershed Area



Area in Existing Municipal: 3.9 sq. mi.; existing 100 percent of land area of Town of Hillsborough

Area in future urban growth area: 34.8 sq. mi.; future: 100 percent of land area of Town of Hillsborough

Existing development regulations:

- 3.6 lb/ac/yr nitrogen loading limit for new development
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development >10 percent imperviousness

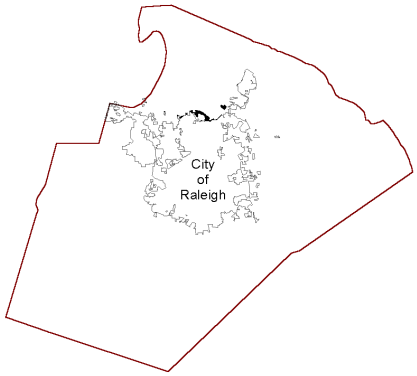
Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for City of Raleigh's Subwatershed

Falls Lake Critical and Protected Areas



Area in Existing Municipal: 0.89 sq. mi.; 0.8 percent of land area of City of Raleigh

Existing development regulations:

- 3.6 lb/ac/yr nitrogen loading limit for new development
- With utilities: 24 percent impervious surface area maximum
- Without utilities: 12 percent impervious surface area maximum
- Stream buffer: 50 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development > 10 percent imperviousness

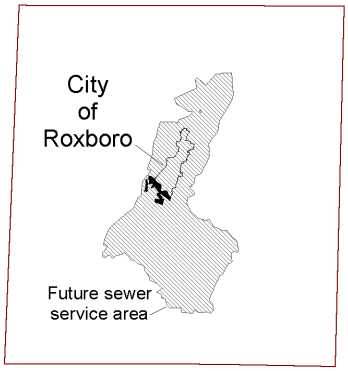
Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for City of Roxboro's Subwatershed

Lake Michie



Existing Area in Roxboro: 0.79 sq. mi.; existing: 19.5 percent of land area of Roxboro

Planned sewer service area: 34.3 sq. mi.; future: 62.7 percent of land area of Roxboro

Existing development regulations:

- Residential
  - 24 percent impervious surface area maximum
- Nonresidential
  - Up to 70 percent impervious surface area in 5 percent of the area
  - Subsequent development limited to 24 percent impervious surface area

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development ≥10 percent imperviousness

Options for Managing Water Quality

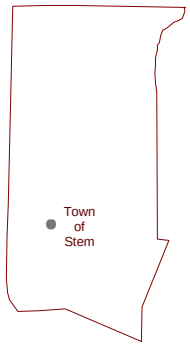
1. Performance standards for all new developments: maximum nitrogen and phosphorus surface loading of 3.6 lbs/ac/yr and 0.6 lbs/ac/yr, respectively or
2. Durham builds upland lake in Person County

Note: Impacts of the enlarged service area were not modeled. Therefore, potential adverse impacts on Lake Michie may be greater than those reported in the assessment results.

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Town of Stem's Subwatershed

Lake Rogers



Area in Existing Municipal: 0.79 sq. mi.; 100 percent of land area of Town of Stem

Existing development regulations:

- Stream buffer: 50 ft.

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development >10 percent imperviousness

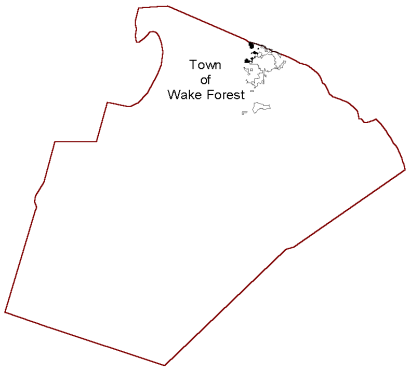
Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Development Ordinance Changes Recommended for Town of Wake Forest's Subwatershed

Falls Lake Critical and Protected Areas



Area in Existing Municipal: 0.54 sq. mi.; 7.9 percent of land area of Town of Wake Forest

Existing development regulations:

- 3.6 lb/ac/yr nitrogen loading limit for new development
- Critical Area
  - 6 percent impervious surface area maximum; 2 acre minimum lots
- Protected Area
  - With municipal services: 24 percent impervious surface area maximum
  - Without municipal services: 12 percent impervious surface area maximum
- Stream buffer: 100 feet

Development regulation changes required to meet non-degradation target:

Habitat Requirement

Require enhanced peak flow control for any development >10 percent imperviousness

Options for Managing Water Quality

Existing regulations meet water quality targets

See Chapter 4 for other recommended actions related to monitoring and enforcement, education, point source controls, and stream/wetland restoration.

Appendix B

Example Waivers and Variances for Stream Buffers

A) This ordinance shall apply to all proposed development except for that development which prior to the effective date of this ordinance:
   1) Is covered by a valid, unexpired plat in accordance with development regulations
   2) Is covered by a current, executed public works agreement
   3) Is covered by a valid, unexpired building permit
   4) Has been accepted to apply for a building permit
   5) Has been granted a waiver in accordance with current development regulations

B) The director of the agency may grant a variance for the following:
   1) Those projects or activities where it can be demonstrated that strict compliance with the ordinance would result in a practically difficult or financial hardship
   2) Those projects or activities serving a public need where no feasible alternative is available
   3) The repair and maintenance of public improvements where avoidance and minimization of adverse impacts to wetlands and associated aquatic ecosystems have been addressed
   4) For those developments which have had buffers applied in conformance with previously issued requirements

C) Waivers for development may also be granted in two additional forms, if deemed appropriate by the director:
   1) The buffer width may be relaxed if use of the Development Performance Evaluation Model demonstrates the site design meets nitrogen and phosphorus loading performance standards.
   2) (Planning Department) may offer credit for additional density elsewhere on the site in compensation for the loss of developable land due to the requirements of this ordinance. This compensation may increase the total number of dwelling units on the site up to the amount permitted under the base zoning.

Appendix C

Cost Estimate for Upper Neuse Management Plan

Appendix C. Cost Estimate for Upper Neuse Management Plan

			Counties						Municipalities								
	Program Year	Marginal Cost	Durham	Franklin	Granville	Orange	Person	Wake	Creedmoor	Durham	Hillsborough	Raleigh	Roxboro	Stem	Wake Forest	Butner	Upper Neuse River Basin - All Jurisdictions
New Development Site Management																	
Scenario 1 - Nitrogen Performance Standards (2)	1	✓	$ 520.00	$ 260.00	$ 520.00	$ 260.00	$ -	$ 780.00	$ 520.00	$ 5,460.00	$ 520.00	$ 260.00	$ -	$ 260.00	$ 260.00	$ 1,820.00	
	25	✓	$ 1,057.06	$ 528.53	$ 1,057.06	$ 528.53	$ -	$ 1,585.59	$ 1,057.06	$ 11,099.13	$ 1,057.06	$ 528.53	$ -	$ 528.53	$ 528.53	$ 3,699.71	
-OR-																	
Scenario 2 - Density Limits	1	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ 520.00	$ 5,460.00	$ 520.00	$ 260.00	$ 520.00	$ 260.00	$ 260.00	$ 1,820.00	
	25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,057.06	$ 11,099.13	$ 1,057.06	$ 528.53	$ 1,057.06	$ 528.53	$ 528.53	$ 3,699.71	
100 ft. Stream Buffers (on all streams for all new development in rural/conservation areas)	1 and 25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Scenario 1 - Peak Flow Management (24 hr., 1 yr. Storm; for all new development above 10% impervious)	1	✓	$ 2,000.00	$ 1,000.00	$ 2,000.00	$ 1,000.00	$ 1,000.00	$ 3,000.00	$ 2,000.00	$ 21,000.00	$ 2,000.00	$ 1,000.00	$ 2,000.00	$ 1,000.00	$ 1,000.00	$ 7,000.00	
	25	✓	$ 4,065.59	$ 2,032.79	$ 4,065.59	$ 3,032.79	$ 2,032.79	$ 6,098.38	$ 4,065.59	$ 42,688.68	$ 4,065.59	$ 2,032.79	$ 4,065.59	$ 2,032.79	$ 2,032.79	$ 14,299.56	
Scenario 2 - Peak Flow Management (24 hr., 1 yr. Storm; for all new development above 10% impervious)	1	✓	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ -	$ 1,000.00	$ 3,000.00	$ 2,000.00	$ 21,000.00	$ 2,000.00	$ 1,000.00	$ 2,000.00	$ 1,000.00	$ 1,000.00	$ 7,000.00	
	25	✓	$ 2,032.79	$ 2,032.79	$ 2,032.79	$ -	$ 2,032.79	$ 6,098.38	$ 4,065.59	$ 42,688.68	$ 4,065.59	$ 2,032.79	$ 4,065.59	$ 2,032.79	$ 2,032.79	$ 14,229.56	
Monitoring and Enforcement																	
Septic Tank Inspection and Certification Program	1	✓	$ 1,128,725.00	$ 66,625.00	$ 313,625.00	$ 705,250.00	$ 249,275.00	$ 606,450.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
	25	✓	$ 2,628,097.90	$ 239,158.20	$ 1,017,413.50	$ 1,899,392.00	$ 611,108.70	$ 2,484,074.40	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Inspections and Maintenance of Storm Drainage Systems	1	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ 12,224.90	$ 224,215.20	$ 22,336.97	$ 5,027.00	$ 4,539.44	$ 4,556.47	$ 3,083.98	$ 39,455.47	
	25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ 24,850.70	$ 455,783.25	$ 45,406.45	$ 10,218.86	$ 9,227.74	$ 9,262.36	$ 6,269.09	$ 80,204.84	
Inspections and Maintenance of Sanitary Sewer Systems	1	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ 54,332.88	$ 996,511.80	$ 99,275.40	$ 22,342.24	$ 20,175.28	$ 20,250.96	$ 13,706.56	$ 175,357.64	
	25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ 110,447.56	$ 2,025,703.31	$ 201,806.45	$ 45,417.17	$ 41,012.19	$ 41,166.03	$ 27,862.61	$ 356,465.98	
Enhanced Construction Site Inspection and Enforcement Action	1	✓	$ 734.80	$ 367.40	$ 734.80	$ 1,469.60	$ 367.40	$ 2,204.40	$ 734.80	$ 7,715.40	$ 734.80	$ 367.40	$ 734.80	$ 367.40	$ 367.40	$ 2,571.80	
	25	✓	$ 1,493.70	$ 746.85	$ 1,493.70	$ 2,987.39	$ 746.85	$ 4,481.09	$ 1,493.70	$ 15,683.82	$ 1,493.70	$ 746.85	$ 1,493.70	$ 746.85	$ 746.85	$ 5,227.94	

Appendix C. Cost Estimate for Upper Neuse Management Plan (cont.)

			Counties						Municipalities								Upper Neuse River Basin - All Jurisdictions
	Program Year	Marginal Cost	Durham	Franklin	Granville	Orange	Person	Wake	Creedmoor	Durham	Hillsborough	Raleigh	Roxboro	Stem	Wake Forest	Butner	
Enhanced Animal Operations Inspections (work with State to target potential problem areas)	1 and 25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Scenario 1 - Storm Water Quality BMP Inspection and Enforcement (for all development exceeding 10% Imperviousness)	1	✖	$ 684.00	$ 342.00	$ 684.00	$ 342.00	$ 342.00	$ 1,026.00	$ 684.00	$ 7,182.00	$ 684.00	$ 342.00	$ 684.00	$ 342.00	$ 342.00	$ 2,394.00	
	25	✖	$ 26,418.19	$ 5,561.72	$ 18,770.82	$ 17,380.39	$ 13,904.31	$ 49,360.31	$ 32,675.13	$ 353,864.73	$ 33,370.35	$ 11,123.45	$ 28,503.84	$ 1,390.43	$ 16,685.17	$ 113,320.14	
Scenario 2 - Storm Water Quality BMP Inspection and Enforcement (for all development exceeding 10% Imperviousness)	1	✖	$ 342.00	$ 342.00	$ 342.00	$ -	$ 342.00	$ 1,026.00	$ 684.00	$ 7,182.00	$ 684.00	$ 342.00	$ 684.00	$ 342.00	$ 342.00	$ 2,394.00	
	25	✖	$ 12,513.88	$ 5,561.72	$ 2,085.65	$ 18,075.61	$ 13,904.31	$ 45,884.23	$ 32,675.13	$ 353,864.73	$ 33,370.35	$ 11,123.45	$ 28,503.84	$ 1,390.43	$ 16,685.17	$ 113,320.14	
Education/Citizen Stewards																	
Scenario 1 - Education for Low-Impact Design (for development applications greater than 5 acres or exceeding 10% Imperviousness)	1	✓	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
	25	✓	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Scenario 2 - Education for Low-Impact Design (for development applications greater than 5 acres or exceeding 10% Imperviousness)	1	✓	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
	25	✓	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Education for Homeowners Regarding Buffer Maintenance	1	✓	$ 841.00	$ 23.00	$ 173.75	$ 516.50	$ 156.00	$ 431.00	$ 18.50	$ 1,531.00	$ 100.00	$ 58.50	$ 10.00	$ 3.25	$ 7.50	$ 25.50	
	25	✓	$ 1,964.70	$ 116.89	$ 599.67	$ 391.31	$ 427.90	$ 1,810.71	$ 70.13	$ 5,163.30	$ 290.69	$ 170.75	$ 33.54	$ 9.15	$ 45.74	$ 71.15	
Agricultural BMPs (possible cost-sharing with State and co-education with NRCS, Cooperative Extension)	1 and 25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Targeted Land Acquisition/Conservation Easements (cost to prepare and submit grant/other funding applications)	1	✓ (1)	$ 3,000.00	$ 3,000.00	$ 3,000.00	$ 3,000.00	$ 3,000.00	$ 3,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
	25	✓ (1)	$ 6,098.00	$ 6,098.00	$ 6,098.00	$ 6,098.00	$ 6,098.00	$ 6,098.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Adopt-a-Stream (with State assistance)	1	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
	25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	

Appendix C. Cost Estimate for Upper Neuse Management Plan (cont.)

			Counties						Municipalities								
	Program Year	Marginal Cost	Durham	Franklin	Granville	Orange	Person	Wake	Creedmoor	Durham	Hillsborough	Raleigh	Roxboro	Stem	Wake Forest	Butner	Upper Neuse River Basin - All Jurisdictions
Point Source Controls																	
NPDES Program Requirements	1 and 25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
DENR Policy: Regional WWTPs w/Tertiary Treatment	1 and 25	✖	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Total Cost (with Scenario 1)	1		$ 1,136,504.80	$ 71,617.40	$ 320,737.55	$ 711,838.10	$ 254,140.40	$ 616,891.40	$ 70,515.08	$ 1,263,615.40	$ 125,651.17	$ 29,397.14	$ 28,143.52	$ 26,780.08	$ 18,767.44	$ 228,624.41	$ 4,903,223.88
	25		$ 2,669,195.14	$ 254,242.98	$ 1,049,498.34	$ 1,929,810.41	$ 634,318.55	$ 2,553,508.48	$ 174,659.87	$ 2,909,986.22	$ 287,490.28	$ 70,238.41	$ 84,336.60	$ 55,136.14	$ 54,170.79	$ 573,289.32	$ 13,299,881.53
Total Marginal Cost (with Scenario 1)	1		$ 1,135,820.80	$ 71,275.40	$ 320,053.55	$ 711,496.10	$ 253,798.40	$ 615,865.40	$ 3,273.30	$ 35,706.40	$ 3,354.80	$ 1,685.90	$ 2,744.80	$ 1,630.65	$ 1,634.90	$ 11,417.30	$ 3,169,757.70
	25		$ 2,642,776.95	$ 248,681.26	$ 1,030,727.52	$ 1,912,430.02	$ 620,414.24	$ 2,504,148.17	$ 6,686.48	$ 74,634.93	$ 6,907.04	$ 3,478.92	$ 5,592.83	$ 3,317.32	$ 3,353.91	$ 23,298.36	$ 9,086,447.94
Total Cost (with Scenario 2)	1		$ 1,134,642.80	$ 71,357.40	$ 318,875.55	$ 710,236.10	$ 254,140.40	$ 616,111.40	$ 70,515.08	$ 1,263,615.40	$ 125,651.17	$ 29,397.14	$ 28,663.52	$ 26,780.08	$ 18,767.44	$ 228,624.41	$ 4,897,377.88
	25		$ 2,652,200.97	$ 253,714.46	$ 1,029,723.31	$ 1,926,944.31	$ 634,318.55	$ 2,548,446.81	$ 174,659.87	$ 2,909,986.22	$ 287,490.28	$ 70,238.41	$ 85,393.66	$ 55,136.14	$ 54,170.79	$ 573,219.32	$ 13,255,643.11
Total Marginal Cost (with Scenario 2)	1		$ 1,134,300.80	$ 71,015.40	$ 318,533.55	$ 710,236.10	$ 253,798.40	$ 615,085.40	$ 2,753.30	$ 30,246.40	$ 2,834.80	$ 1,425.90	$ 2,744.80	$ 1,370.65	$ 1,374.90	$ 9,597.30	$ 3,155,317.70
	25		$ 2,639,687.09	$ 248,152.73	$ 1,027,637.66	$ 1,908,868.70	$ 620,414.24	$ 2,502,562.58	$ 5,629.42	$ 63,535.80	$ 5,849.98	$ 2,950.39	$ 5,592.83	$ 2,788.79	$ 2,825.38	$ 19,528.65	$ 9,056,024.25

(1) Wake, Orange, and Durham Counties are already performing this activity

(2) An upland lake scenario, proposed by the City and County of Durham, at a cost of approximately $129.2 million, will meet nitrogen performance standards for Lake Michie

Glossary

Basin—The watershed of a major river system. There are 17 major river basins in North Carolina.

Benthic macroinvertebrates—Aquatic organisms, visible to the naked eye (macro) and lacking a backbone (invertebrate), that live in or on the bottom of rivers and streams (benthic). Examples include, but are not limited to, aquatic insect larvae, mollusks and various types of worms. Some of these organisms, especially the aquatic insect larvae, are used to assess water quality.

Best Management Practices—Structural and nonstructural techniques that store or treat stormwater runoff to reduce flooding, remove pollutants, and provide other amenities. BMPs can include structural controls such as grass swales or level spreaders, nonstructural controls such as buffer protection, or operation and maintenance procedures.

Biochemical Oxygen Demand—A measure of the amount of oxygen consumed by the decomposition of biological matter or chemical reactions in the water column. Most NPDES discharge permits include a limit on the amount of BOD that may be discharged.

BMPs—see *Best Management Practices*

BOD— see Biochemical Oxygen Demand

Buffer—An area adjacent to a shoreline, wetland, or stream where development is restricted or prohibited.

Chlorophyll *a*—The primary photosynthetic pigment of plants that gives them their green color. High concentration of chlorophyll *a* in a water body, usually indicate a large biomass of algae.

Degradation—The lowering of the physical, chemical, or biological quality of a waterbody caused by pollution or other sources of stress.

Dissolved Oxygen (DO)—A measure of the amount of oxygen available for biochemical activity in a given amount of water. Adequate levels of DO are needed to support aquatic life. Low DO concentrations can result from inadequate waste treatment.

DENR—North Carolina Department of Environment and Natural Resources

DO—See *Dissolved Oxygen*

DWQ—Division of Water Quality, an agency of DENR

Effluent—The treated liquid discharged from a wastewater treatment plant.

EMC—Environmental Management Commission

EPA—United States Environmental Protection Agency

Eutrophication (Eutrophic)—The process of physical, chemical, or biological changes in a lake associated with over-enrichment of a water body by nutrients, organic matter, and silt. Often, corresponding excessive algal growth can deplete dissolved oxygen and threaten certain forms of aquatic life, cause unsightly scum on the water surface and result in taste and odor problems.

Fecal Coliform Bacteria—A group of microorganisms found in the intestinal tracts of warm-blooded animals. Often used as indicators of the sanitary quality of water.

HU—see *Hydrologic Unit*.

Hydrologic Unit—A watershed area defined by a national uniform hydrologic unit system that is sponsored by the Water Resources Council. This system divides the country into 21 regions, 222 sub-regions, 352 accounting units, and 2,149 cataloging units. A hierarchical code consisting of two digits for each of the above four levels combines to form an eight-digit hydrologic unit (cataloging unit). An eight-digit hydrologic unit generally covers an average of 975 square miles. There are 54 eight-digit hydrologic units in NC, one of which is the Upper Neuse. The Natural Resource Conservation Service breaks eight digit hydrologic units into 14-digit hydrologic units. There are 28 14-digit hydrologic units in the Upper Neuse Watershed.

Hydromodification—Alterations to the natural hydrologic regime have resulted in changes in flow pattern in water bodies. Examples of hydromodification include dams, stream bank stabilization projects, and increases in impervious cover.

Impaired—The term that applies to a water body that has a use-support rating of partially supporting (PS) or not supporting (NS) its uses.

Impervious Area (Impervious Cover)—Impermeable surfaces, such as pavement or rooftops, that prevent the infiltration of water into the soil.

Indicators—Measurable quantities of chemicals (i.e., elements or compounds) or biota (i.e., organisms, species, or communities) that can be used to evaluate the relationship between pollutant sources and their impact on environmental conditions.

Loading—Mass rate of addition of pollutants to a water body (for example, kg/year)

Low-Impact Development—The use of small-scale and non-structural site design techniques that store, infiltrate, evaporate, and/or detain stormwater runoff in an effort to mimic the predevelopment hydrology of a site and minimize the impacts of development on water quality and water resources.

Macroinvertebrates— Aquatic organisms, visible to the naked eye (macro) and lacking a backbone (invertebrate). See *Benthic Macroinvertebrates*.

Macrophyte—An aquatic plant large enough to be seen by the naked eye.

Mesotrophic—A state of moderate biological productivity in lakes related to intermediate concentrations of available nutrients. Mesotrophic lakes show little, if any, signs of water quality degradation while supporting a good diversity of aquatic life.

Mg/l—Milligrams per liter

Non-degradation—A management target that sets as its goal to avoid any further degradation of a water body. Non-degradation targets do not necessarily mean improving the water quality of a water body.

Nonpoint Source Pollution—Diffuse sources of water pollution in a drainage area generally associated with runoff of rainfall or snowmelt. The quality and rate of runoff of NPS pollution is strongly dependent on the type of land cover and land use from which the rainfall runoff flows. For

example, rainfall runoff from forested lands will generally create much less runoff and contain much less pollution than runoff from urban lands.

Nutrients—Substances that are necessary for the growth of all living things (i.e., carbon, nitrogen, and oxygen).

NCDENR—North Carolina Department of Environment and Natural Resources

NPDES—National Pollutant Discharge Elimination System

NSW—Nutrient Sensitive Waters. A supplemental surface water classification intended for waters needing additional nutrient management due to their subjectivity to excessive growth of microscopic or macroscopic vegetation. The Neuse River Basin is classified as NSW.

Reservoir—Any holding area, natural or artificial, used to store, regulate, or control water.

Riparian area—A land area directly influenced by a body of water. Riparian areas usually have visible vegetation or other physical characteristics showing this water influence. Stream banks, lake borders, and marshes are typical riparian areas.

Runoff (Stormwater Runoff)—The rainfall that does not evaporate or infiltrate the ground but instead flows across land and into water bodies.

Sedimentation—Soil particles suspended in stormwater. These particles (for example, sediment, algae, and dead organisms) can settle in stream beds and disrupt the natural flow of the stream or degrade aquatic habitat.

Stormwater Runoff—See *Runoff*.

Stressor—Any physical, chemical, or biological entity that can induce an adverse response.

Sub-basin—A designated sub-unit or subwatershed area of a major river basin. Sub-basin typically encompass the watersheds of a significant stream or lake within a river basin. Every river basin is subdivided into sub-basins. The Upper Neuse River Watershed Management Plan divides the Upper Neuse Basin into 32 sub-basins.

303(d) list—Section 303(d) of the Clean Water Act requires states to develop a list of waters not meeting water quality standards or having impaired uses. Listed waters must be prioritized, and a management strategy or total maximum daily load (TMDL) must subsequently be developed for all listed waters.

TMDL—see *Total Maximum Daily Load*

TOC—see *Total Organic Carbon*

Total Maximum Daily Load (TMDL)—The maximum amount of pollutant loading that a waterbody segment can receive and still support water quality standards/designated uses.

Total Organic Carbon—Concentration of all organic (carbon-containing) chemicals.

Toxic Substance—Poisonous matter (either chemical or natural) that causes sickness, disease and/or death to plants or animals.

Tributary—A stream that flows into a larger stream, river, or other water body.

TSS—Total Suspended Solids

USEPA—United States Environmental Protection Agency

Village—Defined for purposes of watershed modeling, a village is a 50-acre area that would develop under a high density option (70 percent imperviousness), and that would be required to meet the Neuse Total Nitrogen requirement of 3.6 lbs/day. It is assumed that a village would have on-site water (i.e., well) and wastewater (i.e., septic) systems. The village concept was tested for Orange and Granville Counties, and the Little River Reservoir watershed that contains portions of Durham and Person Counties.

Watershed—The region, or land area, draining into a body of water (such as a stream, river, pond, lake, or sound). A watershed may vary in size from several acres for a small stream to thousands of square miles for a major river system (the Upper Neuse watershed is 770 square miles). The watershed of a major river system is referred to as a basin or river basin.

Water Supply Waters—Water Supply is a classification denoting fresh waters used as sources of water supply. There are five Water Supply categories. These range from WS-I, which supplies the highest level of protection, to WS-V, which provides no categorical restrictions on watershed development or wastewater discharges.

Wetland—An area of land that is regularly wet or flooded, such as a marsh or swamp.

WWTP—Wastewater treatment plant