Proposal for

DEVELOPMENT OF A WATERSHED EVALUATION TOOL FOR THE UPPER NEUSE RIVER BASIN, NORTH CAROLINA

Prepared for the

North Carolina Wetlands Restoration Program

and

Upper Neuse River Basin Association

by

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INTRODUCTION

The Upper Neuse River basin is located in the Piedmont Physiographic Province of North Carolina (fig. 1). The 770-square-mile portion of the basin upstream from the Falls Lake dam encompasses nine public drinking-water supply reservoirs that serve approximately 450,000 people, many of whom reside outside of the basin. While water-quality is generally good throughout the basin, the North Carolina Division of Water Quality designated 13 stream segments totaling 56.8 stream miles as impaired, because of low dissolved-oxygen concentrations or degraded benthic macroinvertebrate communities (North Carolina Department of Environment and Natural Resources, 2003). Suspected causes of degradation include hydro-modification and pollution from nonpoint sources, such as urban runoff and storm sewers, construction, and agriculture (North Carolina Department of Environment and Natural Resources, 2003).

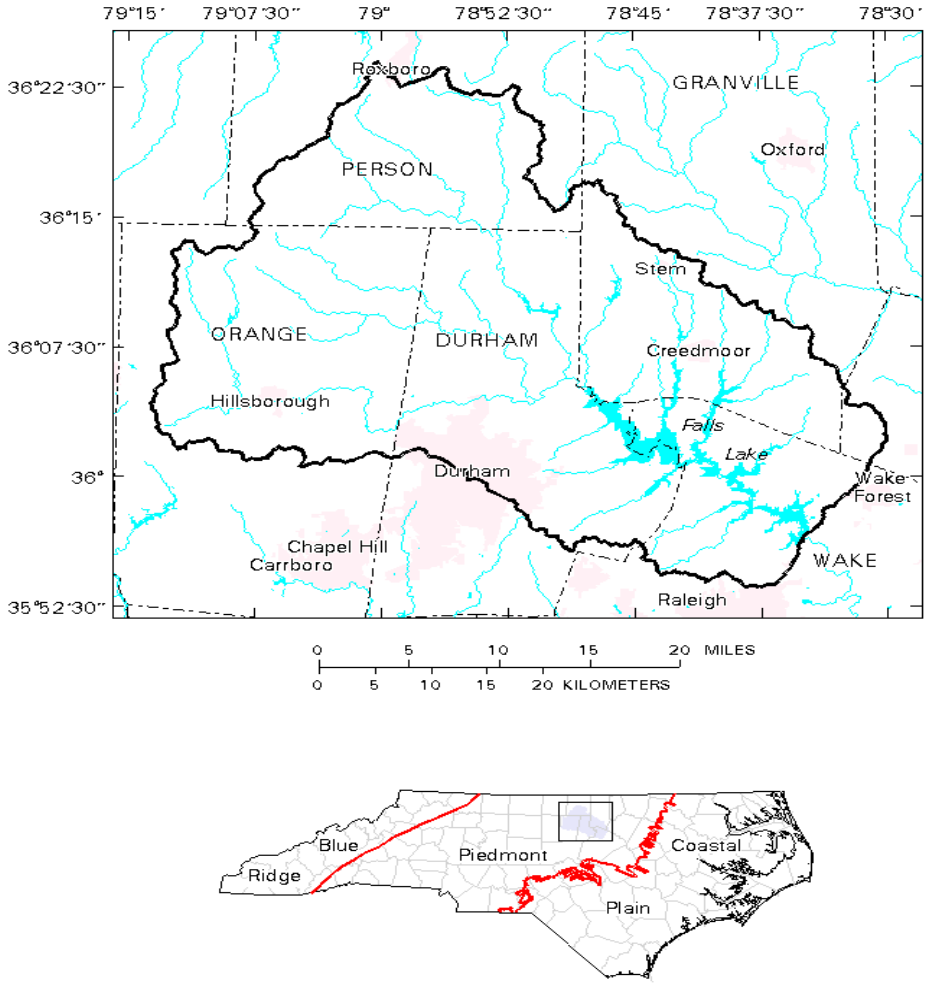

Figure 1. Location of the Upper Neuse River basin upstream from Falls Lake dam in the Piedmont Province of North Carolina.

Population in the basin grew by 21 percent between 1990 and 2000 (from 157,000 to 190,000; Tetra Tech (2003)). Over the next 25 years, population is projected to grow by 53 percent (from 190,000 to 280,000; Tetra Tech (2003)). In the process, rural and agricultural lands will be converted to urban and suburban uses. These changes likely will be accompanied by increased demands for drinking water and could result in additional water-quality degradation. Multiple local and State agencies have responsibility for water-resource management in the basin. In 1996, eight municipal and six county governments, along with local Soil and Water Conservation Districts, voluntarily formed the Upper Neuse River Basin Association (UNRBA) to provide a forum for cooperation in water-quality protection and water-resource planning and management. In May 2003, UNRBA members approved an Upper Neuse Watershed Management Plan (Tetra Tech, Inc., 2003), which identifies the following priority issues:

1. Protecting drinking-water quality
2. Protecting aquatic and riparian habitat and supporting recreational use
3. Maintaining adequate water supply and protecting aesthetics

The plan offers general strategies for meeting these goals in each of 32 "watershed-management units," which range in size from 5 to 55 square miles. However, the UNRBA, individual local governments, and State agencies such as the North Carolina Wetlands Restoration Program (NCWRP) need more detailed and more readily accessible information regarding stream and watershed characteristics to support planning efforts in the basin.

The National Hydrography Dataset (NHD) is a nationally consistent stream and waterbody geographic information system (GIS) dataset for the United States produced as a cooperative effort between the U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS). The nationwide dataset is available at a 1:100,000 scale, which is not detailed enough to support many local-scale analyses. Numerous State and local agencies and the U.S. Forest Service are cooperating with the USGS to create a high-resolution (1:24,000) NHD for the entire State to better support water-resource management at the local level. The NHD has been completed for the Upper Neuse River basin.

The NHD provides unique reach identifiers, or "addresses," for every stream segment in a basin, and the capability to navigate up- and downstream from any point in the network (fig. 2). It allows users to associate additional spatial information to the "address" of a stream reach, so that analysis can be done on these features in relation to the hydrologic network. Examples of useful ancillary data include land use/land cover, jurisdictional boundaries, and locations of water-supply intakes, monitoring sites, and pollution sources. Once these ancillary data are incorporated, the resulting NHD model is a tool that will support multiple applications, such as delineating watersheds for user-defined stream locations, summarizing acreages of different land uses upstream, and identifying areas with high potential for nonpoint-source runoff or pollutant loading. This watershed-evaluation capability would be useful for water-resource managers working in the Upper Neuse River basin.

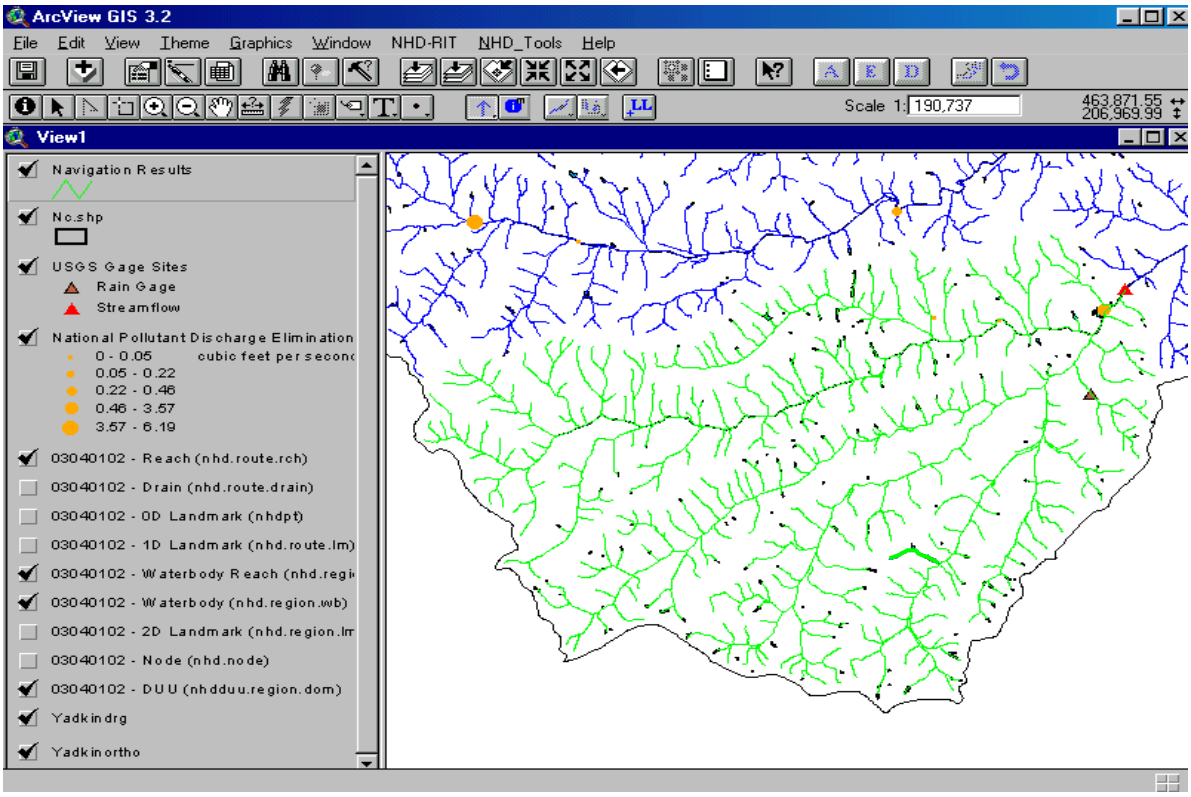

Figure 2. Screen image showing how stream reaches upstream from a gaging station are selected by using NHD navigation tools.

A spatially detailed, geographically referenced database that is based on the NHD and merges water-resource and other environmental information would assist these agencies in accomplishing several tasks. For example, the UNRBA has committed to developing a water-quality monitoring plan for the basin. Having digital access to stream maps, waterbody use-support ratings, land cover, locations of pollution sources, and historical monitoring results can help the UNRBA evaluate different monitoring sites and approaches. Local planners and utilities can use stream-network and related information to facilitate retrofitting pollution-control practices and develop plans for stormwater management and water-supply protection. The NCWRP can use information on hydrology, land cover, aerial photography, and watershed-delineation tools to streamline development of local watershed plans and to characterize potential mitigation sites.

PROBLEM

Spatial data needed to support decision-making in the Upper Neuse River basin exist in various physical locations, at disparate scales and levels of quality, and are of limited utility because they are not linked to a geo-referenced hydrologic network. Furthermore, evaluation of water-resource management options in the basin is slowed and complicated by the absence of tools for combining and evaluating spatial data. Agencies responsible for water-resource management in the Upper Neuse River basin, such as the NCWRP, UNRBA, and local governments, would benefit from high-resolution, spatially consistent, and accessible waterbody and watershed information to support decision-making. To be most useful, information on characteristics, such as stream features, land cover, high-resolution elevation, land and stream slope, imagery, contaminant sources, sites with water-quality or streamflow data, etc., would be integrated into a GIS database that could be accessed through a computer interface. Tools to navigate stream networks, delineate watersheds for user-defined stream segments, and to summarize stream and watershed characteristics would assist the UNRBA, NCWRP, and local governments in developing monitoring strategies and targeting scarce financial resources for protection and restoration efforts in the Upper Neuse River basin.

OBJECTIVE

The USGS proposes to provide a watershed evaluation tool for decision makers in the Upper Neuse River basin by developing an NHD model. Cooperators in this project will be the UNRBA and NCWRP. Specific objectives of this project are to:

1. Develop an NHD-based watershed evaluation tool for the Upper Neuse River basin, for access through a computer interface running ArcView GIS software,

2. Provide hands-on training in the use of the watershed evaluation tool to water-resource planners and managers in the basin, including members of the UNRBA and NCWRP, and

3. Demonstrate the capability of the watershed evaluation tool by using it to summarize geo-referenced information for sites being considered by the UNRBA for long-term water-quality monitoring.

SCOPE

The study area includes the Upper Neuse River basin, from its headwaters to the Falls of the Neuse Reservoir dam near Raleigh, North Carolina. This 770-square mile area represents approximately the uppermost third of the USGS hydrologic unit 03020201. The study will be conducted during an 18-month period. Pending receipt of the Joint Funding Agreement by October 1, 2003, the project will begin October 2003 and end March 2005.

RELEVANCE AND BENEFITS

Information obtained from this study will support USGS water-resource priorities at both the national and district levels. In support of national Cooperative Program issues, the proposed study will provide information to support efforts to improve water quality and stream ecosystems in degraded watersheds; improve the availability and dissemination of water-quality and hydrologic information; provide a better understanding of the relations between water quality and the health of stream ecosystems; and improve watershed characterization for better management of water supplies and ecosystems (U.S. Geological Survey, 2002). The study will support the North Carolina District Science Plan (Bales and others, 2002) by compiling and distributing hydrologically relevant geospatial data to support water-resource management; providing a framework for future water-resources studies in an urbanizing area; and supporting the efforts of State water-resources programs, especially the Wetlands Restoration Program.

The watershed evaluation tool will be useful for guiding management measures in the basin, such as targeting future monitoring efforts, supporting water-quality models, acquiring land for conservation, establishing streamside buffers, selecting stream restoration sites, and prioritizing pollution-control practices to achieve maximum benefits.

APPROACH

To meet the project objectives, the USGS will complete the tasks outlined below. USGS project staff will meet with the cooperators at least once every quarter to discuss progress on the project.

1. The high-resolution NHD data (1:24,000 scale) for hydrologic unit 03020201 will be downloaded, the accuracy of the flow direction table will be verified, and all layers will be clipped to the study area.

2. NHD tools for indexing outside data sources, navigation, and watershed delineation will be downloaded from the USGS National Hydrography Dataset website (http://nhd.usgs.gov/tools.html). Watershed characterization tools available from USGS-Massachusetts District also will be installed.

3. Environmental features will be incorporated by indexing (linking with a reach-code address) ancillary datasets to the NHD. Ancillary datasets may include but not be limited to those listed in table 1. Final selection will be made following discussions with the cooperators. Only datasets that are available electronically and that can be easily compiled/converted to GIS coverages will be included. The USGS will include as many of these datasets (and others identified by the cooperators) as time and funding permit.

Table 1. Potential datasets to be incorporated into the proposed watershed evaluation tool for the Upper Neuse River basin.

[USGS, U.S. Geological Survey; NCCGIA, North Carolina Center for Geographic Information and Analysis; USEPA, U.S. Environmental Protection Agency; NCDOT, North Carolina Department of Transportation; NCDENR, North Carolina Department of Environment and Natural Resources; NPDES, National Pollutant Discharge Elimination System; NCDWQ, North Carolina Division of Water Quality; NRCS, Natural Resources Conservation Service]

Potential Dataset	Source
BASE LAYERS	
1:24K National Hydrography	USGS/NCCGIA
Aerial photography	USGS
Digital raster graphics (7.5 minute topographic maps)	USGS
Land cover (Neuse basin)	USEPA
Municipal boundaries	Local governments
Transportation features	NCDOT
INDEXED DATA	
Point Data	
NPDES sites	NCDENR
Landfills	NCDENR
Hazardous waste sites	NCDENR
Confined animal feeding operations	NCDENR
NCDWQ monitoring sites	NCDA
Public water-supply intakes	NCDENR
Over-water bridges	NCDOT
USGS gages and monitoring sites	USGS
USGS low-flow and flood-frequency sites	USGS
Line Data	
NCDWQ use classifications for surface water	NCDENR
NCDWQ use support ratings for surface water	NCDENR
Polygon Data	
Wetlands	NCDENR
Soils (SSURGO, 1:24,000)	NRCS

4. The North Carolina Flood Mapping Program's LIDAR-derived elevation data will be compiled for the study area to create a continuous-surface digital elevation model (DEM) at a 20-foot spacing. A continuous surface of slope values, flow direction, and a stream network will be derived from the DEM.

5. In order to take full advantage of the higher resolution and more recent LIDAR-derived elevation products, the NHD will be correlated to the derived stream network so that each derived-stream has a reach code associated with it. A watershed boundary will be delineated for each reach based on the higher resolution LIDAR-derived streams. Links will exist between the LIDAR-defined watersheds and the

NHD, allowing for navigation along watersheds in the same manner that navigation along streams is done.

6. Selected watershed characteristic, such as those listed in table 2, will be summarized for each reach. Final selection of watershed characteristics will be made following discussions with the cooperators.

Table 2. Potential watershed characteristics to be computed for each reach

Watershed Characteristic
Boundary
Area
Land cover
Road miles
Slope statistics
Soil permeability, thickness, and hydrologic group

7. The preliminary watershed evaluation tool will be circulated to cooperators for testing and review.

8. Meetings in which UNRBA members discuss long-term water-quality monitoring in the basin will be attended. The watershed evaluation tool will be used to supply information for potential monitoring sites identified by the UNRBA, such as watershed characteristics (land cover, etc.), the presence of existing water-quality and streamflow data, potential pollutant sources, etc.

9. Datasets included in the watershed evaluation tool will be documented with metadata.

10. Training will be provided to the cooperators in the use of the watershed evaluation tool.

11. Project results will be summarized in a published journal article.

PRODUCTS

The watershed evaluation tool will consist of an ArcView project that incorporates the 1:24,000 NHD, a digital elevation model, linked ancillary data, and derived watershed characteristics. The USGS will provide tools and extensions to run in ArcView but will not provide ArcView software to the cooperators. Datasets produced by the USGS for this project will be fully documented with metadata. The USGS will provide the cooperator with hands-on training in the use of the tool and in methods of indexing additional data as the data become available. Training will include a demonstration for testers of the preliminary watershed evaluation tool and one

training session for a core group of cooperators upon delivery of the final tool. The final training session will consist of a tutorial describing the datasets and use of four NHD functions incorporated in the tool--routing and navigation, indexing, watershed delineation, and watershed characterization.

Results will be published in a peer-reviewed journal, such as the Journal of the Urban and Regional Information Systems Association or the Journal of the American Water Resources Association. The journal article will describe development of the tool, how it will be used to support the development of a monitoring plan for the Upper Neuse River basin, and potential future applications. The USGS also will present results to interested parties convened by the cooperators.

PERSONNEL

This project will require the following personnel on a part-time basis: a hydrologist (Mary Giorgino) to serve as project chief; a GIS specialist (Silvia Terziotti) to process LIDAR data into an elevation model and to build the watershed evaluation tool; a technician to index ancillary datasets; and a writer-editor and illustrator to assist with preparation of the journal article.

FUNDING

Proposed expenditures total $150,000. Subject to Federal funding, matching funds of up to $75,000 may be provided by the USGS. Expenditures include labor, equipment, supplies, travel, and costs associated with publication of the journal article.

TIMELINE

An 18-month period is needed to complete the tasks outlined in the Approach (table 3).

Table 3. Project timeline with proposed start date of October 1, 2003

	2003			2004												2005		
TASK	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Planning and progress meetings with cooperators	X	X			X				X		X			X				X
Download and quality-assure the NHD data and tools	X	X																
Compile ancillary data	X	X	X	X														
Index ancillary data to NHD			X	X	X	X	X											
Create a digital elevation model from LIDAR data			X	X	X													
Delineate reach watershed boundaries; derive and incorporate watershed characteristics						X	X	X										
Circulate draft watershed evaluation									X									

tool to cooperators for testing and review																		
Meetings with UNRBA to discuss monitoring sites and approaches	X				X				X				X					
Summarize information for potential monitoring sites and provide technical expertise regarding monitoring plans							X	X	X	X	X	X						
Revise watershed evaluation tool based on input from testers											X	X	X					
Document data sets (metadata)		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Prepare and submit article for publication											X	X	X	X	X	X	X	X
Deliver final tool to cooperator and provide training																	X	X

REFERENCES:

Bales, J.D., Chapman, M.J., Oblinger, C.J., and Robbins, J.C., 2002, North Carolina District science plan--Science goals for 2003-2008: Raleigh, U.S. Geological Survey North Carolina District, 31 p.

North Carolina Department of Environment and Natural Resources, 2003, North Carolina water quality assessment and impaired waters list (2002 Integrated 305(b) and 303(d) Report): Raleigh, North Carolina Department of Environment and Natural Resources Division of Water Quality, 101 p.

Tetra Tech, Inc., 2003, Upper Neuse watershed management plan: Research Triangle Park, North Carolina, 70 p.

U.S. Geological Survey, 2002, Program priorities for 2003: U.S. Geological Survey, Water Resources Discipline Informational Memorandum 2002.07, accessed on March 14, 2003, at http://water.usgs.gov/coop/priorities.html.