Neuse ModMon investigations confirm recovery of Neuse River Estuary will be slow

The Neuse River Estuary is a troubled ecological system. Algae blooms, fishkills, and what many perceive as a decline in fisheries have plagued the system for decades, reaching a peak in 1995 with appearance of the toxic dinoflagellate *Pfiesteria piscicida* and a number of large fishkills.

In 1995 the N.C. Senate Select Committee on River Water Quality and Fish Kills assembled a group of university scientists to focus on Neuse water quality issues. In January 1996, the group issued a set of findings and recommendations for improving water quality in the estuary. It was the judgment of the group that the estuary is suffering from nutrient overenrichment and that capping nitrogen loading at 70% of the 1990-95 average load will produce a detectable improvement in water quality within five years after loading reduction to that level has been achieved.

The N.C. General Assembly and the N.C. Environmental Management Commission responded to the scientists’ recommendations. In August 1998 a package of rules went into effect aimed at reducing nitrogen loading to the Neuse River Estuary by 30% of the 1995 baseline. The rules are intended to reduce eutrophication, as measured by chlorophyll concentrations, in the estuary.

Although there is much public support for efforts to improve water quality in the Neuse River, there are also many questions about whether the “Neuse River rules” will accomplish what the public wants:

- Just what are the goals that people who live in the Neuse River Basin, especially near the estuary, want to see accomplished by the Neuse River cleanup?
- Are we using all the scientific knowledge we have about the Neuse to try to make sure we are targeting the right problems?
- If the rules are effective at reducing nitrogen loading by 30%, will the reduction accomplish the desired goals?
- If a 30% reduction will accomplish the desired goals, how long will it be before we begin to see results?

Neuse ModMon investigations confirm recovery of Neuse River Estuary will be slow

Retirements at WRRI

The Water Resources Research Institute will soon say farewell to two long-time staff members. Eva Walters will retire on March 31. Eva has been the cheerful and helpful first point of contact for investigators and the public for 30 years, having served as secretary to 5 directors. Frances Yeargan will retire April 30. As accounting technician, Frances has kept the ledgers, helped investigators manage their budgets, registered workshop and conference participants, filed timesheets for interns and graduate students, and handed us all our checks for 20 years.

We will miss Eva and Frances, and wish them lots of relaxation, family company and travel in retirement.

IN THIS ISSUE

<table>
<thead>
<tr>
<th>In This Issue</th>
<th>March/April 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director’s Forum: How to establish practical water quality standards</td>
<td>2</td>
</tr>
<tr>
<td>Improving water quality takes time: Success on the Chowan River brings new hope for the Neuse</td>
<td>8</td>
</tr>
<tr>
<td>February-March action of the N.C. Environmental Management Commission</td>
<td>11</td>
</tr>
<tr>
<td>Division of Water Quality begins new enforcement initiative to protect wetlands</td>
<td>12</td>
</tr>
<tr>
<td>Neuse Basin Oversight Committee presents method for accounting for agricultural nitrogen reductions</td>
<td>12</td>
</tr>
<tr>
<td>Aging dams pose threats to life, property, and water quality</td>
<td>13</td>
</tr>
<tr>
<td>PLUS Water Resources Conditions . . . People . . . Publications</td>
<td></td>
</tr>
</tbody>
</table>
Director’s Forum

How to establish practical water quality standards

Kenneth H. Reckhow, Director, Water Resources Research Institute

Surface water standards should be among the more practical measures to protect water quality in North Carolina. Given the importance of standards, how should standards be established, and how might they be interpreted for effective enforcement?

It is common practice for an environmental agency to establish guidelines for the acceptability of water quality in terms of criteria and standards. A water quality criterion is typically a numeric value or narrative statement that largely reflects a judgment concerning the scientific evidence on the effects of the contaminant of interest. A water quality standard is typically based on the scientific evidence in support of the water quality criterion, but the standard is a rule established by an authority (e.g., the Environmental Management Commission).

One implication of the distinction between a criterion and a standard is the fact that a standard essentially elevates a scientific assessment (the criterion) into a legal rule (the standard) formalized by an authority. Establishment of the standard implies that some balancing of costs and benefits has occurred. To be specific, achievement of water quality standards usually comes at a cost (e.g., the cost of additional wastewater treatment), so there should be some recognition that the benefits achieved in meeting the standards are comparable to those costs.

Beyond that, standards are effective only if there is a clear means for enforcement. To understand the difficulties associated with enforcement, consider North Carolina’s chlorophyll a water quality standard of 40 µg/l. For selected water bodies, violation of this standard may be determined through either monitoring or prediction and may result in action by the Environmental Management Commission. Unfortunately, it is not uncommon for water quality monitoring results to yield chlorophyll a in excess of 40 µg/l. Should each of those cases constitute a violation?

Based on the written standards, each water quality sample that exceeds 40 µg/l could be called a standard violation. However, practical considerations such as naturally occurring eutrophication, spatial/temporal variability in chlorophyll a, and measurement error could make this an enforcement nightmare. A better, more operational approach to water quality standards is to incorporate natural variability and sampling error into the standard (Barnett and O’Hagan 1997). For example, an appropriate standard might be expressed as “the concentration of chlorophyll a should not exceed 40 µg/l for more than 10% of the time in a given year.” This statement reflects natural variability. To completely operationalize this standard, a compliance criterion is needed that acknowledge...
In 1997, with funding from the N.C. Department of Environment and Natural Resources, scientists at four universities undertook an effort to help answer these and other questions. Under the coordination of Kenneth H. Reckhow, Director of the Water Resources Research Institute, scientists began:

- compiling and analyzing existing information about the Neuse to detect historical water quality trends and connect water quality trends with problems in the estuary;
- monitoring intensively in the Neuse Estuary to learn more about how the complex system works;
- calibrating and improving a model to predict the response in the estuary to a 30% nitrogen reduction;
- comparing various models to find the best approach for predicting—a long-term basis—the likelihood that the 30% reduction goal will be accomplished by controls throughout the basin, and
- surveying citizens and “stakeholders” throughout the Neuse River basin to learn what they want to see accomplished by the Neuse River cleanup and how they will measure progress toward the goals.

### Top ten rankings of stakeholder interests in the Neuse River from 50 written and phone surveys

Scale: 1=least important, 5=most important.

(Research by Maloney, Maguire, and Lind. In press.)

<table>
<thead>
<tr>
<th>Interest</th>
<th>Average Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision-making based on sound science</td>
<td>4.52</td>
</tr>
<tr>
<td>Healthy oxygen levels</td>
<td>4.00</td>
</tr>
<tr>
<td>Water safe for swimming and recreation</td>
<td>3.96</td>
</tr>
<tr>
<td>Fair allocation of cleanup costs</td>
<td>3.92</td>
</tr>
<tr>
<td>Confidence in safety of seafood</td>
<td>3.80</td>
</tr>
<tr>
<td>Avoiding excessive regulations</td>
<td>3.68</td>
</tr>
<tr>
<td>Shellfish beds open for harvest</td>
<td>3.36</td>
</tr>
<tr>
<td>Good supply of commercial fish</td>
<td>3.32</td>
</tr>
<tr>
<td>No more Pfiesteria</td>
<td>3.25</td>
</tr>
<tr>
<td>Clear water</td>
<td>3.23</td>
</tr>
</tbody>
</table>

### Neuse ModMon investigations continued

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- surveying citizens and “stakeholders” throughout the Neuse River basin to learn what they want to see accomplished by the Neuse River cleanup and how they will measure progress toward the goals.

The first stage of the so-called Neuse ModMon Program ended in December 1998, and researchers have completed draft reports on their investigations. Their findings confirm that it is likely to take many years to nurse the Neuse River Estuary back to health—that is to the point that healthy oxygen levels prevail, massive algae blooms and Pfiesteria have become a thing of the past, and benthic communities that support fisheries are restored to their former robustness.

However, investigators also found that many stakeholders in the Neuse Basin understand that restoring the estuary is a long-term project and want to see the State stay the course and more thoroughly educate the general public about its responsibilities to the Neuse.

**What are the goals that people who live in the Neuse River Basin, especially near the estuary, want to see accomplished by the Neuse River cleanup?**

To answer this question, Karin A. Maloney and Lynn A. Maguire of the Duke University Nicholas School of the Environment and E. Allan Lind of the Fuqua School of Business monitored public meetings, administered and analyzed written questionnaires, and surveyed citizens and “stakeholders” throughout the Neuse River basin to learn what they want to see accomplished by the Neuse River cleanup and how they will measure progress toward the goals.

Reference

conducted personal and telephone interviews with Neuse stakeholders. When they asked people what is most important to them in relation to the Neuse River, they found that stakeholders are as concerned with fairness and economic rationality as they are with water quality.

At the top of the list of stakeholder interests in the Neuse River is “decision making based on sound science.” Also high on the list are “fair allocation of cleanup costs” and “avoiding excessive regulations.” As far as water quality goals, stakeholders ranked “healthy oxygen levels” number 2 on the list of interests and “water safe for swimming and recreation” number 3. Interest in the safety of seafood, open shellfish beds, and good supplies of commercial and sport fish was high. “No more Pfiesteria” and “clear water” ranked 9 and 10 on the list.

In discussions of citizen involvement in managing the Neuse, stakeholders told the investigators that citizens throughout the basin must be educated about what the short-term and long-term effects of the Neuse cleanup program are likely to be so that they will not be unrealistic in their expectations.

Are we using all the scientific knowledge we have about the Neuse to try to make sure we are targeting the right problems?

People have been concerned about the Neuse Estuary for decades, and government agencies and university scientists have conducted monitoring and research programs in the river since the early 1970s. While all the Neuse ModMon projects built on work done in the Neuse by earlier investigators, two projects used existing data exclusively to analyze how the system works and to detect historical trends.

**Nutrient Trends.** Craig A. Stow and Mark E. Borsuk of the Duke University Nicholas School of the Environment used long-term nutrient concentration data collected by the N.C. Division of Water Quality and river flow data collected by the U.S. Geological Survey to examine nutrient-loading patterns in the Neuse River and nutrient concentrations in the Neuse Estuary from the 1970s through 1997. They found that phosphorus loads have declined at all monitoring stations considered and that the 1988 phosphate detergent ban was quickly mirrored by a decrease in phosphorus concentration in the estuary. They found that nitrogen loading decreased at the monitoring station above Raleigh following completion of the Falls Lake dam; that nitrogen loading steadily increased at the Clayton monitoring station beginning in the mid-1980s (probably from increased wastewater discharge); and that there is no clear trend in nitrogen loading—either increase or decrease—over the period considered at the Kinston station or in the estuary.

The investigators say it is most likely that nitrogen increases seen at Clayton are not reflected at Kinston or in the estuary because instream denitrification removes nitrogen from the system. They say this finding—plus nutrient loading estimates based on land use changes from 1880-1985 and recent sediment core analyses—suggests that the current water quality problems in the estuary are the result of chronic nutrient overloading and not recent increases in nutrient loading.

They also say that the important role that denitrification apparently plays in the Neuse River will make it more difficult to predict how loading reductions upstream will affect the estuary. The rate at which denitrification takes place has been shown to be higher when nitrate loading is higher. If loading is decreased, the rate of denitrification may decrease and offset the loading reduction.

**Nitrogen Cycling.** Robert R. Christian and Cassondra Thomas of East Carolina University used data from 4 years of study by Christian and other ECU researchers to construct a model of how nitrogen flows between the many bio-geo-chemical compartments that make up the Neuse River Estuary. Their “network” model of the Neuse Estuary shows that an atom of nitrogen entering the estuary is cycled many times among the river sediments, water column, living algae, and decomposing detritus before it is finally buried below surface sediments or exported from the system as dinitrogen gas. Algae growth in the estuary may take up the same atom of nitrogen up to 35 times.

This work indicates that since the recycling phenomenon maintains a pool of nitrogen in the estuary for most of the year, the availability of nitrogen for algae growth does not depend on loading from outside the estuary. Indeed, statistical analyses done by Christian and Thomas using loading estimates at Kinston provided by Stow and Borsuk show little correlation between current nitrogen...
loading and algae production in the estuary.

These investigators say that because recycled nitrogen can continue to fuel algae growth in the estuary for some time, a 30% reduction in nitrogen loading may produce no immediate observable reduction in algae production.

If the rules are effective at reducing nitrogen loading by 30%, will the reduction accomplish the desired goals?

Water quality prediction. To create a tool to predict water quality responses in the Neuse Estuary to a 30% nitrogen loading reduction, UNC-Charlotte investigators James D. Bowen and Jeffrey Hieronymus tailored an existing mechanistic water quality model (CEQUAL-W2) to simulate conditions in the estuary. Using hydrodynamic and water quality data from 1991, Bowen ran a simulation to predict what would have happened that year if nitrogen loading had been reduced 30%. The model predicted that a 30% nutrient load reduction would have resulted in a 16-23% reduction in median chlorophyll (indicative of algae production) throughout the estuary. The greatest reduction would have occurred in the lower, mesohaline or more salty, portion of the estuary. The model also predicted minor improvement in dissolved oxygen levels in the estuary.

The investigator says the model results suggest that while the 30% reduction will likely produce water quality improvement—as measured by chlorophyll and dissolved oxygen—the improvement will not be dramatic and may not be observable to the public right away. And, he cautions that because model predictions depend so heavily upon weather-related factors such as river flow, predictions for any one year in the future are problematic.

New knowledge about the estuary. The intensive monitoring effort conducted by scientists at the UNC-Chapel Hill Institute of Marine Sciences and Duke University Marine Lab has provided important new understandings of the physical processes that drive circulation and hydrography in the Neuse River Estuary as well as the estuary’s benthic (or bottom) environment and its biological communities. This new knowledge may shed light on fishkills and fish habitat and help in predicting the effect on fish of the 30% nitrogen reduction.
kill occurred in this region after an extended period of stratification and at the time of a rapid wind shift that caused upwelling near Minnesott Beach and presumably along a significant section of the northern shore. They also note that of the 5 reported fishkills in the Neuse Estuary in 1998, 4 occurred in this section and that in 1995, one of the worst recorded years of fish mortality in the Neuse, all 9 kills were in this region.

They say that if fishkills in the Neuse are related to anoxic bottomwaters upwelling and trapping fish, as they suspect, this reach of Neuse River may be a region of chronic fish kills because of a unique combination of physical factors.

**Nutrients in the water column and algae growth.** James L. Pinckney, Tammi L. Richardson and Hans W. Paerl of the UNC-CH Institute of Marine Sciences conducted extensive water quality monitoring in the Neuse Estuary to help improve the ability of the nutrient response model to predict how algae will react to a 30% nitrogen reduction. The data collected under ModMon, combined with water quality data collected by various agencies and scientists since January 1994, provide a continuous water quality record of nearly 5 years for the segment of the estuary from Streets Ferry to Cherry Point. These data show that algae are most productive from early spring through summer and that the highest growth takes place between New Bern and Cherry Point. Different groups of phytoplankton bloom at different seasons and different locations in the estuary.

**Sediment and water column interactions.** Studies have shown that the Neuse River Estuary serves as an efficient sediment trap and that accumulated estuarine bottom sediments—mostly fine, organic muds—are washed out of the estuary and into Pamlico Sound only when storms send very high flows down the Neuse River. In a shallow estuary like the Neuse, the benthic or bottom environment is the scene of intense biochemical activity. Organic matter, such as algae, in the water column settles to the surface of sediments, where it is converted by organisms to ammonium ($NH_4^+$). This process of remineralization reduces the amount of oxygen in the bottom environment and, if the activity is intense enough, can completely eliminate oxygen in sediments and overlying bottomwater. Some ammonium produced through remineralization diffuses to the water column where it provides nitrogen for algae growth, while some is converted by bacteria to dinitrogen gas which rises into the atmosphere.

Under ModMon, intensive studies of sediment accumulation and of interactions between sediments and the water column in the Neuse Estuary were conducted by M.J. Alperin, E.J. Clesceri, J.T. Wells, D.B. Albert, J.E. McNinch, and C.S. Martens of the UNC-CH Institute of Marine Sciences. In the Neuse Estuary, fine sediments have accumulated in the deeper areas along the estuary, with the most highly carbon- and nitrogen-enriched muds occurring in the area between New Bern and Cherry Point. An investigation of stable nitrogen isotope ratios in sediment cores revealed heavier isotopes in more recently deposited sediments. This finding indicates that despite increases in nitrogen loading to the estuary, the system is still nitrogen limited, meaning that algae still depend upon an adequate supply of nitrogen for growth. The finding provides no evidence that the contribution of nitrogen from either chemical fertilizer (lighter isotopic composition) or municipal sewage (variable isotopic composition but not as heavy as that found) has increased in recent years. The investigators say that the appearance of heavier nitrogen isotopes in newer sediments can probably be explained by an increase in nitrification-denitrification—processes which are stimulated by high nitrogen loading and which remove isotopically light nitrogen from the system.

Sediment studies also revealed that remineralization (production of ammonium) is taking place at unusual depths in Neuse estuarine sediments, indicating that there is a vast store of organic matter which can continue to supply nitrogen to the water column. They estimate that the upper 2 centimeters of Neuse Estuary sediments contain 7,800 tons of nitrogen and 86,000 tons of organic carbon. The investigators also found significant sulfate concentrations in sediments. This
finding is important because biochemical action in sulfate-rich sediments can produce hydrogen sulfide, a gas that is both poisonous and oxygen-demanding.

The investigators also studied the rates at which Neuse Estuary sediments release and demand oxygen. They concluded that, during periods of stratification, the average sediment oxygen demand is sufficient to completely consume bottomwater oxygen in about 10 days and that oxygen demand in the upper water column is capable of consuming the bottomwater oxygen pool in about 6 days. They say the huge accumulation of oxygen-demanding organic carbon in the sediments could offset any reduction in organic inputs (from reduced algae blooms) and continue to trigger oxygen depletion in bottomwater for at least 2.6 years and possibly longer.

The investigators also measured the rates at which Neuse Estuary sediments release ammonium and found that nitrogen loading from sediments is three to four times greater than external loading. They calculated that the nitrogen pool in the upper 2 centimeters of sediments could continue to fuel ammonium release and therefore nitrogen enrichment for about 1.2 years. However, they caution that this must be considered a lower limit since there are indications that ammonium is being produced in sediment depths of up to 40 centimeters. They point out, however, that sediments can also take up nitrate (through denitrification) and thereby moderate the effects of ammonium release. Monitoring revealed one site where sediments were serving as a net sink for nitrogen. However, they say that much more information is needed about the process and rates of denitrification throughout the estuary to predict how much the process may speed the purging of nitrogen from the estuarine system.

**Bottom creatures and fish habitat.**
Creatures that live in sediments of the Neuse Estuary, such as clams and worms, are important members of the ecological community. They provide food for many species of fish, and by burrowing activity, they help oxygenate sediments and bury nitrates. When total oxygen depletion (anoxia) occurs in sediments, many of these creatures die. Loss of benthic infauna reduces the food available for fish and changes the biochemical activities in sediments. Even oxygen reduction (hypoxia or dissolved oxygen below 2 milligrams per liter) in sediments can damage benthic infauna by stimulating production of toxic sulfides and forcing them up to more shallow sediments where they are more vulnerable to predation. After an anoxic or hypoxic episode, benthic infauna will recolonize an area, beginning with the more shallow-burrowing creatures such as worms. However, if the same areas of estuarine sediments repeatedly experience anoxic or hypoxic episodes, deeper-burrowing, longer-lived creatures such as clams may not have a chance to return and the normal benthic community may never be reestablished.

To determine how anoxic and hypoxic events affect benthic communities and fish in the Neuse Estuary, Elizabeth E. Thomson, Charles H. Peterson, and Henry C. Summerson of the UNC-CH Institute of Marine Sciences collected data on oxygen and macrofaunal abundances at stations throughout the estuary in the summer of 1997 and again in June 1998 as part of the ModMon project. They sampled benthic infauna abundances and examined gut contents of Atlantic croaker taken from the same areas before and after hypoxic conditions. The investigators found that the most severe oxygen depletion occurred in sediments and bottomwater at deeper parts of the estuary. They found that where hypoxic episodes occurred, the numbers and richness of infauna decreased dramatically and that in the most severe cases complete mortality occurred. In samples taken before hypoxic events, they also found that impoverished infauna communities predicted where hypoxic events would later occur, indicating that the same areas of the estuary are repeatedly subjected to hypoxia. When they compared the diets of croaker taken in June before hypoxic events and those taken in September after hypoxia, they found those taken in September were relying more on worms and plant material than on tissue of bivalves.

The investigators say that loss of deep burrowing animals, as they observed in this study, can cause an increase in toxic sulfide release from sediments and a decrease in the removal of nitrogen through nitrification-denitrification. These losses can set up a negative feedback loop, in which reoxygenation of bottomwaters is inhibited and more bioavailable nitrogen spurred even more algae blooms. They say this complex loop poses serious concerns for water quality managers because it is likely that even drastic reductions in external nitrogen loading may have little effect on algae blooms and hypoxic/anoxic events for years to come.

**Effect on fish.** Fish prefer waters where dissolved oxygen (DO) is above 5 milligrams per liter (mg/l). Some will avoid areas where DO is below 5 mg/l. Most will leave areas where DO is below 2 mg/l if they can.

To evaluate how hypoxic/anoxic episodes affect habitat and the fish community, Lisa Eby, Larry Crowder, and Catherine McClellan of the Duke University Marine Lab sampled the fish community at the same time they sampled dissolved oxygen. They collected their data biweekly from June through October. Combining data on fish distribution with data on areas of low dissolved oxygen, the investigators estimated short-term habitat loss in the Neuse Estuary during this period. They found that, on average, 50% of the habitat had DO of below 4 m/gl and 25% of the habitat had DO of less than 2 mg/l. Their findings indicate that a substantial portion of the bottom habitat in deeper waters was temporarily lost because of poor water quality, concentrating fish and other mobile organisms in more shallow, more oxygenated waters. They point out that less mobile species, such as oysters, are more severely affected than species that can avoid oxygen depleted areas. They say the effects of aggregation are
Improving water quality takes time: Success on the Chowan River brings new hope for the Neuse

by Barbara Doll, water quality specialist for North Carolina Sea Grant

Everybody talks about the Neuse River these days. *Pfiesteria piscicida*, excessive nutrients and fish kills make headlines. Mention of the Chowan River is pretty infrequent, even among water quality professionals. But the Chowan River is where North Carolina began its fight against excess nutrient pollution.

Nutrients are essential to river and coastal estuarine ecosystems; they feed the growth of phytoplankton, which form the base of the food chain. But in excess they cause unmanageable growth of algae and other aquatic plants that rob the water of oxygen. The lack of oxygen results in fish kills, and fish disease often increases as a result of environmental stress.

Severe algal blooms, fish kills and fish disease in the Chowan River during the 1970s catalyzed landmark research and regulatory action. In response, North Carolina Sea Grant was first printed in the Winter 1999 issue of *WaterWise*, a free quarterly newsletter devoted to water quality issues in North Carolina. For more information about the newsletter or to subscribe, call N.C. Sea Grant at 919/515-2454.

This article, reprinted here by permission, was first printed in the Winter 1999 issue of *WaterWise*, a free quarterly newsletter devoted to water quality issues in North Carolina. For more information about the newsletter or to subscribe, call N.C. Sea Grant at 919/515-2454.

Neuse ModMon investigations continued

likely to be an increase in the number of predators in relation to prey and an increase in competition among species for food. While some species may benefit when more benthic organisms are forced out of their burrows, the investigators say, these beneficial effects are probably short-term.

If a 30% reduction will accomplish the desired goals, how long will it be before we begin to see results?

The goal of the Neuse River rules is to accomplish a 30% reduction in nitrogen loading to the Neuse Estuary by 2001. Neuse ModMon studies indicate that a 30% reduction in nitrogen delivered to the estuary will improve water quality but that it is likely to be years before the results are reflected in noticeably reduced algae blooms, higher dissolved oxygen levels, and healthier habitat. Tons of nitrogen and carbon accumulated in estuarine sediments must be purged from the system before the reduced external loading will have observable effects.

To make a good prediction of how long it will take to cleanse the system requires a better understanding of the biochemical processes that take place in sediments and the interaction between sediments and the water column. Specifically, how will the process of denitrification be affected by reduced nitrogen loading?

Another key area of uncertainty is how the process of denitrification upstream will affect the effort to reduce loading downstream. If nitrate loading from wastewater discharge is reduced, will changes in instream denitrification slow or offset the loading reduction?

Many questions about whether and how efforts at reductions upstream will be translated into reductions at the estuary remain to be investigated.

As the Neuse ModMon program enters its second stage, researchers will focus on these key areas of uncertainty. Monitoring in the estuary will continue in an effort to better understand its complex ecology. Data gathered in one or two years may lead investigators to describe processes that change when weather and climate factors change. Another year of monitoring will produce new data and increase the certainty that general conclusions about the system are not highly dependent on varying weather factors.

To improve the reliability of the nutrient response model, investigators will use results of research now nearing completion to estimate atmospheric nitrogen loading to the Neuse and integrate this source into the model. They will also provide new and better estimates of nitrogen loading from major sources.

They will also undertake additional modeling to predict improvements not just in chlorophyll concentrations but in other factors that stakeholders have said they care about such as dissolved oxygen levels, safety of waters for recreation, fish and shellfish habitat, avoidance of *Pfiesteria* blooms, and water clarity.

Researchers will also turn their attention upstream, estimate loading from sub-watersheds in the basin, and focus efforts on developing a river basin model that will help determine how upstream reduction efforts will affect the estuary.

By the end of next year Neuse ModMon investigators expect to be able to answer some key remaining questions and hope to be more certain in predicting a timeframe for recovery of the estuary.

Technical completion reports on the Neuse ModMon projects are undergoing peer review and editing. It is expected they will be published by July. Along with the reports, Neuse ModMon investigators will make their data available for review and analysis by other researchers.
Carolina passed its first laws for controlling the discharge of nutrients. In May 1979, the Environmental Management Commission established the Nutrient Sensitive Water (NSW) supplemental use classification. The Chowan River was the first river to receive this supplemental classification, which placed nutrient limits on wastewater plant discharges to the river.

The Chowan River begins in southeastern Virginia at the confluence of the Nottaway and Blackwater rivers. Three-quarters of its 8,980-square-mile drainage area lies in Virginia. It flows southeast to Edenton, where it pours more than 1 trillion gallons of fresh water into Albemarle Sound every year.

Though nonpoint sources contribute more than 70 percent of the nutrients polluting the water in both the Neuse and Chowan river basins, the rivers’ watersheds are very different in terms of land use and development. The Neuse River basin contains one of the state’s largest metropolitan areas and experiences high population growth. By contrast, the Chowan River basin contains small towns like Murfreesboro, Ahoskie and Rich Square. Overall growth declined by 1 percent in the North Carolina portion of the river basin between 1970 and 1990.

**A Dying River**

The problem with nutrients in the Chowan surfaced in the early 1970s. The most severe blooms of blue-green algae were reported in the lower portions of the river in 1972 and 1978, when warm, dry summers followed high spring flows. Fish kills and a high incidence of red sore disease in fish also indicated water quality problems in the river.

The 1972 bloom concentrated in the area near Colerain and lasted from June to August. Conditions were so severe that one newspaper described the bloom as “gangrenous velvet blanketing the river.” By October of that year, the *Winston-Salem Journal* declared the river dead.

Fishers and riverside residents were especially outraged at the situation. Shoreline residents complained that the rotting algae smelled bad and that their bathing suits were stained green.

Volunteer groups formed to increase awareness of the problem and to search for solutions.

By the late 1970s, the massive growths had expanded to cover more than a 20-mile stretch of the river, from Holiday Island to below Edenton. Edenton town officials complained in 1978 that the water turned green in July and remained that way until December, putting a damper on tourism. During several summer kills it seemed a person could walk across the dead bass and catfish on the surface of the river.

Fishers feared for their livelihood, complaining that catches had declined and that red sore disease was on the rise. Many claimed that they had not seen red sores on fish until the early 1970s, when the algal blooms began. Surveys revealed red sore outbreaks from the Chowan River to the Scuppernong River, with the highest incidence in the Chowan.

In 1976, an outbreak of the disease killed about 95 percent of the Albemarle Sound’s white perch population. Researchers determined that the sores were caused by *Aeromonas hydrophila*, a bacteria that flourishes in polluted water.

They suspected that environmental stress from the declining water quality in the Chowan River was contributing to the outbreaks. The only way to fight the disease was to improve water quality.

A fertilizer plant near Tunis was implicated as a primary source of nutrients contributing to the algal bloom problem in the Chowan River. As many as 4,000 pounds of nitrogen were being discharged from the plant into the river each day.

Research also strongly implicated farming practices and changes in drainage and forest cover as contributors to the problem. Researchers from the University of North Carolina at Chapel Hill noted that though there had been a decrease in farmland in the river basin since 1950, the yields for all major crops had increased due to mechanization and increased fertilizer usage. This study also documented that 67 percent of the North Carolina farmland in the Chowan River had been ditched for drainage to the river, compared to only 6 percent of Virginia farmland. In addition, there was a 30 percent decrease in wetlands forested with oak, gum and cypress in the North Carolina portion of the basin between 1964 and 1974.

These changes in land use are all significant to nutrient loading. Increased fertilizer use means there is greater potential for runoff of excess nutrients. Ditching and draining of cropland decreases the travel time of water moving from a field to a nearby creek or stream, thus reducing the time for microbes in the soil to break down excess nutrients. Research has shown that swamp forests in the Chowan River basin can remove 83 percent of the nitrogen and 51 percent of the phosphorus from streams that pass through them. Therefore, the loss of these habitats means greater release of nutrients into waterways.

The Chowan, Pasquotank and Roanoke are the primary rivers that feed the Albemarle Sound. The Albemarle is considered a lagoonal estuary because it is very shallow and has a slow flushing rate since the Outer Banks restrict the water’s exchange with the ocean. The Albemarle Sound is only about 20 feet deep at its center. As a result, the lower portions of the rivers and the sound they drain into have a relatively small volume and are very sensitive to nutrient loading.

**A Decade of Research**

The problems on the Chowan River stimulated extensive research on river and estuarine processes. In conjunction with the Water Resources Research Institute, North Carolina Sea Grant focused research efforts on the study of flow dynamics, nutrient loading and algal response in major coastal river systems.

Studies located areas where nutrients were deposited and confirmed that those areas were prone to algal blooms.

Through more than a decade of work, researchers were able to identify limiting nutrients over seasonal, spatial and climate changes, and they characterized——continued next page
ized the dominant algal communities during various seasons and nutrient loading patterns.

Charles Daniel, a researcher from the U.S. Geological Survey, developed a model to describe the water flow in the Chowan River. The model verified that both lunar and wind tides are present in the Chowan, but that the wind tides are far more significant to the river than the small lunar tides. During low flows, however, lunar tides can influence the river as far north as the Blackwater River, which is six miles north of Franklin, Va.

Augustus Witherspoon, an N.C. State University researcher, showed that the river could be subdivided into two sections. The upper river had nutrient concentrations great enough to support relatively high algal growth, but flow rates in this portion of the river were too high to allow for excessive phytoplankton growth. By contrast, the lower river had a more stagnant flow and acted more like a lake than a river. This allowed for more interaction between algae and nutrients, thus resulting in high algal growth. Bluegreen algae that formed surface blooms dominated the species composition of the lower river, which is common in nutrient enriched freshwater areas.

Other work focused on nutrients and algal growth. John Hobbie and Don Stanley found that high rates of nitrogen loading prompted algal blooms. Nitrogen and phosphorus are the key nutrients that support algal growth in aquatic systems. Often there is plenty of one nutrient but not enough of the other. The lacking nutrient is considered the limiting nutrient because it controls the productivity that can take place.

In freshwater systems, phosphorus is usually the limiting nutrient. In estuarine systems, on the other hand, nitrogen generally controls algal production. In the lower Chowan, however, Hbbie and Stanley found that nitrogen from decomposing organic matter in the sediments functioned as the limiting nutrient for algal growth mainly during the summer instead of year-round.

Later studies by Ed Kuenzler, a UNC-Chapel Hill researcher, found that both phosphorus and nitrogen simultaneously limited total algal growth in most experiments, but that phosphorus was the most critical limiting nutrient to certain species of blue-green algae that dominated algal blooms in freshwater segments of the lower Chowan River.

Hans Paerl, also from UNC-Chapel Hill, confirmed these findings and showed that high nitrogen inputs during the spring created a potential for blooms of species other than blue-green algae. His work also showed that once these blooms died and sank to the bottom of the river, their decomposition caused oxygen depletion. Phosphorus was then released in this anaerobic (oxygen-free) environment and stimulated blue-green algae blooms later in the summer.

From this decade of research, scientists were able to conclude that controls of both nitrogen and phosphorus were necessary to reduce the frequency and magnitude of algal blooms in the river. Reducing the amount of nutrients flowing into the river would also reduce the concentration of chlorophyll-a, a plant pigment used to measure phytoplankton growth. Witherspoon and Roger Pearce provided quantitative estimates for the needed reduction of these nutrients.

**Two Decades of Management**

The fertilizer plant in Tunis stopped discharging nitrogen into the river in 1972, and the next few years saw a marked reduction in algal blooms. In 1976, however, small pulse blooms appeared, and in 1978, severe blooms recurred. State regulators verified that nutrients continued to seep from storage lagoons at the fertilizer plant.

In addition, the United Piece Dyeeworks plant and the Union Camp pulp and paper facility in Franklin, Va., were identified as significant point sources of nutrients in the basin. North Carolina and Virginia cooperated to reduce the pollutant load from the Union Camp discharge to the river. The paper plant began storing its waste for the eight months of the year when river flow is low, only discharging between December and March.

In 1979, implementation of the Nutrient Sensitive Water classification placed nutrient limits on wastewater treatment plants discharging to the river. As a result, major municipalities removed their discharges from the river and began spraying it onto land as a form of irrigation. This was the only means of reaching the strict nutrient limits of 3 parts per million (ppm) total nitrogen and 1 ppm phosphorus. With land available and reasonably affordable to most of the major municipalities that bordered the river, this was a feasible solution. Land application of wastewater had previously been tried only in experimental demonstration projects in North Carolina.

Land application of wastewater enables microbial communities in the soil to break down and transform nutrients and other pollutants before they reach the river. It is difficult to quantify the nutrient reduction that resulted from this change, but estimates show that the contribution from municipal sources in the North Carolina portion of the basin are down from approximately 20 percent of the total load to around 1 percent.

Despite aggressive measures to deal with point source pollution, regulators soon realized that more effort was needed to solve the problem. With forests, wetlands and agriculture comprising the primary land uses in the river basin and agricultural runoff and animal waste contributing to an estimated 80 percent of the total nitrogen and phosphorus flowing to the river, nonpoint sources of pollution had to be reckoned with in order to solve the bloom problem.

In 1982, the N.C. Department of Natural Resources and Community Development (now known as the N.C. Department of Environment and Natural Resources) developed the Chowan/Albemarle Action Plan and the Chowan River Water Quality Management Plan.
The Chowan River plan called for a 30 to 40 percent reduction in phosphorus and a 15 to 20 percent reduction in nitrogen. The plan included control of nonpoint sources of pollution in addition to the limits on point sources.

Agricultural Best Management Practices (BMPs) became an important component of the water quality improvement plans for the Chowan River. Farmers were asked to voluntarily establish BMPs to reduce erosion and nutrient loading from their crops and animal facilities. A three-year study concluded that farmers in the basin needed education and technical assistance because they had not adjusted the application rates of fertilizer to take into account the animal waste they were also applying to their crops.

In 1985, with funding appropriated by the North Carolina legislature, the North Carolina Agriculture Cost Share Program was implemented in the Chowan River basin. The program was designed to provide technical and financial assistance to farmers who implemented BMPs. The BMPs were intended to reduce erosion, properly manage and improve land application of animal wastes, improve application of fertilizer in relation to crop needs to reduce potential for excess nutrient loading, and ensure proper handling and disposal of pesticides and reduce their use.

Farmers began testing their soil, using conservation tillage, splitting applications of fertilizer and establishing grass waterways and field borders. In some cases hogs had to be removed from swamps, but most animal farmers only needed better storage and training in the proper land application of animal waste. Drainage and irrigation systems also were improved throughout the basin to reduce subsurface movement of nitrogen to surface waters.

Over a five-year period, the state made 809 agreements with farmers in the Chowan River basin to address nonpoint source problems on 63,655 acres of land. An estimated 123,244 tons of soil erosion has been prevented annually as a result. Forty-eight million gallons of animal waste were applied to crops rather than stockpiled in feedlots or overflowing lagoons.

**Documenting Success**

In 1990, regulators began compiling the figures on the nutrient loads and chlorophyll-a levels in the river since the Chowan River Plan was put into effect in 1982. They found substantial reductions in nutrient loads, achieved primarily through the elimination of wastewater treatment plant discharges, the departure of the Tunis fertilizer plant and the implementation of the agricultural BMPs. Calculations revealed that phosphorus had been reduced by 29 percent and nitrogen by 22 percent.

Consistent monitoring in the river at several stations revealed seasonal fluctuations in levels of phytoplankton growth through the mid-1980s, accompanied by a downward trend in growth from the 1980s to the present. Near Colerain and Edenton, the areas previously most plagued by algal blooms, summer chlorophyll levels continued to be high until 1991 but have since dropped significantly.

Today, the Chowan River is a lot healthier than it was in the 1970s. There has been a notable decrease in the duration and frequency of algal blooms. Tourism now thrives in Edenton. Striped bass and white perch fisheries have improved steadily since the early 1980s.

Volunteers continue to patrol the river and are much happier with the river’s health. Regulators realize there is more work to be done, but they are pleased with their progress.

With the implementation of the Neuse River nutrient reduction rules in August 1998, the Neuse River should also begin the journey to improved health. The Neuse River basin could take more than 20 years to flush out the nutrients already stored in its soils and sediments, but the Chowan’s rebirth teaches us patience and gives us hope. Water quality improvement takes time.

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**February/March Action of the N.C. Environmental Management Commission**

At its regular meetings in February and March, the N.C. Environmental Management Commission took the following action:

- Adopted temporary rules to control odors from animal operations, as required by the Clean Water Responsibility Act (SL 97-0458). These rules require all animal operations to implement listed management practices. They define the conditions for determining when an objectionable odor exists and require a best management plan if an operation is causing an odor problem. For a copy of the temporary rules in pdf format go to website: http://daq.state.nc.us/Rules/Adopted/TemporaryRule.pdf.

- Approved holding public hearings on the following proposed reclassifications:
  - Lake Waccamaw as Outstanding Resource Waters (6 pm, June 21, Southeastern Community College Auditorium, Whiteville)
  - Lake Phelps as Outstanding Resource Waters (6 pm, June 24, Town Hall-Fire Dept. Building, Creswell)
  - Lake Montonia as High Quality Waters (6 pm, July 13, City Hall, Kings Mountain)

- Approved initiating rulemaking and holding a public hearing on the proposed designation of 15 counties in the central Coastal Plain as a capacity use area. The Central Coastal Plain Capacity Use Area will regulate water use through permitting to avoid damage to the ground and surface water resources and to maintain the usefulness of the sources of water. According to Nat Wilson with the N.C.
Division of Water Resources, the public hearing will be held in mid- to late June. For additional information, contact Wilson at (919) 715-5445.

- Approved appointment of members of Local Advisory Committees under the Neuse Agricultural Nitrogen Reduction Strategy. Local Advisory Committees will work with farmers to tailor local nitrogen reduction strategies. Appointments had already been approved by the N.C. Soil and Water Conservation Commission.

- Approved variances from the Neuse River Riparian Area (Buffer) Protection Rule for Capital Broadcasting Corp.'s new HDTV tower near US 70 between Clayton and Garner and for Thorne Place, an affordable housing development in Cary.

- Delegated to the EMC Water Quality Committee the responsibility for hearing and making decisions on requests for variances from the Neuse River Riparian Area (Buffer) Protection Rule.

**Division of Water Quality begins new enforcement initiative to protect wetlands**

In February, the N.C. Environmental Management Commission heard a report from staff of the Division of Water Quality (DWQ) on recent ditching and draining of wetlands in eastern North Carolina and a new enforcement initiative to stop such activities and prevent them in the future.

DWQ staffer John Dorney told commissioners that recent court decisions prevent the U.S. Army Corps of Engineers from requiring Clean Water Act 404 permits for ditching in wetlands. Because DWQ had relied on the 404 process to trigger the 401 Water Quality Certification review, the mechanism through which the State had regulated wetlands draining disappeared. Dorney said that since the original U.S. District Court decision (American Mining Congress v. U.S. Army Corps of Engineers) was upheld by the U.S. Court of Appeals for the District of Columbia Circuit in June 1998, an estimated 6,500 wetland acres (more according to some estimates) in southeastern N.C. counties have been ditched and drained for development.

He told the EMC that effective March 1, 1999, DWQ would begin independently regulating ditching and draining by enforcing its wetland water quality standards, particularly those related to hydrologic conditions necessary to support wetlands function (15A NCAC 2B .0231 (b) (5) and biological integrity (15A NCAC 2B .0231 (b) (6). He also said that DWQ will examine projects that started before March 1, 1999, to see if they are causing violation of downstream water quality standards and, if they are found to do so, will take enforcement action. DWQ will be joined in the enforcement initiative by the Division of Land Resources’ Land Quality Section, which will also be looking at wetlands ditching and draining projects for possible violations of the N.C. Sedimentation Pollution Control Act.

For information on DWQ’s regulation of wetlands draining go to website http://h2o.enr.state.nc.us/wetldsfact.html.

**Neuse Basin Oversight Committee presents method for accounting for agricultural nitrogen reductions**

The committee responsible for implementing the strategy to reduce agriculture’s contribution to nitrogen loading to the Neuse River Estuary has unveiled the tool to be used to account for nitrogen reductions. Tom Jones, chairman of the Neuse Basin Oversight Committee (BOC), presented an agricultural nitrogen tracking and accounting methodology to the Environmental Management Commission’s Water Quality Committee in March. The Neuse River Basin Nutrient Sensitive Waters Management Strategy requires the BOC to finalize the agricultural “accountability process” by August.

Jones told EMC members that his committee proposes to use the Nitrogen Loss Estimation Worksheet (NLEW) to estimate nutrient export from agricultural management units. NLEW was developed by the Natural Resources Conservation Service in 1995 as a tool for technicians to use to estimate and report nitrogen loading from agricultural fields. The N.C. Division of Soil and Water Conservation adopted it in 1996 to estimate the effects of BMPs implemented through the N.C. Agriculture Cost Share Program, and it was used to prepare estimates for the Tar-Pamlico Nutrient Management Plan. The worksheet was modified by the N.C. Division of Water Quality in 1997 to conduct a quick estimation of agricultural nitrogen dynamics at the county level.

Using data on soil, crop and crop acreage, crop nitrogen use efficiency, fertilizer source and rates, and BMPs on the ground, the worksheet estimates nitrogen exports from a management unit. However, Jones told commissioners, evaluating every field in all counties in the Neuse Basin is not possible within the timeframe imposed by the Neuse rules. Instead, the BOC intends to survey each county for soil, crop, BMP and fertilizer information and perform estimates on a county-by-county basis. The BOC wants to use statistical sampling of fields in the basin to verify the survey results.

Jones told commissioners that a problem area for the agricultural nitrogen reduction strategy is determining the baseline, which is by rule to be the average of 1991-1995 loading. Reconstruction of agricultural crop distribution and management practices for these years using available information is likely to produce a poor estimate. Commissioner Charles Peterson commented that because crops change from year to year among crops that are more or less nitrogen “leaky,” reduction estimates are likely to change every year and progress toward the overall goal may be difficult to assess.
Local governments will have to rehabilitate many

Aging dams pose threat to life, property, and water quality

by Carl Weaver, WRRI intern

In 1997 and again this year, Oklahoma Congressmen Frank Lucas and Wes Watkins introduced bills to authorize the Secretary of Agriculture to provide cost share assistance to rehabilitate certain dams built by local governments on private land using federal cost share assistance. Lucas and Watkins are acutely aware of a problem that other lawmakers will soon be hearing about. They represent the state that is home to the first flood control dam built under what has long been known as the Small Watershed Program (implemented first under Public Law 534 and subsequently under PL 566) administered by the Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service).

Cloud Creek Watershed Site 1, built in 1948 near Cordell, OK, and designed to last 50 years, celebrated its 50th anniversary in July 1998. Cloud Creek is the first of more than 10,400 small watershed dams that local entities—mainly counties and cities in partnership with soil conservation districts—must rehabilitate over the coming decades, and most have not set aside the money to do so.

Although later project dams were designed to last 100 years, many of the earlier small watershed dams were built with a 50-year lifespan. NRCS says that almost 1,000 will reach the end of their evaluated lifespan in the next 10 years. When a dam reaches the end of its evaluated lifespan, major renovations will likely be necessary. The actual lifespan, though, depends on regular maintenance and may also be affected by land use changes, such as urbanization, in the watershed.

North Carolina has 74 small watershed dams between the ages of 9-45 years, with an average age of 29.6 years. Some of these dams are popular attractions, such as Raleigh’s Shelley Lake and Lake Lynn, both built in the mid-1970s along Crabtree Creek.

State Dam Safety Engineer Jim Leumas says that North Carolina’s small watershed dams are generally in good condition, but many of them need maintenance and minor repairs which can easily become larger problems if left unattended. Leumas says that when an agency plans on spending a certain amount of money on a dam, it looks mainly at construction costs and not costs of repair and maintenance. Although the small watershed program has been of great benefit in creating dams for multiple purposes—flood prevention, water supply and irrigation—the program does not provide for maintenance of the structures.

The Army Corps of Engineers has classified 42% of the state’s small watershed dams as having a high hazard potential, meaning that, in the event of a breach, loss of human life would be expected. Thirty-five per cent would cause significant economic loss, environmental damage, or cause disruption to lifeline services, and only 23% of the dams would cause little to no damage outside of the owner’s property.

Leumas points out that one factor that makes dams more of a potential hazard is population growth. As areas grow and new people move in, new developments have to be built, and many of these new developments encroach on dam spillways. In the event of a breach, this encroachment could spell disaster.

North Carolina has dam failures every year. While most of these incidents do not end in fatalities, they are serious. The most recent dam failures in North Carolina that resulted in fatalities were one in the early part of the century in Winston-Salem and in 1976 when a family of four was killed in Buncombe County. With so few recent fatal incidents, it may be easy to forget the danger that dams pose for those who live downstream.

In testimony before the U.S. House Committee on Transportation and Infrastructure Subcommittee on Water Resources and the Environment, NRCS Chief Pearlie S. Reed reminded Congressmen that small watershed dams protect billions of dollars in transportation infrastructure such as highways and bridges.

In addition to threatening life and property, older dams may pose threats to water quality. In Oklahoma, a group of landowners has sued the Lincoln County Conservation District saying that polluted waters from a small watershed dam killed their livestock. As is often the case, the local conservation district owns the easement for the project and holds the legal right to enter private land for dam maintenance. The plaintiffs say that makes the conservation district responsible for water quality in the dam. The case is now with the Oklahoma Supreme Court.

Recent research by UNC-Charlotte investigators documented that aging ponds and dams in the Charlotte area have become sources of pollution to surface waters. In dams with severe sedimentation, sediment—along with attached metals, nutrients, and other contaminants—is constantly in suspension, and when runoff from storms displaces resident water, that water is often much more polluted than the runoff itself.

NRCS Chief Reed reports that his agency’s fiscal year 2000 budget includes $1 million to educate the public about the condition of aging watershed structures. Small watershed dams are not the only dams in need of repair and maintenance. The Federal Emergency Management Agency (FEMA) will devote some of the extra $1 million it

continued next page
received for the 1999 National Dam Safety Program to educate dam owners and the public about the regulatory and repair needs of the country’s 75,000 dams for which states and local governments are largely responsible.

However, neither NRCS nor FEMA is offering major funding to help with dam repair and renovation. (NRCS has committed some funds to a pilot rehabilitation project in Oklahoma.) Even if Reps. Lucas and Watkins are successful in getting some funding for small watershed dam rehabilitation, local governments will still be the main responsible parties.

UNC-Charlotte researchers Randall Forsythe, Craig Allen, and John Diemer suggest that rehabilitation of aging ponds and dams should be considered as part of required urban stormwater management programs—perhaps trading rehabilitation of old structures for construction of new ones where water quality would be better served. Leumas suggests the state needs to think about a revolving loan fund for local governments that need to rehabilitate aging dams.

Public meetings on Tar-Pamlico River Basinwide Plan

The Tar-Pamlico River Basinwide Plan is now being updated. Public meetings have been scheduled to receive input on the draft plan.

7 pm, April 27
Pitt County Agricultural Center
Greenville

7 pm, April 29
City Council Chambers, Town Hall
Rocky Mount

For a copy of the draft plan call Hope Thompson of the N.C. Division of Water Quality at (919) 733-5083, Ext 360. For additional information about public hearings call Alan Clark at (919) 733-5083, Ext 570.

1998-99 Water Resources Research Seminar Series


Tuesday, April 20, 1999, 3 pm. 1132 Jordan Hall, NCSU Campus. “Effect of Management Practices on Land Application of Swine Waste.” Assistant Professor Steve Whalen, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill.


North Carolina Precipitation/Water Resources

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<th>January</th>
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<td>Rainfall (+/- average)</td>
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<tr>
<td>Asheville</td>
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<td>Charlotte</td>
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<td>(County, Basin)</td>
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<tr>
<td>Valley River at Tomotia (Cherokee, Hiwassee)</td>
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<td>Oconaluftee River at Birdtown (Swain, Tenn)</td>
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<td>French Broad River at Asheville (Buncombe, FB)</td>
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<td>South Fork New near Jefferson (Ashe, New)</td>
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<td>Elk Creek at Elkville (Wilkes, Yadkin/Pee-Dee)</td>
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<td>Fisher River near Copeland (Surry, Yadkin/Pee-Dee)</td>
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<td>South Yadkin River near Mocksville (Rowan, Yadkin/PD)</td>
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<td>Rocky River near Norwood (Stanly, Yadkin/Pee-Dee)</td>
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<td>Deep River near Moncure (Lee, Cape Fear)</td>
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<td>Black River near Tomahawk ( Sampson, Cape Fear)</td>
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<td>Trent River near Trenton (Jones, Neuse)</td>
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<td>Lumber River near Boardman (Robeson, Lumber)</td>
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<tr>
<td>Little Fishing Creek near White Oak (Hartford, Pamlico)</td>
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<td>Potecasi Creek near Union (Hertford, Chowan)</td>
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Groundwater

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<td>Blantyre (Blue Ridge)</td>
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<tr>
<td>Mocksville (Piedmont)</td>
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<td>Simpson (Coastal Plain)</td>
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Source: U.S. Geological Survey’s Water Resources Conditions in North Carolina
**Water Quality Systems Analyst**

The Mecklenburg County Department of Environmental Protection, Charlotte, NC, seeks a science and people oriented professional with technical background and strong computer and modeling skills. This position in the Water Quality Program develops and applies watershed computer modeling, provides computer hardware and software support, consults with the public and industry and prepares letters and reports.

Must have BS or BA degree in environmental health, biology, chemistry, engineering or one of the natural or environmental sciences including work in computer modeling, mathematics and statistics, and computer modeling experience, or equivalent combination of education and experience. Salary range: $32,952-$41,191. Submit resume (suitable for scanning) with job title on resume by April 16, 1999, to Mecklenburg County Environmental Protection, 700 N. Tryon ST., Ste 205, Attn: Personnel, Charlotte, NC 28202-2236

For additional details or to submit a resume via the Internet visit website: http://www.co.mecklenburg.nc.us/coenv/. Additional information also available by calling (704) 336-5500.

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**People**

**Dewey Botts**, formerly Director of the N.C. Division of Soil and Water Conservation, is now Assistant Secretary for Natural Resources with the N.C. Department of Environment and Natural Resources.

**George Everett**, formerly Executive Director of the Manufacturers and Chemical Industry Council of North Carolina, has joined Duke Energy as Director of Legislative and Environmental Affairs.

**Preston Howard**, formerly director of the N.C. Division of Water Quality, is the new Executive Director of the Manufacturers and Chemical Industry Council of North Carolina. At the March meeting of the N.C. Environmental Management Commission, Howard was presented the Order of the Long Leaf Pine, the highest award the Governor can present for service to the state. In addition, the EMC passed a unanimous resolution thanking him for outstanding service during his six-year tenure as director.

**Suzanne Hoover**, formerly a basinwide planner with the N.C. Division of Water Quality, has joined the N.C. Cooperative Extension Service as Project Coordinator for Watershed Education for Communities and Local Officials. She works within the Department of Agricultural and Resource Economics at N.C. State University.

**Jane Stavely**, formerly with the Cadmus Group, has joined ARCADIS Geraghty & Miller, Inc. as Principal Scientist.

**Tom Bean**, formerly Executive Director of the N.C. Wildlife Federation, is now working for a variety of conservation organizations in the Upper Pamlico-Tar River Basin. **Dock Kornegay**, formerly of Duke Power and Duke Power Foundation, is the new NCWF Executive Director.

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**Water Resources Scholarships**

The American Water Resources Association is now accepting applications for the Richard A. Herbert Memorial Scholarships for students in programs related to water resources. Deadline is April 30. For information visit website http://www.uwin.siu.edu/~awra/student/herbert99.html

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**Correction**

In the Jan/Feb 1999 issue of the News, we printed an incorrect telephone number for Lisa Martin, Director of the Upper Neuse River Basin Association. The correct phone number is (919) 558-2702. We apologize for any inconvenience.

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**Publications**

**Stream Corridor Restoration: Principles, Practices, and Processes.** The Federal Interagency Stream Restoration Working Group has completed and made available its document on stream corridor restoration. It provides broadly applicable guidance for common elements of the restoration process but also provides alternatives which may be appropriate for site-specific restoration activities. A draft can be downloaded in pdf format from the Natural Resources Conservation Service web site at http://www.usda.gov/stream_restoration/copies.html. The total files are about 17 MB. The manual and/or CD can be ordered from the National Technical Information Service at website http://www.ntis.gov/yellowbk/1nty821.htm or by phone at 1-800-553-6847. Manual NTIS Order Number is PB98-158348; cost is $71 plus $5 handling. CD ROM NTIS Order Number is PB98-502487/INQ; cost $60 plus $5 handling.

**TMDL videotape.** A 22-minute videotape on the role of Total Maximum Daily Loads (TMDLs) state water quality standards is available for loan from EPA. The tape covers issues such as TMDL authorization, the importance of TMDLs in the water-quality based approach to pollution control, and how TMDLs are developed. The video also discusses the important role played by stakeholders in TMDL development. The videotape is one in a series of similar presentations on water quality criteria and standards available from EPA. All the tapes are in the public domain and may be duplicated at no cost without prior permission from EPA. The tapes may be requested from EPA, Water Resource Center (RC4100), 401 M Street SW, Washington, DC 20460,(202) 260-7786. For more information, visit www.epa.gov/OST/pc/video.html.

**Issues in Potable Reuse.** The National Research Council’s Committee to Evaluate the Viability of Augmenting Potable Water Supplies with Reclaimed Water has published a report on its study of the plausibility of augmenting a community’s raw water supply with treated municipal wastewater. Christine L. Moe of UNC-Chapel Hill served on the committee, and Russell Christman and Daniel Okun of UNC-CH were reviewers.
to those involved in management of nonpoint sources of water pollution. “Detecting Water Quality Changes before and after BMP Implementation: Use of a Spreadsheet for Statistical Analysis” was written by Garry Grabow, Jean Spooner, Laura Lombardo and Daniel Line. The newsletter can be downloaded from the web in PDF format at http://www.5.bae.ncsu.edu/programs/extension/wqg/issues/92.pdf or requested from the Water Quality Group at (919) 515-7448.

**Watershed learning guide.** The Oregon State University Extension Service has developed *Watershed Stewardship: A Learning Guide* to help readers learn how to form effective partnerships, know the parts of their watersheds and how they fit together, understand assessments of watershed conditions, develop strategies for enhancing watershed resources, and implement effective enhancement projects. The guide is available for $32.00 from Publications Orders-WS1, Extension & Station Communications, Oregon State University, 422 Kerr Administration, Corvallis, OR 97331-2119, FAX 541-737-0871 or email: puborders@orst.edu.

**New water management journal.** The American Water Resources Association has launched a new publication, *Water Resources IMPACT*. Written for consultants, community and NGO leaders, government personnel, and other practitioners, IMPACT will focus on today’s water management problems and programs. For information visit website http://www.uwin.siu.edu/~awra/hydata/index.html or call AWRA at (703) 904-1225.

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**North Carolina Water Resources Association**

**North Carolina Section of the American Water Resources Association**

**Luncheon and Forum Schedule**

- **April 12, 1999**
  - Wetlands Restoration and Related Programs

- **Sept 13, 1999**
  - Stormwater: NPDES Phase II and Neuse River Rules

- **Dec 6, 1999**
  - Cape Fear Basin Water Quality Issues

All luncheons/forums take place at 11:30 am at the Jane S. McKimmon Center on the N.C. State University campus. For additional information call Robert Holman at WRRI (919/515-2815).

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**New water management journal.** The American Water Resources Association has launched a new publication, *Water Resources IMPACT*. Written for consultants, community and NGO leaders, government personnel, and other practitioners, IMPACT will focus on today’s water management problems and programs. For information visit website http://www.uwin.siu.edu/~awra/hydata/index.html or call AWRA at (703) 904-1225.

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**North Carolina Water Resources Association**

**North Carolina Section of the American Water Resources Association**

**Luncheon and Forum Schedule**

- **April 12, 1999**
  - Wetlands Restoration and Related Programs

- **Sept 13, 1999**
  - Stormwater: NPDES Phase II and Neuse River Rules

- **Dec 6, 1999**
  - Cape Fear Basin Water Quality Issues

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