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Water Storage in Steep Decline Relative to Population

by David H. Moreau, WRRI Director

The recent drought of 2007-2008 brought attention once again to increasing demand on a limited supply of fresh water in North Carolina. That supply comes from two very different kinds of sources, surface and groundwater. In 2000, the most recent year for which statewide estimates of water use have been published, figures reported by the United States Geological Survey (USGS) showed that 94 percent of water withdrawn in North Carolina for all uses was taken from surface sources. Even if the large portion of withdrawals that is used for cooling thermoelectric power plants is removed from the calculations, surface water sources still account for 71 percent of all withdrawals in 2000.

Clearly, surface water sources are of critical importance to the continued well being of North Carolinians. North Carolina is advantageously located in a humid region of country, blessed with abundant rainfall most of the time, but the very large year-to-year and season-to-season variation in rainfalls and streamflows necessitate the storage of large quantities during wet months to meet needs during dry months. This report updates an earlier study of trends in reservoir capacity and its relation to population growth.

Variability of Supply

The supply of surface water in North Carolina at any given location is highly variable from one year to the next and from one month to the next. In most cases, municipalities that rely on streamflow find it necessary to store water during wet seasons to meet demand during dry seasons. The nature of variability over an annual cycle is shown in Figure 1. Despite the fact that rainfall tends to peak in July and August, losses due to evaporation and evapotranspiration cause streamflows to drop in the period August–October to only 25 to 50 percent of their averages in March. Year-to-year variability is also significant. For example, five percent of annual streamflows in the Haw River at

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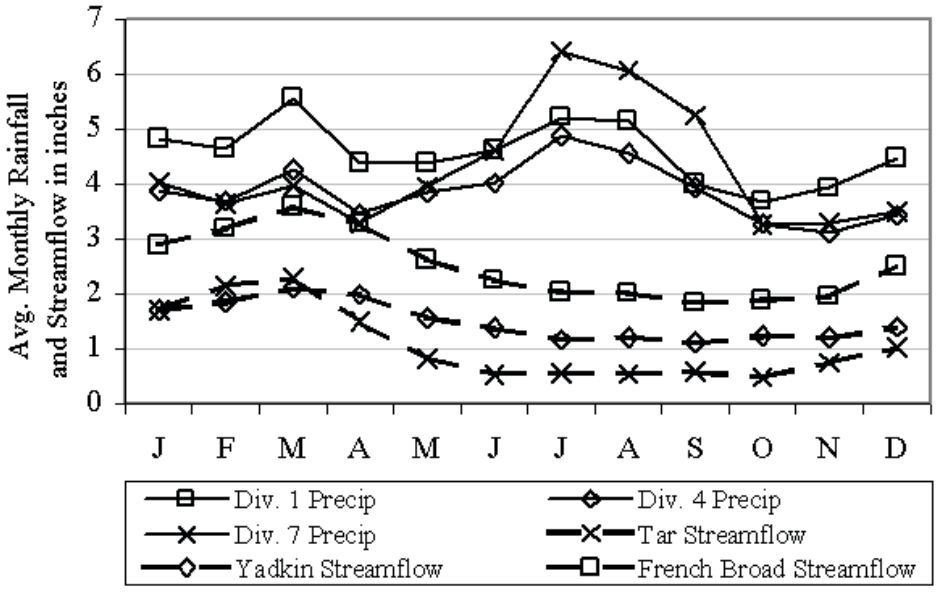

Figure 1. Within-Year Variation in Precipitation and Streamflow at Selected Locations Div.1 = NOAA Climate Division 1 in Western North Carolina; Div.4 = NOAA Climate Division 1 in Central North Carolina; Div.7 = NOAA Climate Division 7 in Eastern North Carolina; Tar Streamflow is flow at Tarboro, NC; Yadkin Streamflow is flow at Yadkin College, NC; French Broad Streamflow is flow at Asheville, NC.

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Haw River, NC are less than 48 percent of median values; ten percent of annual flows are less than 55 percent of median values.

Water Use

Of the fresh water withdrawn from surface sources in 2000, nearly 81 percent was for cooling of thermoelectric power plants. That statistic gives somewhat of a distorted picture of the distribution of withdrawals among purpose because most of the withdrawals for that purpose are returned directly to lakes and streams. If withdrawals for thermoelectric plants distribution are excluded from the calculation, 60 percent of withdrawals were for public water supply, 21 percent for self-supplied industry, and 17 percent for irrigation.

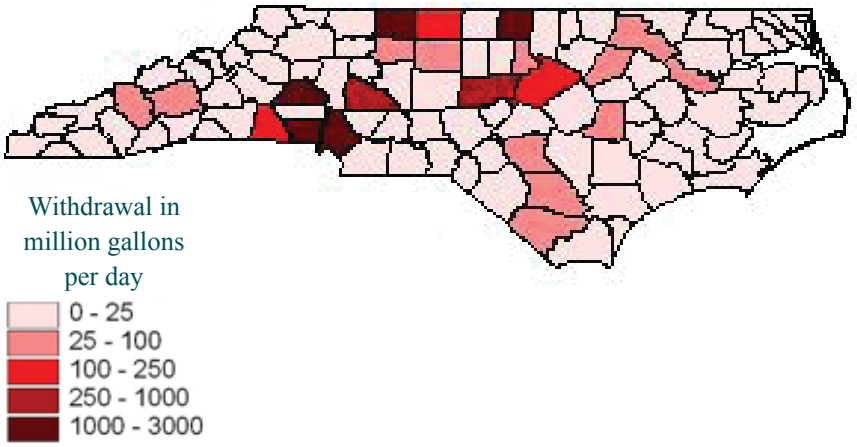

Figure 2. Withdrawals of Surface Water in Year 2000

The spatial pattern of surface withdrawals is important. As shown in Figure 2, the largest withdrawals are located primarily in the Piedmont where most of the people reside, where a large share of thermoelectric power capacity is located, and where groundwater sources are quite limited. More abundant groundwater is found in aquifers underlying the Coastal Plain of North Carolina, but even with lower population densities in that area, withdrawals were so great that a substantial portion of that area was placed under strict regulations in 2002.

Reservoir Capacity

Best available data for reservoirs in North Carolina are in the Inventory of Dams (IOD) maintained by the Division of Land Resources, Department of Environment and Natural Resources. When accessed in March 2008, the file contained entries for 5,327 dams, including 230 that had been breached and 89 that had been drained.

Storage capacity as used in this report refers to normal pool. Both normal pool and maximum pool storage capacities are listed for the impoundments in the IOD. For some of the large multiple purpose dams, the difference between normal and maximum pool storage is storage reserved for flood control. Missing data for normal pool storage in two large reservoirs, Falls Lake and Lake Norman, were filled in from other sources. For smaller reservoirs, normal pool and maximum pool are generally the same.

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WRRI
NC State University. Box 7912,
Raleigh, NC 27695-7912

water_resources@ncsu.edu
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Reservoir *continued from page 1*

Of the 5,008 reservoirs not breached or drained, the normal pool storage is 6.28 million acre-feet (MAF; one acre-foot is the volume of water that would cover one acre to a depth of one foot). A distribution of reservoirs by size is given in Table 1. About 72 percent of all storage is in the 17 largest reservoirs, and 95 percent (5.98 MAF) is in the 162 reservoirs that have at least 1,000 acre-feet of storage (equivalent to 100 acres, 10 feet deep). The other 4,846 reservoirs are very small, averaging 60 acre-feet of capacity.

Table 1. Distribution of Storage Capacity by Size of Reservoirs

Capacity, acre-feet	No. of Dams	Total Capacity, MAF	Percent of Total Capacity	Incremental Percentage of Total Capacity
≥ 100,000	17	4,535	72.2	72.2
≥ 50,000	23	4,961	79.0	6.8
≥ 25,000	33	5,302	84.5	5.4
≥ 10,000	53	5,627	89.7	5.2
≥ 5,000	76	5,791	92.3	2.6
≥ 2,500	109	5,897	94.0	1.7
≥ 1,000	162	5,984	95.3	1.4
All	5,008	6,276	100.0	4.7

Timing for reservoir capacity expansion at five-year intervals beginning with 1911-1915 is shown in Figure 3. The period of greatest expansion was 1961-1965 when about one-third of current capacity was completed. Another 19 percent was added during 1941-1945 as the Tennessee Valley Authority completed several large projects. Eighty-six percent of current capacity was in place by 1965, and 96 percent was in place by 1985.

Population of the state has grown rapidly over that period. From 1910 to 1965 when 5.04 MAF of storage was added, population increased by 2.6 million. Added storage was 1.9 acre-feet for each new resident. Since 1965, only 0.89 MAF have been added while population has increased by 4.44 million. Added storage was 0.19 acre-feet per new resident, one-tenth the rate from 1910 to 1965.

A large share of reservoir storage built prior to 1965 was for the purpose of providing hydroelectric power. Today, while hydro plays an important role in providing peaking power, it supplies about five percent of electricity generated in the state.

There are many reasons why the addition of new reservoir storage has slowed. Two are especially important. First, most of the large, economically feasible sites have already been developed. Falls Lake, Jordan Lake and Randleman Reservoir were identified by the United States Army Corps of Engineers as the key projects in comprehensive development plans for the Cape Fear and Neuse River Basins. Falls and Jordan were completed in the 1980s, and Randleman was completed in 2002. There are not many good, large sites left to develop. Second, greater value has been placed on environmental resources that are lost or damaged when reservoirs are constructed.

As the state continues to grow, new supplies are not likely to come from development of new large reservoir sites. High on the list of options for balancing supply and demand must be an aggressive program to improve the efficiency of water use—producing the same services with less volumes of water. A second option that will be considered at some future time is reallocation of storage from purposes for which it was originally built to higher valued current and future uses. A third option is to find and preserve remaining sites at which water storage facilities can be developed, including both sites at which streams can be impounded and off-stream sites such as abandoned stone quarries and above ground reservoirs.

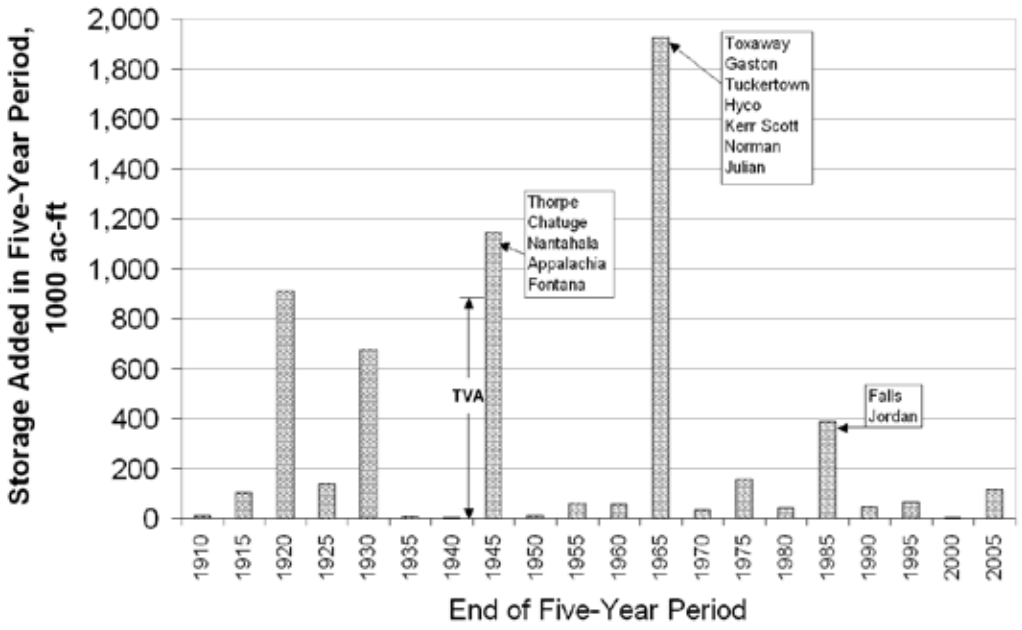

Figure 3. Storage Capacity Added Over Five-Year Intervals 1910-2005 (largest projects are show in boxes)

Congressman Price Addresses National Institutes for Water Resources

On February 26, 2008, Congressman David Price, representing the 4th District of North Carolina, addressed the attendees of the National Institutes for Water Resources Annual Meeting at a breakfast.

Congressman Price began his presentation stating that water issues are paramount in western states and "interstate conflicts over limited water resources have been the norm for nearly 100 years." He then focused on the Southeast for the majority of his talk:

> For most of our lives, most of us in the Southeast have been more concerned about water pollution, flood control, and hydroelectric power than running short of water for public supplies. But that is changing, and new pressures are bringing urgency to the issue in the region.
>
> We have already begun to experience water conflicts. Drought and water resource issues in Atlanta have been widely publicized, and interstate conflicts to establish a permanent water supply for Atlanta have gone unresolved for decades.
>
> Florida faces an internal conflict between meeting the competing needs of 17 million urban residents, very strong agricultural interests, and restoration of the Everglades.
>
> North Carolina, my home state, has fought for about twenty years with Virginia Beach over an 85-mile pipeline that would divert 60 million gallons a day from the Roanoke River in North Carolina to meet demand in Virginia Beach. In addition, South Carolina is now challenging North Carolina's decision to divert 10 million gallons a day from the Catawba River to serve a portion of the Charlotte metropolitan area that lies in another basin.
>
> Against this backdrop of unresolved conflicts, North Carolina finds itself in the midst of an "Exceptional" Drought, which has affected the state for the last six to eight months. As of [February 21], sixty-four of the 100 counties in North Carolina are subject to "Exceptional Drought" status, with another 22 counties in the next-to-worst category, "Extreme Drought", and the other 14 counties just one step below that.

He further noted that Falls Lake was

> at its lowest level since 1993...The City of Raleigh [had] a total water supply of 119 days, and the City [was] under Stage II mandatory conservation conditions." Price continued, "Fifty-five percent of the state's population—including nearly all residents in my district—is served by water supply systems that [were] under mandatory conservation. A large portion of the rest of the population is not served by public systems.

Representative Price credited

> the efforts of those North Carolinians and local public water systems that are working hard to conserve water—due to these efforts, water use in North Carolina has decreased by about 31 percent since last spring. But our current dilemma underscores the importance of taking steps to ensure an adequate supply in the future…

He went on to point out that

> as a region, the Southeast continues to rank high in growth of new residents—in Raleigh, which is in my district, the city has experienced population growth of nearly 30 percent. For an area with few large rivers and limited water supplies, the question of what sorts of limits on sustainable growth lie in the future is suddenly looming very large.
>
> Unfortunately, there are limited options for bringing the demand-supply equation into balance and keeping it that way for the foreseeable future…

Congressman Price addresses the importance of research:

> It is imperative that we find a way to more efficiently use, and reuse, existing resources, and educate the public about these methods. Research is crucial to finding ways to improve our water infrastructure and to more efficiently using the resources we have…

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November, January, and March Actions of the Environmental Management Commission

At its regular meeting on November 8, 2007, the Environmental Management Commission took the following action:

- ❑ Approved the variance from the NCAC 2L .0202 Groundwater Quality Standards for the former Home Concrete Supply, LLC site as proposed with a condition that a land use restriction is implemented to restrict the use of the groundwater at the site.
- ❑ Approved the variance from the NCAC 2L .0202 Groundwater Quality Standards for the former Kaiser Fluid site as proposed with the condition that the staff prepare a letter to the adjacent property owner to explain the variance process and the conditions regarding if a contravention of standards occurs beyond the property boundaries.
- ❑ Approved to proceed to public notice and hearing for revisions to the well construction rules, 15A NCAC 2C .0100. It was approved to waive the 30 day rule going from the Groundwater Committee to the EMC due to the need to move this rule forward that hinges on other rules that the Division of Environmental Health were mandated to adopt by the Legislature related to private drinking water wells. Local and state staff also need to be trained and certified.

At its regular meeting on January 10, 2008, the Environmental Management Commission took the following action:

- ❑ Adopted rules governing permitting and inspection of private drinking water wells 15A NCAC 02C .0301 through .0307 with changes proposed by the Stakeholder Committee in response to public comments received and adopted .0308 as published.
- ❑ Approved amendments to increase Title V permit fees. The Clean Air Act requires that Title V permit fees pay the entire cost of the Title V permit program. The salary increases approved by the General Assembly and other increased costs of operating the program must be funded without appropriations. Current Title V fee receipts were not sufficient to pay for the level of effort needed to maintain the program.
- ❑ Approved to proceed to public hearing on the amendments to the Clean Air Mercury rules (CAMR). Four of the State's mercury rules, which became effective in January 2007, for electric utilities are proposed for amendment in response to USEPA's recommendations. North Carolina should get final approval from USEPA to the State's CAMR implementation with these changes.
- ❑ Approved to proceed to public notice and hearing with the proposed revised Randleman Lake Water Supply Watershed Buffer Rules, 15A NCAC 2B .0250, and the proposed Randleman Lake Water Supply Watershed Strategy: Mitigation Program for the Protection of Existing Buffers, 15A NCAC 2B .0252. The Randleman buffer rules were clarified and modeled after the Neuse buffer rules. A mitigation requirement was also added.
- ❑ Adopted amendments to the State Coastal Stormwater Rule, 15A NCAC 2H .1005, as recommended by the hearing officers. The hearing officers recommendations included: the 50-foot vegetated setback applies to new development but does not affect redevelopment (if there is not a significant increase in impervious surface footprint); no wetlands be included in impervious surface calculations (coastal wetlands very valuable); allowed stormwater control and treatment other than infiltration—a wider range of BMPs applicable; commercial projects greater than 10,000 square feet must get stormwater permit; and residential development that disturbs greater than 10,000 square feet but less than an acre doesn't need a stormwater permit, but would be required to meet certain minimum measures, such as the installation of rain barrels, permeable pavement, rain gardens or other BMPs that control stormwater on the site.
- ❑ Approved to proceed to public notice and hearing with proposed amendments to Non-404 Jurisdictional Water Rules, 15A NCAC 2H .1300. As a result of the US Army Corps of Engineers (ACOE) interpretation and implementation of the US Supreme Court's "Rapanos Decision," the US Army Corps of Engineers (ACOE) has determined in several instances in North Carolina that existing waters or wetlands are not isolated, but are also not under the ACOE's 404 Jurisdiction. This rulemaking corrects the deficiency by amending the existing Isolated Wetlands Rules, which presently permit impacts only to isolated waters, so that in the future these rules will regulate impacts to all waters and wetlands in North Carolina that have been determined by the ACOE to be "non-jurisdictional."
- ❑ Approved recommendation to authorize the Department to contract with the US Army Corps of Engineers for the temporary use of surplus water at Falls Lake if made necessary by drought conditions.
- ❑ Adopted a resolution encouraging the Department and the Ecosystem Enhancement Program (EEP) to move forward with all possible speed to see and secure legislative concurrence with the process of accepting voluntary mitigation fees on a temporary basis and then act to accept the fees as soon as possible. In September the EMC approved a mitigation fee increase. In October the Rules Review Commission received greater than ten letters of objection that automatically defaulted the rule preventing it from going into effect until the Legislature has an opportunity to consider it, which would

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EMC Actions *continued from page 5*

be late May at the earliest. Without the new fee increase going into effect, EEP had begun to reject requests in some watersheds.

At its regular meeting on March 13, 2008, the Environmental Management Commission took the following action:

- ❑ Approved to initiate rulemaking to amend Underground Storage Tank rule, 15A NCAC 2N .0901. The petitioned change would include the use of electronic sensors as an acceptable method for monitoring the interstitial space in double-walled steel USTs.
- ❑ Approved to proceed to public hearing on an amendment to the volatile organic compounds rules. The rule amendment adds a definition of "Stage I" to 15A NCAD 2D .0901 and its purpose is to provide additional clarity to the Gasoline Service Stations Stage I requirements in 2D .0928.
- ❑ Approved to proceed to public hearing on a repeal to the volatile organic compound rules. Rules 15A NCAC 02D .0953 and .0954 are proposed for repeal to remove the Stage II vapor return piping and vapor recovery system requirements. Four volatile organic compound rules, one toxic air pollutant rule and the permit exemption rule are proposed for amendment to remove obsolete language and correct cross-references due to the repeal of the Stage II rules.
- ❑ Approved to proceed to public hearing to allow generators subject to 40 CFR Part 60, Subpart IIII and subpart JJJJ, to be eligible for permit exemption. The rule amendment affects a small part of the regulated community population who will install an emergency generator that is driven by diesel and gasoline engines manufactured in or after 2007.
- ❑ Approved the proposed rule amendments presented in Chapter II of the hearing officer's report on various air quality rules. The rules included the adoption of a new rule section 15A NCAC 02D .2600, Source Testing; the adoption of a permit exemption rule for emergency generators; the modification of the acceptable ambient levels (AALs) for 1,3 butadiene; the repeal of the nitrogen oxides state implementation plan (NOx SIP) trading and banking program rules which will be replaced by the CAIR trading program, to exempt CAIR permitees from the requirement to provide written notification to the State of trading operations in CAIR and CAMR trading program and to correct a rule cross-reference.
- ❑ Approved the proposed rule amendments on prevention of significant deterioration (PSD) and nonattainment new source review (NSR) rules amendments. The amendments will formally incorporate NOx as a precursor to ozone and the use of PM 10 as a surrogate for PM 2.5 and will address the reference changes as identified by USEPA.
- ❑ Approved the proposed rule amendments on clean air interstate rules (CAIR) amendments, 15A NCAC 02D .2400. The amendment addresses the concerns raised by USEPA during its review of North Carolina's submittal for state implementation plan (SIP) approval.
- ❑ Concurred with the Water Quality Committee's recommendation not to designate Tarboro as a Phase 2 municipality.
- ❑ Adopted the proposed changes to the coastal stormwater rules, 15A NCAC 2H .1005, and granted the hearing officers' approval to make any other changes necessary to gain approval by the Rule Review Commission (RRC) prior to the May 2008 EMC meeting. The changes were made in response to objections made by the RRC.
- ❑ Approved to change the name of the Alternative Energy Committee to Renewable Energy Committee.

More information is available at the EMC web site: http://h2o.enr.state.nc.us/admin/emc/

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Denitrification and Sediment-Water Nutrient Exchange in the Upper Neuse River
Report 361 December 2006

Stephen C. Whalen, Department of Environmental Sciences and Engineering, UNC Chapel Hill; Marc J. Alperin, and Yonghong Nie, Department of Marine Sciences, UNC Chapel Hill

The overall objective of this research was to provide broad coverage of spatial and temporal variability in denitrification and sediment-water N exchange in the upper Neuse River. The researchers conducted quarterly (spring, summer, fall and winter) determinations of denitrification at representative sites in the mainstem Neuse River and tributaries. Sites within the Piedmont included Crabtree Creek above and below the Cary Wastewater Treatment Plant and the mainstem Neuse River in Smithfield. Sites within the Coastal Plain included Nahunta Swamp and the mainstem Neuse River at Fort Barnwell. Denitrification measurements were made on intact sediment cores using the N_2/Ar and isotope pairing techniques. They measured nitrate (NO_3^--N) and ammonium (NH_4^+-N) concentrations in the water column at the time of core collection and evaluated rates of sediment-water exchange of NO_3^--N, NH_4^+-N and dissolved oxygen (O_2) in conjunction with denitrification rate determinations. Nitrate concentrations in the stream or river water varied over an order or magnitude, from about 10 to 110 µmol L^{-1}, while NH_4^+-N concentrations were lower, varying from 0.6 to 10.8 µmol L^{-1}. Sediments consistently consumed dissolved O_2, with rates varying from 256 to 1418 µmol m^{-2} h^{-1}. Sediment-water exchange of NO_3^--N and NH_4^+-N was not always observed. However, non-zero values always showed release of NH_4^+-N from sediments and consumption of NO_3^--N by sediments at rates ranging to 104 and 102 µmol m^{-2} h^{-1}, respectively. Most cores actively denitrified with rates ranging to 222 µmol N_2-N m^{-2} h^{-1}. On average, coupled nitrification-denitrification accounted for 66% of total denitrification.

The seasonal survey of denitrification at representative sites in the mainstem Neuse River and tributary streams was not intended to give a firmly based estimate of in-stream N removal via denitrification. Nonetheless, acknowledging the shortcomings of any estimate, comparison with other lotic waters provides at least a qualitative indication of the relative importance of this microbial process in the N biogeochemistry of the Neuse system. The overall estimate of 5% N loss to denitrification falls toward the low end of data reported for rivers and streams worldwide, which show values ranging from 1 to 141% for either total N loss or denitrification. Stream bottoms at all of the study sites except Nahunta Swamp were dominated by rocky substrates that likely show low or undetectable rates of denitrification. Thus, the value of 5% N loss to denitrification is an overestimate if the bottom substrate at the sampling sites is representative at larger scales of space. This study using the most widely regarded enclosure-based methods indicates that denitrification actively removes N from the mainstem Neuse and tributary streams and gives rate estimates for suitable substrate that compare favorably with published rates using a variety of analytical techniques. Although the limited data suggest that denitrification provides a minor sink for N in the Neuse system, other techniques such as mass balance assessments or N_2/Ar open channel methods are better suited to provide firm estimates of total in-river N loss or N loss to denitrification, respectively, as these give information on longer spatiotemporal scales. The researchers recommend further study utilizing appropriate methodology if a firmly based estimate of denitrification or total in-river N loss is deemed necessary to guide policy and management decisions in the Neuse River watershed.

Role of Sediment Processes in Controlling Water Quality in the Cape Fear River
Report 362 October 2007

P.V. Sundareshwar and Curtis J. Richardson, Duke University Wetland Center, Nicholas School of the Environment and Earth Sciences, Duke University

The primary objectives of this pilot study were: a) to identify the chemical forms in which nutrients are input into the Cape Fear River basin, and b) to address the previously overlooked role of sediments in buffering water quality in order to facilitate its incorporation in future water quality management programs. These objectives were achieved with a focus on Phosphorus (P) fractions. The researchers monitored surface water quality parameters for eight months to evaluate present water quality at three lock and dam sites. Water samples collected from above the dams at the three locations were analyzed for dissolved phosphorus, total phosphorus, dissolved organic carbon concentrations and mineral elements such as Ca, Mg, K, Fe and Al. To estimate historical nutrient loading, the researchers collected sediment cores from mudflats along the bank of the Cape Fear River at the three lock and dam sites. Sedimentation rates were estimated using ^{137}Cs dating, and these data were related to total phosphorus mineral element concentrations in corresponding depth fractions. Patterns in total phosphorus accumulation and sediment mineral element composition were then related to land-use practices within the sub-watersheds of the three lock and

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dam sites. The researchers used the phosphorus-binding capacity of floodplain sediments to assess their role as a sink or source of nutrients under sustained nutrient loading. To identify the chemical forms in which nutrients are input into the CFR basin they used ^{31}P solution NMR spectrometry of floodplain sediments and concentrated river water samples.

The results indicate that there are differences in water quality parameters among the three lock and dam (LD) structures. In comparison to the upstream site, LD 3, downstream sites LD 2 and LD 1 generally had higher concentration of nutrient parameters such as dissolved reactive phosphorus (DRP) and total phosphorus (TP) in surface waters. However, the relative contributions of organic and particulate fractions of phosphorus were generally higher at LD 3 than those measured at downstream sites LD 2 and LD 1. While trends in DRP concentrations may partly be due to the difference in the number of permitted discharge locations just upstream of these sites, accumulation of phosphorus in the riverbank sediments is most likely controlled by sediment loading from the sub-watersheds and in situ sediment processes. Results from the previous study indicate that the sedimentation rates vary from 0.5 cm/yr at LD 3 to 1.5 cm/yr and 1.3 cm/yr at LD 2 and LD 1, respectively. The sedimentation rates correspond well to the total sediment phosphorus concentrations, which indicate that sediment deposition during the recent decades (≈ 40 years) has been associated with an increase in phosphorus loading to the CFR at LD 3. The present study reveals that the total phosphorus in sediments at these sites, in general, was positively correlated with the sum of total Fe, Al, Ca and Mg. This positive relationship was observed for surface and sub-surface sediments at all sites except in surface sediments at LD 2. At this site, while sub-surface sediments exhibited a positive relationship, the surface sediments did not. This suggests that recent input of phosphorus and mineral elements from external sources may have altered this relationship. Among the three lock and dam sites, the floodplain sediments at LD 2 had the greatest phosphorus binding capacity, while the most downstream site LD 1 had the lowest. This trend in P-sorption capacity of the riverbank sediments persisted for the sub-surface sediments, although the P-binding capacity of the sub-surface sediments was lower than the binding capacity of corresponding surface sediments. Importantly, the intra-site variability in P-sorption capacity and mineral element composition increases downstream, most likely due to hydraulic sorting of the riverine sediment load. Despite the higher sorption capacity of LD 2 sediments, the surface water concentrations of dissolved phosphorus were highest at this site.

^{31}P Nuclear Magnetic Resonance (NMR) analyses of concentrated river water and floodplain sediments reveal that phosphorus loading in this river occurs in diverse chemical forms. NMR analyses of riverbank sediments reveal the presence of P-forms such as Glyphosate (a commonly used weed-killer), Aminomethylphosphonic Acid (a degradation product of Glyphosate) and pyrophosphate (the smallest chemical form of polyphosphate with wide industrial applications), in addition to more commonly observed P-forms. The concentration of pyrophosphate in surface waters was below detection; however, ^{31}P NMR analysis of surface water that was concentrated 140-fold showed a peak that corresponded to pyrophosphate. Although the surface water concentration of these forms of phosphorus may be very low, over time the phosphorus binding properties of the deposited sediments may concentrate these forms of phosphorus in the floodplain of the CFR.

The NMR analyses of sediment samples from the areas under varying landuse within the Barra Farms site demonstrates that converting natural wetlands to agricultural land results in the loss of natural "diversity" in the chemical forms of phosphorus–analogous to the loss of "biodiversity" in impacted ecosystems. Results from the restored site indicate that restoration of impacted sites may result in re-establishment of the lost diversity in chemical speciation of nutrients. This also provides a valuable tool to track the progress of a restored site relative to a corresponding undisturbed and natural wetland.

The diversity in the chemical forms of phosphorus in the riverbank sediments helps identify the types and sources of nutrient loading in the CFR. It is conceivable that, after a few years of sustained nutrient loading (e.g. phosphorus), floodplain sediments of the Cape Fear River system will eventually become saturated with nutrients and thus will be unable to ameliorate nutrient-driven surface water quality degradation. Importantly, increasing variability downstream in the mineral element composition and the P-binding capacity of riverbank sediments suggests that moving seaward, sediment sorting will lead to creation of "hot spots" for efficient P-sorption and release along the riverbank of the CFR, and this could pose a considerable challenge with regard to water quality management. This implies that sources for sediment load to the CFR need to be identified and effective BMPs implemented to restrict the sediment loading in the upper reaches of the watershed. These findings have important implications for water quality management in this largest river system in North Carolina.

WRRI-funded Proposals for FY 2008-2009

These are proposals that were awarded funding for the fiscal year 2008-2009.

Principal Investigator	Project
Derek Aday NC State University	Exploring Mercury Transport Mechanisms in Aquatic Systems: A Statewide Assessment of Factors Affecting Methylmercury Contamination of Food Webs and Fish
Samkarsubramanian Arumugam NC State University	Improved Drought Management Strategies for the Triangle Area Utilizing Climate Information-based Probabilistic Streamflow Forecasts
Alexandria Graves NC State University	Antibiotic Resistance and Water Quality: Land Application of Swine Lagoon Effluent as a Potential Source of Antibiotic Resistant Genes in Surface Water
Roger H. von Haefen NC State University	Measuring the Benefits of Nutrient Management Strategies at North Carolina Reservoirs Using Linked Nonmarket Valuation and Environmental Assessment Models
Detlef Knappe NC State University	Development of an Analytical Method for Taste and Odor Compounds and Application to North Carolina Drinking Water Sources and Finished Waters
Wayne P. Robarge NC State University	Development of the Semi-empirical Ammonia Deposition and Emission (SEADE) Model for Application to North Carolina Coastal Watersheds
Marc L. Serre UNC Chapel Hill	Improving the Effectiveness of Mercury Water Quality Monitoring Using the Spatiotemporal Integration of Data from Multiple Sources

Notable Accomplishments

John Dorney, Supervisor of the North Carolina Division of Water Quality's Program Development Unit, was one of seven recipients for the 2008 National Wetlands Awards. Dorney "has been instrumental in the development of the state's wetland and stream protection programs." This award is given to citizens that have been recognized nationally for their on-the-ground wetland conservation efforts and decades-long dedication to protecting these important natural resources.

Naresh Devineni, PhD student, working with Dr. Sankar Arumugam in Civil and Environmental Engineering at NC State University, received an outstanding student paper award for his presentation "Multimodel Ensembles of Streamflow Forecasts: Role of Predictor State in Developing Optimal Combinations" at the Fall AGU (American Geophysical Union) conference in San Francisco. The presentation is from his Master's research, supported by WRRI, focusing on developing climate information based streamflow forecasts for the Falls Lake.

North Carolina Water Resources Association 2008 Board Members

The following are the 2008 North Carolina Water Resources Association board members:

Position	Name	Affiliation
President	Sandra Slayton	ENTRIX, Inc.
President Elect	Jason Doll	Stantec
Past President	Ken Carper	WK Dickson
Vice President	Patricia D'Arconte	Town of Chapel Hill Stormwater Management Program
Treasurer	Jean Spooner	NC State University Water Quality Group
Secretary	Sydney Miller	Triangle J Council of Government
Permanent Member	Upton Hatch	Water Resources Research Institute
Member At Large	Michael Burkhard	Mecklenburg County Water Quality Program
Member At Large	Virginia Hodges	City of Charlotte Engineering and Property Management - Land Development Division
Member At Large	Jay Wilson	City of Charlotte Engineering and Property Management - Land Development Division
Member At Large	Vish Chervu	Carter Burgess, Inc.
Member At Large	Scott Job	Tetra Tech, Inc.
Member At Large	Kelly Porter	Water Resources Research Institute
Member At Large	Budd Titlow	Chas. H. Sells, Inc.

Upcoming Events

June 10-13, 2008
Climate Information for Managing Risks (CIMR): Partnerships and Solutions for Agriculture and Natural Resources
St. Pete Beach. FL
http://conference.ifas.ufl.edu/CIMR/

July 22-24, 2008
2008 UCOWR/NIWR Annual Conference: International Water Resources: Challenges for the 21st Century and Water Resources Education
Durham, NC
http://www.ucowr.siu.edu/

October 1-3, 2008
Southeast Stormwater Association (SESWA) Annual Conference
Charleston, SC
http://www.seswa.org/

October 8-9, 2008
WRRI 11th Annual Conference & NCWRA Symposium
McKimmon Center, NC State University
Raleigh, NC
http://www.ncsu.edu/wrri/conference/

November 3-6, 2008
Stream Restoration in the Southeast: Advancing the Science and Practice
Asheville, NC
http://www.ncsu.edu/srp/2008conference

November 5-6, 2008
UNC Institute for the Environment Safe Drinking Water Symposium
Chapel Hill, NC
http://www.ie.unc.edu/content/news_events/symposia/2008/index.cfm

December 8, 2008
NCWRA Forum and Luncheon
McKimmon Center, NC State University
Raleigh, NC

WRRI Annual Conference

October 8-9, 2008
McKimmon Center
NC State University

WRRI is trying something new, we are moving our annual conference to the fall-- October 8-9, 2008. Our focus for this conference will be on drought management and water conservation. We will open the Call for Abstracts for oral and poster presentations in late-June. Our 1.5 day conference will be followed by half-day NCWRA Symposium on October 9.

NCWRA
North Carolina Water Resources Association

NCWRA Symposium

October 9, 2008
McKimmon Center
NC State University

NCWRA will host a half-day symposium that will address **"Half-Billion Dollar Question: How Do We Manage Nutrients from the Built Environment?"** Some key individuals will address different aspects of this topic. More information will be available in June.

The WRRI web site will have information on the WRRI Annual Conference and the NCWRA Symposium in June: http://www.ncsu.edu/wrri/conference/