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of The University of North Carolina

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North Carolina's erosion and sedimentation control program to be strengthened

North Carolina is widely acknowledged to have one of the nation's best regulatory programs to prevent environmental damage from erosion and sedimentation leaving construction sites. Established in 1973 by the Sedimentation Pollution Control Act, the performance-based program is often held up as a model for other states. However, according to Governor James B. Hunt, Jr., erosion and sedimentation control in the fast-growing state need to be improved by tighter standards, more aggressive enforcement, more technical assistance, and an infusion of resources.

After a plume of red, highly turbid runoff from construction sites and other land-disturbing activities in the Research Triangle was spotted on its way down the troubled Neuse River in June, the governor called on staff of the Land Quality Section of the Division of Land Resources, Department of Environment, Health, and Natural Resources (DEHNR) and local governments with delegated responsibility, which jointly administer the program, to assert control over construction sites not complying with regulations. In August, he met with N.C. Sedimentation Control Commission (SCC) Chairman John R. Bratton and other commission members and asked that the body review standards and evaluate program needs in preparation for the next legislative session and budgeting cycle.

In August, the new Secretary of Environment, Health, and Natural Resources, Wayne McDevitt, sent a letter to numerous federal, state, and local agencies; private regulated groups; and environmental groups saying that the SCC and department had developed a plan of action to address concerns about sedimentation pollution and asking for support of the plan.

As a first step in implementing the plan of action, the SCC has activated a technical advisory committee to review provisions of the law, regulations, and standards and make recommendations for changes to the SCC and next session of the General Assembly. Representatives of numerous agencies and the regulated community are cooperating with the technical committee, which is chaired by Dr. Joseph A. Phillips, a long-time member of the SCC and a

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WRRI's Water Resources Research Seminar Series schedule for 1997-98 is printed on page 16 of the Annual Program following page 8 of this newsletter.

The next seminar, to be presented by Terri Woods of East Carolina, is October 20, 1997, in Jordan Hall on the NCSU campus.

Director's Forum

Kenneth H. Reckhow, Director, Water Resources Research Institute

Adaptive Management: Responding to a dynamic environment

Editor's Note: The Director's Forum in this issue reflects material from a paper prepared by Kenneth H. Reckhow and Robert T. Clemen for the Neuse River Modeling and Monitoring study described in this year's WRRI Annual Program following page 8.

It is typical for decisions on the management of surface water quality to impact several environmental, social, and economic factors or attributes important to the public. In theory, this can lead to a difficult and complex problem analysis, but in practice many factors are virtually ignored during analysis and decision making. Further, it is typical for the predictions of the impact of proposed management actions on these attributes to be highly uncertain. Often it is possible to reduce that uncertainty through additional research and analysis, but resources for this are scarce and decision makers may not be inclined to wait for these results as they seek action and quick problem solution.

In part to provide the scientific basis for problem solution and action, large comprehensive simulation models have been developed. For the most part, these models have not proven to be reliable; current experience in the Chesapeake Bay with an extremely complex, and costly, modeling effort is the most recent example. Instead, whether it is the initial intent or not, successful management often involves judgment-based decision, followed by implementation, feedback, and readjustment. This "learning by doing" approach is a pragmatic attempt to deal with growth, change, new information, and imprecise forecasting.

Learning by doing, or adaptive management, is a strategy that treats management as a continually ongoing process utilizing observation and feedback. Management actions may change, or adapt, to the observational feedback; rather than create an elaborate model a priori and base all subsequent decisions on predictions from that model, the adaptive approach emphasizes updating of a model based on observation and learning as time passes. Updating the model may be done informally or formally through the use of statistical methods, and management actions can then be adapted to be consistent with the predictions of the revised model.

This approach may be particularly appealing in the Neuse and other coastal watersheds where population growth, land-use change, and variability in climatic-forcing

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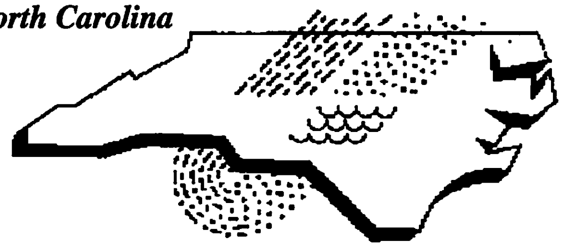

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functions exceed the limited realm of current observation and experience. Such systems involve complex and often highly nonlinear relationships among various elements; prediction in these chaotic environments can be difficult in the short term and useless in the long term. Even state-of-the-art models of such systems require periodic observation, evaluation, and revision in order to improve predictive validity.

In the Neuse River, there is a particularly compelling reason to consider adaptive management. A land-use and nutrient-control plan may soon be adopted to bring about a 30% reduction in nitrogen loading to the Neuse River. As the plan is implemented over time, a well-designed water quality monitoring program can provide two important pieces of information: (1) the actual (not model-projected) system response to management actions, which serves as a precise indicator of effectiveness of the action; and (2) the actual (not model-projected) water quality in the estuary, which allows broad management goals to be re-assessed relative to these continually updated conditions.

Over the past twenty years, coastal river and estuarine eutrophication problems have occurred in North Carolina a number of times; in each instance, scientific studies were conducted, conclusions drawn, and actions taken. During that time, weather patterns have at times created the impression that the eutrophication problem had been solved. However, events in 1995 in the Neuse River should convince us that, despite previous efforts, the problem remains. The pressure for growth in the region will continue, water pollution technology will improve, and public expectations may change. The situation is clearly dynamic, which suggests that adaptive, flexible management and not problem solution is the proper view.

Erosion and sedimentation control program *continued*

Professor Emeritus of Soil Science at N.C. State University.

To support recommendations from the technical committee, the education committee of the SCC will propose new and expanded initiatives for technical assistance to the regulated community and research on improved practices and devices to prevent erosion and control sedimentation. The SCC is expected to act on recommendations from both committees at its meeting on November 19.

The N.C. Erosion and Sedimentation Control Program

In 1973, the N.C. General Assembly studied the effects of erosion and sediment pollution on the state's natural resources and found that "the sedimentation of streams, lakes and other waters of this State constitutes a major pollution problem." The legislature passed the Sedimentation Pollution Control Act of 1973 (SPCA) to provide for a program and adoption of minimal standards that "will permit development of the State to continue with the least detrimental effects from pollution by sedimentation."

Anyone who engages in land-disturbing activity (except those engaged in agriculture, forestry using BMPs, and mining—which is regulated under the mine law) is subject to the SPCA, which means implementing erosion and sedimentation control measures to retain sediment within the boundaries of sites where land is disturbed. If the area of land to be disturbed is one acre or larger, an erosion and sedimentation control plan must be submitted and approved before activity can begin. There are specific requirements for the plan and specific performance standards that control measures must meet.

Staff of the Land Quality Section of the Division of Land Resources of DEHNR administer and enforce the program through seven regional offices and the Raleigh headquarters, except in jurisdictions where local governments have been delegated the authority to administer the program. In order to receive program delegation, local governments must adopt a local erosion and sedimentation control ordinance, which must be at least as strong as the state minimum standards but may be stronger. Currently there are 37 locally administered programs in the state.

Modifications to program being considered

Based on recommendations from staff of both state and local programs, the SCC technical advisory committee is evaluating a number of proposed modifications to the erosion and sedimentation control program. Among the most significant are:

- shortening the time allowed for establishing permanent groundcover on disturbed areas;
- requiring phased erosion and sediment control plans (one plan for clearing and grubbing and another after land grading has taken place);
- requiring undisturbed natural buffer zones along all High Quality waters;
- strengthening stop-work authority for violations;
- streamlining the civil penalty assessment process;
- modifying the process for reviewing and evaluating delegated local programs; and
- use by local programs of other local enforcement tools (such as withholding various building permits) to get compliance.

For additional information on the N.C. Erosion and Sedimentation Control Program or plan of action, contact Mell Nevils, Chief, Land Quality Section, N.C. Division of Land Resources at (919) 733-4574 or visit web site: http://www.ehnr.state.nc.us/EHNR/newsrels/sccact.htm

September action of the N.C. Environmental Management Commission

The North Carolina Environmental Management Commission did not meet in August. At the September meeting, the Commission held swearing-in ceremonies for new Commissioners and heard from Wayne McDevitt, the new Secretary of Environment, Health, and Natural Resources.

McDevitt told the EMC that Governor James B. Hunt, Jr. has set cleaning up the state's streams and rivers as the number one priority for the department.

"This is a defining moment in this state," said McDevitt. "The will of the people is obvious. The commitment of the governor and the General Assembly is clear."

Referring to a recent rash of spills from wastewater treatment plants and press accounts of lax permit enforcement, McDevitt said, "We are going to raise the bar on environmental compliance and send a clear message to bad actors that it will cost more to break the law than to comply."

EMC Chairman David Moreau said that the commission will hold public hearings on issues related to municipal wastewater treatment plants.

At the September meeting, the EMC also took the following action:

- Approved holding public hearings on amendments to the Air Toxics rules, to 112(g) Case-by-Case Maximum Achievable Control Technology Rules, and to Volatile Organic Compound Control Efficiency Rules. For information on air quality rulemaking and public hearings, contact Tom Allen with the N.C. Division of Air Quality at (919) 733-1489.

- Approved Basinwide Water Quality Management Plans for the Chowan River and the Pasquotank River. For information on these plans, call Suzanne Hoover with the N.C. Division of Water Quality at (919) 733-5083, Ext 573.

- Adopted temporary rules for Risk-based Corrective Action for Petroleum Underground Storage Tank leaks, with the temporary rules to become effective Jan 2, 1998. Adoption of the temporary rule was mandated by Senate Bill 114 passed this session. Adoption of a permanent rule by October 1, 1997, was mandated by legislation passed in the 1996 session. However, the EMC delayed action on the permanent rule until its October 9 meeting after new Commissioner Marion Deerhake objected to the inclusion of equations with specific numerical coefficients to be used to establish allowable maximum contaminant concentrations.

  "These rules are setting a precedent for other environmental regulations in the state," said Deerhake. "The door is now open for making other regulations risk-based. Including specific coefficients is dangerous given the dynamic state of risk assessment."

  EMC Chairman David Moreau agreed with Deerhake, pointing out that under the current Administrative Procedure Act, it takes two years to make effective any rule changes to respond to new toxicity data.

- Adopted a resolution supporting a plan by a number of fertilizer and lawn care companies to undertake a campaign to inform homeowners and other users of bagged fertilizer about proper fertilizer application and about the negative effects of overuse. The program was announced at the meeting of the EMC's Water Quality Committee the day before by Anne Taylor, Director of the Office of Environmental Education. Taylor said she approached the companies about an educational effort after the EMC passed a resolution last year suggesting that the legislature impose a tax on bagged fertilizer to fund an educational program on fertilizer use. In July, executives of 9 home lawn fertilizer and lawn care companies met with Taylor, members of her staff, and Senator Fountain Odom and agreed to collaborate in a program expected to generate millions of educational contacts through the companies' existing networks, packaging, and advertising. Companies participating will be authorized to use the N.C. Office of Environmental Education's "Know Your Ecological Address" logo, currently being developed, to identify them as part of the state's river basin environmental education campaign.

New Environmental Management Commission members appointed

The terms of eight members of the N.C. Environmental Management Commission expired on July 1, 1997: Charles L. Baker of Charlotte, Douglas S. Boykin of Willard, Carla E. DuPuy of Charlotte, Robert Epting of Chapel Hill, Dennis C. Loflin of Denton, Jeffrey V. Morse of Valdese, Richard V. Watkins of Apex, and Lawrence R. Zucchino of Raleigh.

Boykin was reappointed by the Speaker of the House.

Epting and Morse were reappointed by the President Pro Tem of the Senate.

The new House appointee is Mark Surles of Charlotte.

Governor James B. Hunt, Jr.'s new appointees are:

- Robert E. Cook of Raleigh
- Marion E. Deerhake of Raleigh, who previously served a term on the EMC
- E. Leo Green, Jr. of Wilson
- L.W. Locke of Enfield

For a complete listing of all EMC members with addresses and phone numbers, call Jennie Odette with the N.C. Division of Water Quality at (919) 733-7015 EXT 202.

Legislation affects cleanup of contaminated sites

A number of laws passed by the 1997 Session of the General Assembly will affect the extent to which sites in North Carolina contaminated with petroleum and hazardous substances must be cleaned up and how the state and local governments keep track of these sites and their use.

Two "brownfields" bills (H 1121 and S 125) were passed to provide for agreements between the Department of Environment and Natural Resources (DENR—see Digest for article on name change) and purchasers and redevelopers of contaminated sites that protect redevelopers from liability for existing contamination and allow risk-based remediation of contaminated sites to levels appropriate for various uses. In order to enter into a brownfields agreement, a prospective developer must demonstrate that s/he has complied with any previous cleanup responsibilities and with all federal and state environmental regulations, that s/he has the financial and technical means to implement the agreement, and that there is public benefit commensurate with the liability protection provided.

A brownfields agreement must include, among other things, a description of the property sufficient to serve as an instrument of conveyance, a description of the area(s) to be remediated, remediation method(s) to be employed, remediation standards, a schedule of activities, methods for evaluating the remediation, and any land-use restrictions that will apply to the brownfields property.

A developer who wants to enter into a brownfields agreement must notify the public and the local government(s) having jurisdiction over the site, provide information on the proposed plan, take comment on the plan, and provide for a public meeting if requested. In developing the final brownfields agreement, DENR must take into account any comment received. The legislation also provides for restrictions on the current or future use of sites subject to such agreements. Agreements which include restrictions on the use of the property must be filed with the register of deeds' office in the county or counties where the site is. When the property is sold, the deed must include a statement that the property has been classified and cleaned up, if appropriate, as brownfields property. Owners or operators of sites are responsible for enforcing restrictions on activities on the site. Land-use restrictions may also be enforced by DENR or by local governments.

"Brownfields property" or "brownfields site" means abandoned, idled, or underused property at which expansion or redevelopment is hindered by actual environmental contamination or the possibility of environmental contamination and that is or may be subject to remediation under any State remedial program (other than Chapter 143, Article 21 Part 2A) or the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

Another bill, H 225 Dry-Cleaning Solvent Cleanup Act, establishes a fund and a program to be administered by the Environmental Management Commission to clean up contaminated dry-cleaning sites and provides for liability protection for responsible parties that enter into a cleanup agreement with the EMC. The law provides for risk-based cleanup of sites contaminated with dry-cleaning solvents and for restrictions on the future use of remediated sites as a means of maintaining an adequate level of protection for public health and the environment. Public and community notice, and a public meeting if requested, are required for proposed cleanup plans that involve land-use restrictions. Public comment must be considered in finalizing the remediation plan. A copy of the final remediation plan must be filed in the office of the register of deeds of the county or counties in which the property is located. When the property is sold, the deed must contain a statement about the contamination and cleanup. Local governments may enforce land-use restrictions.

S 125, which provides for restricting the uses of property where low levels of contamination are allowed to remain, also applies to sites contaminated by petroleum leaking underground storage tanks (LUST). A 1995 bill required the N.C. Environmental Management Commission to establish a risk-based approach for assessment, prioritization, and cleanup of discharges and releases from LUSTs. S 125 passed this year was considered necessary to make the risk-based approach to LUST cleanup feasible, since risk-based rules assume that properties left with low levels of contamination will not be used for purposes such as residential, school, or daycare activities.

S 125 provides that property use restrictions must be agreed to by the owner of the real property, must be included in an approved remedial action plan for the site, and must be implemented as part of the remedial action program. Restrictions may apply to activities on, over, or under the land, including, but not limited to, use of groundwater, building, filling, grading, excavating and mining. The owner of the property subject to use restriction must submit to DENR a survey plat, titled "Notice of Oil or Hazardous Substance Discharge Site," to identify areas restricted. The notice must be filed with the register of deeds in the county or counties where the property is located. If the property is sold, the deed must contain in the description section a statement that the property has been used as an oil or hazardous substance discharge site and a reference to the recordation of the notice.

Environment-related legislation passed by the 1997 Session of the N.C. General Assembly

Some people are calling the 1997 Session of the N.C. General Assembly "historic" in terms of environmental legislation. Following is a listing, in some cases with brief descriptions, of environment-related legislation of which we are aware that was passed by the General Assembly and signed into law by Governor James B. Hunt, Jr. This list may not be complete, and any descriptions provided are bare summaries and should not be relied on for complete provisions. For additional information on legislation visit the General Assembly web site at http://www.ncga.state.nc.us/ or the UNC Institute of Government's daily record of legislative activity at http://ncinfo.iog.unc.edu/daily_summary/. If you want in-depth information on a particular bill, you may call the General Assembly's Printed Bills Office at (919) 733-5648 and ask for a copy of the bill. You must know the number of the bill you want.

H 189 An act to amend the N.C. drinking water act so that it conforms with federal law.

H 211 An act to amend various environmental laws to : (1) provide for continuing education requirements for, and the expiration and renewal of certificates issued by the Water Pollution Control System Operators Certification Commission; (2) include consideration of the compliance history in other states of an applicant for a permit under the Coastal Area Management Act; (3) clarify the distinction between a public hearing and a public meeting in connection with an application for a water quality permit; (4) allow the Environmental Management Commission to delegate its powers by resolution rather than by rule; (5) clarify the assessment of civil penalties for continuing violations of air quality standards; (6) reestablish a schedule of six-year staggered terms for the Mining Commission; (7) reestablish a schedule of two-year staggered terms for the N.C. Parks and Recreation Authority; and (8) make clarifying, conforming, and technical changes to various laws relating to environment, health, and natural resources. Among other things, specifies that the 9 people appointed by the governor to the N.C. Mining Commission, shall include the chairman of the NCSU Minerals Research Lab Advisory Committee, three representatives of the mining industry, three representatives of nongovernmental conservation interests, and two members of the Environmental Management Commission with knowledge of water and air management.

H 225 An act to provide for cleanup of dry-cleaning solvent contamination in North Carolina. Establishes a fund to receive taxes on dry-cleaning solvents and to be administered by the Environmental Management Commission in accordance with specified procedures to help clean up contamination by dry-cleaning solvents. Provides for risk-based approach to cleaning up contamination by dry-cleaning solvents, provides for imposition on dry-cleaning operations of financial responsibility requirements and minimum management practices for handling of dry-cleaning solvent. Fiscal note accompanying law says that from 1997 to 2010, Dry-Cleaning Solvent Cleanup Fund will receive about $10.5 million but that it is not certain fund will cover all costs of cleaning up the 69 sites dry-cleaning industry projects will need remediation.

H 227 An act to provide that recordation of an inactive hazardous substance or waste disposal site is not required in certain cases. Amends G.S. 130A to provide that an inactive hazardous substance or waste site that is undergoing voluntary remediation does not have to be recorded with the Department of Environment and Natural Resources unless there is a danger to public health or the environment or the remediation is not being done in a satisfactory manner. Also provides that the Secretary of DENR may waive recordation of residential property contaminated by migrating off-site contamination.

H 239 An act to specify that one member of the Environmental Management Commission shall have employment experience in industrial air and water pollution control at an industrial manufacturing facility.

H 251 An act to create the Well Contractors Certification Commission, to require that well contractors be certified, and to make various amendments to the Well Construction Act. In addition, provides that the Environmental Management Commission may issue notices of violation for violations of well construction rules and other EMC rules and can issue orders requiring specific remedial action.

H 260 An act to increase the cap on the income tax credit for real property donated for conservation purposes, to ensure that conservation and preservation agreements are considered in determining the appraised value of land and improvements, and to establish the conservation grant fund

H 515 An act to enact the **Clean Water Responsibility and Environmentally Sound Policy Act**, a comprehensive and balanced program to protect water quality, public health and the environment.

- Establishes a Mar 1, 1997, to Mar 1, 1999, moratorium on issuance of permits for waste management systems for new or expanding swine operations, with certain exceptions, including DENR-approved innovative waste management systems that do not employ an anaerobic lagoon. Provides that counties may adopt zoning regulations governing large swine farms. Mandates that NCSU report on animal operations odor control technology by Sept 1, 1998, and if economically feasible technology is available, the EMC must adopt a temporary rule to regulate odor by Mar 1, 1999. Amends laws governing siting of swine operations, including prohibition of construction of animal waste management systems in 100-year floodplain.
- Provides for new criteria for priority ranking of applications for loans and grants from the Clean Water Revolving Loan and Grant Fund, including mandated upgrades to meet nutrient requirements and existence of a satisfactory comprehensive land-use plan that protects water resources.
- Limits existing wastewater discharges greater than 500,000 gallons per day into nutrient sensitive waters to an average concentration (based on

annual mass load) of 5.5 milligrams per liter of nitrogen. New dischargers must meet limit regardless of size. Limits existing discharges greater than 500,000 gpd into nutrient sensitive waters where phosphorous is designated the nutrient of concern to an average concentration (based on annual mass load) of 2 milligrams per liter of phosphorous. New dischargers must meet limit regardless of size. Provides that if a calibrated nutrient response model has been developed for nutrient sensitive waters that meets certain requirements, that nutrient limitations imposed on dischargers be substantiated by the model. Provides that, if the model substantiates different nutrient limits than set in the law, those limits be imposed by the EMC.

- Provides that the EMC shall develop and adopt a statewide stormwater control plan to protect surface waters where stormwater is a major polluter. EMC to develop a model stormwater management program that local governments may adopt, but local governments may develop their own stormwater management plans and submit them for approval. Mandates that the Department of Transportation "work diligently" with the N.C. Division of Water Quality to develop, by Oct 1, 1997, an NPDES stormwater permit to cover all its programs.
- Mandates that the EMC shall develop and implement basinwide water quality management plans for each of the 17 major river basins in the state, considering the cumulative impacts of all point and nonpoint sources of pollutants and seeing that both share responsibility for reducing pollution. For nutrient sensitive waters, the plan must establish a nutrient reduction goal and require incremental progress toward the goal each year.
- Mandates that the EMC prioritize impaired waters and develop total maximum daily loads (TMDLs) for pollutants of impaired waters in accordance with federal law. Provides that in developing strategies for meeting water quality standards, the EMC may adopt any rules it deems necessary to deal with point or nonpoint sources of pollutants, "including but not limited to, additional monitoring, effluent limitations, supplemental standards or classifications, best management practices, protective buffers, schedules of compliance, and the establishment of and delegations to intergovernmental basinwide groups."
- Clarifies that the EMC may require individual as well as general permits for animal waste management systems. Mandates that the EMC develop a violation points system for animal waste management system for swine farms stating circumstances that will lead to revocation of permits. Directs DENR to develop a recommended system of civil penalties applicable to integrators of swine operations and to present findings to Environmental Review Commission.
- Provides that the Secretary of DENR refer to the State Bureau of Investigation any discharge of waste to waters that is believed to involve commission of a felony and that the SBI may conduct an investigation and refer the matter to the district attorney in whose jurisdiction any criminal offense has occurred.
- Revises EMC's power as to permits to provide that permits may be denied or conditioned when necessary to prevent "any significant increase in pollution of the waters of the State from any new or enlarged sources" and to prevent "violation of water quality standards due to the cumulative effects of permit decision." Provides that EMC may require applicants for permits to demonstrate financial responsibility and past environmental compliance.
- Provides that the Environmental Review Commission shall study (1) the amounts of fertilizers and pesticides used (virtually anywhere except agricultural operations) and the desirability of requiring persons who apply fertilizers to be certified and (2) development of best management practices for golf courses.
- Requires the Department of Agriculture to develop a plan to phase out the use of anaerobic lagoons and sprayfields as primary methods of disposing of animal waste at swine farms, including the feasibility of using solid waste management systems and aerobic wastewater management systems and to present the plan to the General Assembly no later than May 1, 1998.
- Requires the N.C. Public Utilities Commission, the Local Government Commission, and the Environmental Management Commission to study issues relating to publicly owned treatment works (POTWs) that persistently fail to comply with wastewater discharge rules and to make recommendations to the 1998 Regular Session of the General Assembly as to whether a State agency should assume control such PTOWs.

H 847 An act to authorize certain water and sewer authorities to enter into certain agreements and to authorize a water and sewer authority holding a certificate under G.S. 162A-7 to exercise the power of eminent domain for specified purposes. Gives water and sewer authorities power to enter into agreements with participating political subdivisions obligating subdivisions to make payments for treated water made available regardless of whether actually delivered or made available. Also gives water and sewer authorities power to acquire property by any lawful method, including eminent domain (1) to relocate or construct a road, (2) to establish or improve storm sewer and drainage systems or sewer and septic tank lines and systems, (3) to establish and improve drainage programs, and (4) for wetlands mitigation.

H 899 An act to modify the requirements for disclosures upon the sale of residential properties. Amends G.S. 47E-4 to delete the prescribed form for residential property disclosure and require the N.C. Real Estate Commission to develop and require use of a standard disclosure statement relative to (1) water supply and sanitary sewage disposal system; (2) roof, chimneys, floors, foundation, basement and other structural components; (3) plumbing, electrical, heating, cooling and other mechanical systems; (4) presence of wood-destroying insects or past unrepaired damage; (5) zoning laws, restrictive covenants, building code, land use restrictions, encroachments, or government notices affecting property; (6) presence of lead-based paint, asbestos, radon gas, methane gas, underground storage tank, hazardous material or toxic material (whether buried or covered), and other environmental contamination. On the disclosure statement the owner may indicate whether s/he has actual knowledge of the specified conditions or is making no representations as to any condition. The statement must be delivered to the purchaser when the offer to purchase is made.

H 990 An act to exempt certain nonprofit and consumer-owned water or sewer utilities and certain small water or sewer utilities from regulation by the Utilities Commission. Repeals automatic exclusion from regulation by Utilities Commission for corporations or consumer-owned water system financed by certain federal government agencies. Provides that the N.C. Utilities Commission MAY exempt from its regulation water and sewer utilities owned by nonprofit membership or consumer-owned corporations if (1) a governing board is elected according to established bylaws, and (2) if the Commission finds that the quality of service is adequate to protect the public interest.

H 1097 An act to enact the Fisheries Reform Act of 1997 to protect, enhance, and better manage coastal fisheries in North Carolina.

H 1121 An act to promote the safe reuse of properties where actual contamination, or the possibility of contamination, has impeded redevelopment. (See "brownfields" article on page 5.)

H 1137 An act to create a special license plate to promote soil and water conservation and to provide that a portion for the sales revenue goes to fund water quality and environmental education. Provides for development of a special motor vehicle registration plate with an appropriate phrase and picture related to subject of water quality and environmental protection in North Carolina, if 300 or more applications for such a plate are received. Establishes within Department of Environment and Natural Resources, the Soil and Water Conservation Account to receive revenue from sale of special license plates and to fund environmental education and water quality education in North Carolina. (This special plate will cost an additional $20.)

S 32 An act to authorize studies by the Legislative Research Commission, to create various commissions, to continue a council, to direct state agencies and legislative oversight committees, and commissions to study specified issues, and to impose a moratorium on service corporation conversions.

- Provides that the Legislative Research Commission MAY study (among other things) (1) coastal beach movement issues, (2) municipalities annexation and incorporation issues, (3) storm hazard mitigation and wastewater systems permits, (4) emerging issues in fiscal reform and intergovernmental relations including the fiscal relationship between the State and its local governments and the extent to which environmental regulatory programs administered by state agencies might be delegated in whole or in part to local governments.
- Provides that the Environmental Review Commission MAY study (1) air pollution from asphalt plants, (2) remediation and reuse of brownfields property (subcommittee may be established), (3) transferring vehicles emission inspection and maintenance program from Motor Vehicles to Division of Air Quality, (4) interbasin transfer of water, (5) feasibility of having the N.C. Cooperative Extension Service develop a voluntary public education program about the impact of lawn maintenance chemicals (fertilizers and pesticides) on the environment of the state, (6) preliminary evaluation of proposed sites for wastewater systems, (7) evaluation of all State-funded water quality studies conducted since 1992.
- Provides that the EMC, Division of Air Quality with cooperation of Division of Motor Vehicles shall study whether the emissions inspection and maintenance program should be expanded to include all metropolitan counties.

S 114 An act to establish a framework for developing and implementing cooperative state-local water quality protection plans for river basins and segments of river basins and to expedite the permanent closure of low-risk sites under the Leaking Petroleum Underground Storage Tank Cleanup Act of 1988. Provides that the EMC may, as an alternative method of attaining water quality standards in a river basin, approve a coalition plan proposed by a coalition of local governments organized as a nonprofit corporation. Sets out requirements for coalition plan and conditions for approval by EMC. Provides plan may involve pollutant trading between and among point source discharger and nonpoint sources. Provides that "no person shall be required to clean up a discharge or release from a leaking petroleum underground storage tank that has been classified as having a Class CDE impact" (as established in a 1995 law).

S 125 An act to authorize the Secretary of Environment, Health, and Natural Resources to encourage the redevelopment of brownfields by approving the imposition of restrictions on inactive hazardous substance or waste disposal sites and on oil or hazardous substance discharges or releases. (See "brownfields" article on page 5.)

S 140 An act to add two members to the Environmental Review Commission.

S 151 An act to clarify the duty of an owner, operator, or other responsible party of an inactive hazardous substance or waste disposal site to notify the Department of Environment, Health and Natural Resources of the existence of the site, to require owners, operators, and other responsible parties to furnish information regarding the site, and to simplify the inactive hazardous substance or waste disposal site inventory.

S 153 An act to extend the scrap tire disposal tax at its current rate for five more years, to amend the scrap tire disposal act to discourage the disposal of scrap tires from outside the state, and to complete the cleanup of nuisance tire collection sites.

S 251 An act to modify the common law to permit the creation of easements, restrictions, and covenants by a landowner. (According to the head of the On-Site Wastewater Branch, this amendment clarifies the objection raised in complying with sewage system ownership or control requirements of 15A NCAC 18A.1938(g).)

S352 "Budget Bill"

- The Clean Water Management Trust Fund is set at $30 million per year and the chair of the trustees of the fund is directed to report quarterly on projects awarded grants.
- Most agencies dealing with health services are transferred to a new Department of Health and Human Services (DHHS). All agencies dealing with environment and natural resources are transferred to a new Department of Environment and Natural Resources (DENR). A Division of Environmental Health is created within DENR and all the functions of the former division of the same name are transferred to it, including on-site wastewater and public water supply. On-site wastewater and drinking water programs may NOT be merged into the Division of Water Quality, and the Environmental Review Commission is to study appropriate responsibilities relating to various water programs. Radiation Protection is transferred from Human Resources to a new Division of Radiation Protection in DENR. A new Division of Waste Management is created to carry out responsibilities of the former Solid Waste Management Section of the Division of Health Services. The N.C. National Park, Parkway and Forests Development Council is transferred to DENR from the Department of Commerce. DENR and Office of State Budget and Management is to study whether DENR should be split into two departments, one dealing with natural resources and one dealing with environmental protection and regulations.

Water Resources Research Institute

of The University of North Carolina

ANNUAL PROGRAM

CURRENT RESEARCH JULY 1, 1997, TO JUNE 30, 1998

The Water Resources Research Institute is a unit of The University of North Carolina system headquartered in Jordan Hall on the North Carolina State University campus.

It is one of 54 state water institutes authorized by the Water Resources Research Act of 1964 to administer and promote federal/state partnerships in research and information transfer on water-related issues.

The mission of WRRI is threefold: to identify the state's ever-changing research needs, to motivate and support research by qualified scientists, and to provide for technology transfer.

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WRRI, State of North Carolina cooperate to focus research on Neuse management needs

The centerpiece of the 1997 North Carolina General Assembly's environmental legislation, the Clean Water Responsibility Act, authorizes a number of management actions aimed at improving water quality in the troubled Neuse River Estuary.

Lawmakers had to make these management decisions about the Neuse under intense pressure from opposing groups. Making political decisions that try to balance interests is the role of elected officials, and they want to make decisions that will bring about the best results with the least overall pain to their constituencies. In an effort to make the best decisions about management of water resources, lawmakers turn to scientists for assurance that what's being proposed will have the desired results. Over the last two years, North Carolina legislators sat through many long hours of scientific presentations on the problems of the Neuse. However, in the end, they had to make their decisions without any assurance that scientists know the precise linkages that produce water quality problems in the Neuse Estuary or precisely what steps will solve water quality and related problems.

Because of the complexity of the natural world, environmental management decisions will always be made amid scientific uncertainty and even scientific disagreement, and there will always be questions about whether enough information exists to make management decisions. In these circumstances, results are likely to be better if management decisions are made within a framework that imposes logic and focuses on key scientific issues, linking proposed actions to desired outcomes.

In a project sponsored by the N.C. Department of Environment, Health, and Natural Resources (DEHNR) and WRRI, scientists from four North Carolina universities and the U.S. Geological Survey have teamed up to develop such a framework to support decisionmaking for the Neuse River Basin. Dubbed "Neuse River Estuary MODMON" by the research team, the project involves three interrelated efforts:

- **Monitoring:** A massive undertaking of fish, sediments, water quality, and hydrology sampling from New Bern to the mouth of the Neuse River to provide data for water quality modeling
- **Short-term Modeling:** Calibration, improvement, and error analysis of a water quality process simulation model (CE-QUAL-W2) for the estuarine portion of the Neuse
- **Long-term Modeling:** Development of a framework for making management decisions and selection of an approach to developing a comprehensive (watershed-river-estuary) water quality model to support decisionmaking.

Each effort involves a team of scientists. Each scientist is working within his area of expertise to contribute to a common end product. All products are designed—not just to produce scientific data and understanding—but primarily to support management decisionmaking.

Monitoring

The UNC Institute of Marine Sciences at Morehead City, DEHNR, and Weyerhaeuser Corporation cooperatively operate an eight-station monitoring network that collects weekly water quality data in the Neuse Estuary. In an intense, year-long effort, scientists at the Duke and UNC-Chapel Hill marine sciences programs at Morehead City are expanding by 9 stations and enhancing this network to:

- **Obtain continuous measurements of water quality parameters at several locations.** Continuous measurement will allow better prediction of phytoplankton

continued

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Members of the Board of Directors of the Water Resources Research Institute are appointed by the President of The University of North Carolina system. The Board establishes Institute policy, and the Chairman of the Board makes appointments to the Technical Committee.

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WRRI ADVISORY COMMITTEE

The Advisory Committee of the Water Resources Research Institute is composed of representatives from state and federal programs, local government, industry, environmental organizations, private consultants, water and wastewater treatment plants, the university research community and others. The committee advises the Institute on the need for water-related research in North Carolina, the region, and the nation.

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INSTITUTE RESEARCH PRIORITIES

Priorities established by the WRRI Advisory Committee for the current year reflect an effort to focus research in areas of key scientific uncertainty to produce knowledge useful for management decision making:

- Development of basinwide predictive models relating point and nonpoint sources to decision-sensitive water quality responses, incorporating uncertainty analysis.
- Evaluation of urban, forest, and agricultural Best Management Practices (BMPs) for both effectiveness and cost effectiveness and development of useful predictive techniques to guide selection of BMPs for specific circumstances.
- Characterization and prediction of the transport of nutrients, pesticides, and sediment from field edge to estuary, including the actual (removal and addition) mechanisms, with emphasis on filter strips.
- Analysis of past experiences (successes and failures) in the Chowan and Albemarle-Pamlico to assess what we might learn from those experiences and studies that might be applied to coastal rivers and estuaries.
- Determination of the relationship between nutrient concentrations (or nutrient loads) and algal density (blooms) in the Neuse and other coastal rivers so that management goals can be established.
- Assessment of unintended impacts of nitrogen controls in the Neuse River (shifts in species composition).
- Determination of expected reduction in water use from various water conservation programs.
- Assessment of effectiveness of a state wetland mitigation bank as a wetland mitigation tool.
- Estimation of the nitrogen budget for the lower Neuse River - sources, sinks, residence time, and uncertainties.
- Determination of a reasonable minimum flow associated with in-stream flow structures (e.g. dams).

responses to changing water quality conditions.

- **Monitor the distribution of parameters across as well as along the river axis.** Cross-river data will support the effort to produce a three-dimensional model at the point where the river widens and becomes estuarine in nature.
- **Monitor the capacity for exchange of oxygen and nutrients between sediments and water.** Data from 40 diver-collected cores, 200 sediment grab samples, and suspended sediment sampling will be used along with data from N.C. Division of Water Quality's in-situ stirred microcosm dome monitoring to understand sediment composition and biogeochemical activity along the river bottom, to identify zones of hypoxia/anoxia, and to help model processes in the estuary.
- **Monitor flow velocities across the river and along the river downstream of New Bern.** A broad band acoustic Doppler current profiler mounted on the side of a boat will be used to collect data on estuarine longitudinal circulation (downstream at the surface and upstream at the bottom) and lateral currents. This information will help to better model how nutrients, phytoplankton, and oxygen move through the estuarine system.
- **Monitor how fish respond to changes in water quality conditions, particularly dissolved oxygen.** Biweekly simultaneous water quality and trawl fish sampling from the mouth of the Neuse to New Bern will produce data to discover how zones of hypoxia/anoxia affect fish distribution. Divers will also collect data to explore effects on shellfish.

During the monitoring project, researchers are making graphical summaries of the data available through a World Wide Web site: **http://www.marine.unc.edu/neuse/modmon/monitor/monitor.htm**

An Interdisciplinary Observational Program for the Neuse River Estuary, NC (50220)
Richard A. Luettich, Jr, PI
UNC-Chapel Hill Institute of Marine Sciences; **Larry B. Crowder**, Duke University Marine Laboratory (50223); **Marc J. Alperin, Christopher S. Martens**, and **Daniel B. Albert**, UNC-Chapel Hill Curriculum in Marine Sciences; **Hunter S. Lenihan, Jesse McNinch, Hans W. Paerl, C.H. Peterson, James L. Pinckney, John T. Wells**, UNC-CH Institute of Marine Sciences

Short-term modeling

Because of the urgent need and public demand to "do something" about water quality problems in the Neuse River Estuary, efforts to produce a model to predict water quality responses to management actions and thereby support decision making are being conducted in two phases. In the short-term modeling phase scheduled for completion by December 31, 1998, an existing model designed to simulate natural processes in rivers is being calibrated by Dr. Jerad Bales of the U.S. Geological Survey using 1991-95 data on hydrodynamic processes (flow, transport, mixing, etc.) in the Neuse Estuary, and the model is being improved with data from other locations to better represent sediment-water column interactions. While researchers will attempt to incorporate some data from the sediment studies described above into the short-term model, for the most part, data from ongoing monitoring cannot be incorporated into ongoing modeling because they cannot be analyzed and input to the model quickly enough.

Because the CE-QUAL-W2 model is being tailored for the Neuse Estuary quickly, using data known to be lacking in certain respects, scientists will put a great deal of emphasis on "uncertainty analysis," that is, determining how likely it is the model predictions are correct, where the biggest errors may occur, and what information can be provided to bring about the best error reduction.

The scientists say that in an ideal situation, uncertainty analysis of the model would take place prior to designing the monitoring program to better target data collection to reduce uncertainties. Under urgent circumstances, they say, judgment of experts on what data will best support decision making will have to suffice.

Neuse River Water Quality Modeling (50222)
James D. Bowen, UNC-Charlotte
Web site for short-term modeling:
http://www.coe.uncc.edu/~jdbowen/neem/

Long-term Modeling

In this phase of the project, scientists will interact with resource managers to determine what kind of management approach is likely to produce the best long-term results.

Scientists and managers will identify what system responses, such as fishkills and algae blooms, they want a model to predict. They will then identify proposed management actions. Some actions already proposed are forested riparian buffers and nutrient reductions in wastewater discharge. Once management actions and desired responses are put into scientific terms, quantified, and perhaps simulated mathematically (no small feat itself), then scientists have to begin combing through models and modeling approaches to find what will best predict if management actions will produce desired responses.

For example, if managers are interested in predicting algae blooms, they must first decide how algae blooms are to be represented in a model. The current way is by modeling chlorophyll *a* concentrations. At least two approaches exist to predicting chlorophyll *a* concentrations. One is a statistical model based on observation. The other is a mechanistic model that attempts to simulate the eutrophication process. The former is more accurate but generalizes its predictions across a waterbody. The latter is less accurate but can predict chlorophyll *a* concentrations in distinct geographical areas.

To give managers the ability to predict—with known and acceptable levels of uncertainty—specific details about algae blooms, lethal and sublethal effects on fish, and other responses of interest, the scientific team will evaluate:

- widely used process simulation models
- linked process models
- a probability network model coupled with ecological network analysis
- adaptive management

The goal of the long-term modeling phase is to begin development of a comprehensive water quality model for the Neuse Basin within a decision support framework. Progress reports on the modeling components of the Neuse

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Duke scientist will develop new way of determining characteristics of fractured rock aquifers

In order to efficiently manage groundwater for water supply or to clean up contaminated groundwater, managers must be able to model the flow of groundwater in an aquifer. To construct reliable models, they must know several characteristics of the aquifer, including the crucial parameters of "storativity," which controls the rate at which water is released from each layer of the aquifer, and "transmissivity," or the rate at which water is conducted through various aquifer media.

One of the most efficient and economical ways of obtaining information about hydraulic properties of aquifers is through the flowmeter test. This test consists of running a flowmeter device in a pumped fully penetrating well and measuring flow velocities in the well at all layer junctures. Contributions to the pumping rate from each layer are calculated from these velocities, and they are used to estimate the horizontal hydraulic conductivity of each layer.

The current theory of the flowmeter test requires that the borehole be pumped at a constant pumping rate until a quasi steady state is reached before the test is performed. However, this test allows estimation of only the downhole distribution of hydraulic conductivity. It provides no information about the downhole distribution of specific storativity. Moreover, in contaminated aquifers, pumping to reach a quasi steady state may take tens of hours and increase the spread of hazardous contaminants.

The only way to measure specific storativity is through a short "transient" test, that is a test performed during initial pumping before the steady state is reached.

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USGS Section 104(g) Regional Grants

In the 1996 Water Resources Research Act reauthorization, Congress authorized $3 million each year from 1996 through 2000 for research on "water problems of interstate nature," and provided that grants made to Water Resources Research Institutes by the U.S. Geological Survey under the act must be matched on at least a two-to-one basis by non-federal funds.

Funds appropriated for these "Section 104(g)" research grants are distributed through a program of regional competition.

In 1996, four projects involving North Carolina researchers won Section 104(g) funding in this regional competition. For 1997, two N.C. projects were awarded Section 104(g) grants.

Dr. Hans Paerl and Dr. J.L. Pinckney of the UNC-Chapel Hill Institute of Marine Sciences were awarded a grant for their project to provide information on denitrification rates in the Neuse River Estuary and information to help predict the response of nitrogen-fixing algae to proposed reductions in nitrogen loading in the Neuse.

In addition, Dr. Zbigniew J. Kabala of Duke University was awarded a grant for his project to develop a theory of the transient flowmeter test and test interpretation methodology and adapt the theory for fractured rock aquifers.

Project will examine whether nitrogen-fixing algae might interfere with goals of Neuse River cleanup

The nitrogen (N)-sensitive Neuse River has been the site of periodic massive scum-forming blooms of blue-green algae (cyanobacteria), a problematic (i.e.toxic, hypoxia/anoxia inducing, food chain altering) symptom of nutrient over-enrichment. When biologically available forms of N such as nitrate and ammonium are in short supply, some cyanobacteria can use atmospheric nitrogen gas (N_2) as a nutrient source, through the process of nitrogen fixation. The bloom organisms thus far identified in the Neuse River (Microcystis and Oscillatoria) are incapable of nitrogen fixation. Blooms of these non-N_2 fixers is one of several indicators that the Neuse is experiencing excessive nitrogen loading.

Earlier research (dilution bioassays carried out in the mid-1980's) indicated that to minimize the potential for cyanobacterial and other nuisance algal blooms in the Neuse River during bloom-sensitive periods, nitrogen loading should be reduced by 30% to 40%. However, there are serious questions about the effects that such a reduction in nitrogen loading would have without an accompanying reduction in phosphorous (P) loading. Altering the N:P ratio could result in negative water quality impacts.

In systems where N has been reduced without parallel P reductions, blooms of non-N_2-fixing species have simply been replaced by blooms of N_2-fixing species. The relatively high concentrations of P favor the growth of N_2-fixing (diazotrophic) cyanobacteria. In the Neuse, inducing N-limitation through unilateral N reductions may shift the algal species composition toward diazotrophic cyanobacteria, with potentially negative water quality implications.

Scientists and managers need more information about how, and at what rates nitrogen in its various forms is cycled in the Neuse River and Estuary to determine if this scenario will occur. A key component in addressing this important question is the identification of factors that trigger the growth and dominance of bloom-forming diazotrophic cyanobacteria.

In this project, Drs. Hans W. Paerl and James L. Pinckney of the UNC-CH Institute of Marine Sciences will investigate these fundamentally important and timely questions. Denitrification is a very important N-controlling process in which a biologically available form of N, nitrate, is converted to nitrogen gases (N_2O and N_2) that are released into the atmosphere. Environmentally, denitrification is considered a "sink" for combined nitrogen because it reduces the amount of biologically useful N compounds. This process is mediated by microbes in sediments lining the river floor. Knowing the rates of denitrification and the spatial distribution are crucial for understanding N cycling and determining N budgets, essential informational ingredients for development of nutrient-eutrophication models, including kinetic models to predict the role and importance of denitrification at reduced N loads, needed for long-term management of N-sensitive systems like the Neuse. At present, very little is known about denitrification rates in the Neuse and other North Carolina estuaries.

Drs. Paerl, Pinckney and their associates will collect sediment core samples at 5 transect sites on a monthly schedule to assess denitrification in the Neuse. These rate determinations will be used to estimate N losses through denitrification for key regions of the river and estuary experiencing various symptoms of nitrogen-driven eutrophication, including nuisance algal blooms, hypoxia, anoxia and associated adverse effects on fin- and shellfish.

Drs. Paerl and Pinckney and associates will also perform nutrient dilution bioassay experiments to determine what effects a reduction of N loading might have on algal species abundance and blooms in the Neuse. Using Neuse River water from an estuarine and a riverine site, the researchers will incubate replicate dilution treatments in ambient

Nitrogen-fixing algae *continued*

temperature and light conditions, then measure the relative biomass of algal groups in each treatment and a control. By comparing responses in the various dilutions to the control, they expect to detect community shifts. With additional analyses, they also expect to estimate N_2 fixation rates and gain insights into the mechanisms (environmental conditions, physiological state, nutrient availability) that turn on the N_2-fixing genes that control the potential for microbial N_2 fixation.

Biologically Mediated Nitrogen Dynamics in Eutrophying Estuaries: Assessing Denitrification and N_2 Fixation Responses to Proposed N Loading Reductions in the Neuse River Estuary (70166)
Hans W. Paerl and James L. Pinckney
(Contact: Hans_Paerl@unc.edu)
UNC-CH Institute of Marine Sciences
July 1, 1997, to June 30, 1998
Funded by WRRI
and the U.S. Geological Survey

NCSU researchers will examine effectiveness of system of agricultural BMPs

Nonpoint source pollution from agricultural runoff is a major water quality concern throughout North Carolina, the Southeast, and the nation. Pollutants include sediments, nutrients, and pesticides. State and federal farm-related and natural resource agencies and USDA Cooperative Extension personnel are encouraging farmers to adopt Best Management Practices (BMPs) to conserve soils and reduce nonpoint source pollution. To effectively use BMPs for water quality management, information is needed about their pollutant reduction effectiveness and costs of installing and maintaining them as well as their effects on crop yields and quality. Many studies have investigated the effectiveness of individual best management practices or compared two BMPs, such as grassed waterways, conservation tillage, grassed filter zones, or forested filter zones. However, few studies have considered the effectiveness, cost, and crop impacts of a fully integrated system of field, field edge, and adjacent woodland BMPs.

In this project Dr. Carlyle Franklin of the NCSU Department of Forestry and Dr. Gregory Jennings of the NCSU Department of Biological and Agricultural Engineering will investigate the ability of an integrated system of BMPs to handle runoff from tobacco fields in Piedmont North Carolina. Tobacco is a good crop to use for this study because heavy cultivation and heavy applications of fertilizers and pesticides are conventionally used.

On two well-instrumented 1.5-hectare agricultural watersheds at the Oxford Tobacco Research Station in Granville County, the researchers will evaluate effectiveness and costs of conservation tillage, grassed waterways/filter zones, and forested filter zones used to control runoff. The research will build on the investigators' previous studies of the hydrology, sedimentation and nitrogen cycling in the forested filter zones. It is expected to provide information on whether or not conservation tillage is cost-effective when used in combination with other BMPs, whether grassed waterways/filters are effective in reducing pollutants in major storm events, and whether management of woody vegetation in forested filter zones can enhance their nutrient removal capability. It is also expected to yield information on costs of installing and maintaining BMPs and effects of conservation tillage on tobacco yields and quality.

Effectiveness of Four Best Management Practices for Reducing Nonpoint-Source Pollution from Piedmont Tobacco Fields (70163)
E. Carlyle Franklin and Gregory D. Jennings (Greg_Jennings@ncsu.edu)
North Carolina State University
June 15, 1997, to December 31, 1998
Funded by WRRI

Project will reveal past environments of Neuse and Tar-Pamlico Estuaries

Water quality problems in the Tar-Pamlico and Neuse River estuaries are well documented and are thought to be related to both point source discharges of pollutants and nonpoint source pollution from changes in land use. However, scientific studies and monitoring that could link land-use changes and water quality changes in these systems have been conducted only in the last 30 to 40 years. These studies provide only a limited view of short term changes in the system—changes that may reflect seasonal or annual shifts and not long-term human influences. Nevertheless, a record does exist that can be used to provide managers and regulators with a much broader picture of how the systems have changed with human and climatic influences as well as the data to separate climatic from human impacts. That record lies in the accumulated sediments that underlie the estuaries and is accessible through the use of paleoecological methods. Paleoecology is the study of relationships between past organisms and the environment in which they lived. Paleoecological methods are used to reconstruct past ecosystems and to measure human influences against the naturally occurring state of those ecosystems.

In this project, Dr. Sherri R. Cooper of the Duke Wetland Center will collect and use paleoecological data to re-create the history of water quality and diatom community structure in the Tar-Pamlico and Neuse estuaries through time and to relate changes in water quality to changes in watershed land use history and other anthropogenic influences. She will take sediment cores from each estuary and examine them to discover and assess indicators of past water quality. Using radiocarbon dating, Pb-210 dating and Cs-137 dating along with pollen dating techniques, she will calculate sedimentation rates for each interval of the core and produce a time axis dating from about 1,000 years ago to the present, along which she can plot corresponding water quality and geochemical parameters. Plant and animal fossils, particularly pollens and preserved silica exoskeletons of diatoms (a form of algae), can be used to assess past eutrophication, nutrient availability, light availability, and sedimentation rates. Organic carbon in sediment layers can reveal information about past benthic oxygen demand, and sulfur compounds can tell whether oxic or anoxic conditions prevailed at the time sulfur was deposited.

The paleoecological record resulting from this work will help illuminate the debate concerning the primary factors contributing to declining water quality in estuaries and will support hindcasting models in which predictions about the effects of future environmental change on the ecology can be made.

The History of Water Quality in North Carolina Estuarine Waters as Documented in the Stratigraphic Record (70161)
Dr. Sherri Rumer Cooper
(slcooper@acpub.duke.edu)
Duke University
May 1, 1997, to June 30, 1998
Funded by WRRI

Neuse River ModMon *continued*

River project along with related papers and links are on the World Wide Web at: **http://www.marine.unc.edu/neuse/modmon/modeling/modeling.htm.**

Analysis of Ambient Monitoring Data in the Neuse River Basin (50225)
Craig A. Stow, Duke University
Contribution to Long-term Modeling Tier of the Neuse River and Estuary (50224)
Robert R. Christian, East Carolina University

Overall project coordination and development of decision analytic framework:
Neuse River Modeling and Monitoring (50219)
Kenneth H. Reckhow, WRRI & Duke Univ.
April 1, 1997, to December 31, 1998
Funded by the N.C. Department of Environment, Health, and Natural Resources

Neuse River water quality data now accessible on demonstration World Wide Web site

For decades, local, state, and federal agencies as well as universities have collected water quality data about North Carolina's streams, lakes and wells to support many short-term and long-term studies. Collecting agencies have shared their data, but there has been no comprehensive attempt to store all of these data in a single repository—until now.

Now, a common retrieval system for North Carolina water quality data is being developed as a joint effort of the Office of the Governor of North Carolina, the U.S. Geological Survey, WRRI, UNC-Chapel Hill, and the N.C. State University Computer Graphics Center. Hosted by the N.C. District of USGS, an aggregated database and World-Wide Web site is being developed to make water quality data accessible to the general public, schools, environmental consultants, and various governmental agencies.

A demonstration site with a specially designed graphical interface is now on-line, providing access to 15 basic water quality parameters for the Neuse River. The URL is: **http://wwwnc.usgs.gov/qw-cgi/qwretr.pl.** At this site, users may point and click on basin, county, and watershed maps to select specific monitoring stations and view and/or download data from those stations.

As the site is developed, additional parameters and river basins will be available through cooperation with the N.C. Division of Water Quality.

A Prototype Water Quality Data Retrieval System for the Neuse River Basin (50226))
Hugh A. Devine and Casson X. Stallings
North Carolina State University
March 1, 1997, to September 30, 1998
Funded by the North Carolina Board of Science and Technology

Project will focus on estimating costs of basinwide water quality management options

The N.C. Environmental Management Commission is poised to adopt a set of water quality management rules to be applied throughout the entire Neuse River Basin. Aimed primarily at reducing nutrient inputs to the river, the rules will tighten controls on point source dischargers and mandate use of best management practices (BMPs) to control several categories of nonpoint source pollution. While the Neuse River nutrient management plan will be the state's first set of rules to impose nonpoint source BMPs basinwide, North Carolina has embraced basinwide water quality management and developed many basin plans calling for voluntary nonpoint source BMPs.

Choosing the most efficient water quality management approach requires knowing not only the water quality impacts but also the economic impacts of options. In the case of water quality management rules, estimating the cost of complying with a rule that applies to one category of point source dischargers may be fairly straightforward, since the number of dischargers affected and the cost of employing a specific technology are likely to be known.

However, estimating the cost of implementing a range of nonpoint source BMPs throughout an entire river basin is not at all straightforward, since requirements would affect thousands of economic activities in different, site-specific ways. Calculating the likely costs of BMPs for each activity would require enormous resources and time.

Attempts have been made in other parts of the country, including the Chesapeake Bay area, to estimate the costs of basinwide nonpoint source controls, but these efforts have yielded at best crude estimates based on costs per acre applied to generalized land uses, without regard to site-specific factors that may substantially affect costs.

To fill the need for affordable techniques for estimating costs of basinwide nonpoint source control policy options, Dr. David H. Moreau of the UNC-CH Department of City and Regional Planning will develop statistical techniques to address the kinds of management options being considered by North Carolina and states with similar water quality problems.

After selecting management options to be studied, the investigator will use existing data sets (census data, building permits, computerized tax files, remote sensing aerial photographs, etc.) to define populations of lands and define appropriate sampling units for activities affected by each policy option. He will then, draw samples and make statistical inferences about the entire population.

Using case studies and available literature, he will identify relevant costs to be estimated for sampling units, then develop procedures to estimate costs with and without a given policy to establish costs that are uniquely imposed by that policy.

The final project report will include a manual of procedures with references to appropriate data sets.

Development of Methods for Estimating the Cost of Watershed Management Policies (70164)
David H. Moreau
(moreau.dcrp@mhs.unc.edu)
University of North Carolina
at Chapel Hill
July 1, 1997, to June 30, 1998
Funded by WRRI

NCSU team will develop watershed-scale model for predicting nutrient contributions in Neuse River Basin

Scientists generally agree that nuisance algal blooms and hypoxia and anoxia leading to fish kills in the Neuse River are at least partially due to excessive nitrogen loading. It has been estimated that more than 70% of the nitrogen input is from nonpoint sources, with a large portion of that coming from agricultural and forested lands. While nutrients are delivered to the estuary from watersheds throughout the river basin (and beyond in the case of atmospheric deposition), watersheds in the lower Coastal Plain may contribute a larger share because they are located closer to the estuary. If this is the case, then determining the effect of management practices to reduce nutrient losses at the outlets of lower Coastal Plain watersheds is a very important part of a basinwide management plan.

Water and nutrient management practices have been developed for reducing nutrient and sediment losses from agricultural and forested fields in the lower Coastal Plain, and reliable and fairly straightforward methods exist for estimating losses of sediments and nutrients at the edges of these fields. However, reliable and practical methods have not been developed to quantify effects of these practices on nutrient and sediment losses at the watershed scale.

Existing watershed scale models are complex and require a large number of difficult-to-determine input parameters. There may be great uncertainty in predictions made by these models because of errors associated with each input parameter and the interaction between parameters. Proper use of these complex models to predict

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CONTINUING RESEARCH

✓ ***Assessing the Impact of Septic Discharge on Water Quality on the Cape Hatteras National Seashore*** (70147) May 1, 1995, to November 30, 1997—Funded by WRRI and the National Park Service ■ Drs. David Evans and Aziz Amoozegar of North Carolina State University continue their research into whether groundwater quality on Bodie Island within the Cape Hatteras National Seashore is being degraded by septic effluent and their efforts to identify the sources and pathways of degrading constituents.

✓ ***Compliance with EPA's Information Collection Rule for North Carolina Surface Water Supplies: Bench-scale Testing of the Efficacy of Carbon Adsorption and Membrane Separation*** (70145) July 1, 1995, to September 30, 1997—Funded by WRRI and the U.S. Geological Survey ■ Dr. Francis A. DiGiano of the University of North Carolina at Chapel Hill continues a project to demonstrate the usefulness of bench-scale testing for assessing the effectiveness and cost of activated carbon adsorption and membrane separation for disinfection by-product precursor control.

✓ ***Geochemical Tracers of Groundwater Movement between the Castle Hayne and Associated Coastal Plain Aquifers*** (70148) June 1, 1996, to September 30, 1997—Funded by WRRI ■ Dr. Terri L. Woods of East Carolina University continues her investigation of the chemical and strontium isotopic characteristics of groundwater in the Castle Hayne, Yorktown and Peedee aquifers. By determining the chemical and strontium isotopic signatures of the groundwater from these associated units, she will be able to use mass balance calculations to track water movement between aquifers and possibly to estimate volumes transferred.

✓ ***Development of the Technical Basis and a Management Strategy for Reopening a Closed Shellfishing Area (70149)*** June 1, 1996, to June 30, 1998—Funded by WRRI ■ Dr. William W. Kirby-Smith of the Duke Marine Laboratory continues his project to design a plan to reopen a closed shellfish area in Carteret County that can serve as a model for reducing fecal coliform contamination and allow reopening of other closed shellfish areas in N.C. estuaries.

✓ ***Influence of Protozoan Grazing on Intrinsic Bioremediation under Anaerobic Conditions*** (70153) July 1, 1996, to December 31, 1997—Funded by WRRI and the U.S. Geological Survey ■ Dr. Robert C. Borden of North Carolina State University continues his project to determine if protozoa in soil may be controlling rates of biodegradation of petroleum contaminants by consuming the microbes that degrade hydrocarbon constituents and to model degradation rates in the field.

✓ ***Grass and Riparian Buffer Treatment of Runoff from Land Receiving Animal Waste*** (70146) July 1, 1995, to November 30, 1997—Funded by WRRI and the U.S. Geological Survey ■ Drs. J.W. Gilliam, J.R. Parsons, and R.L. Mikkelsen continue to gather data to help establish guidelines for designing effective buffers for different soil types, slopes, hydrologic, and vegetative conditions and to determine the effectiveness of buffers in removing pathogens found in animal waste.

✓ ***Characterization of Ammonia Emissions from Animal and Poultry Operations in North Carolina*** (50214) July 1, 1996 to June 30, 1999—Funded by the Division of Air Quality of the N.C. Department of Environment, Health, and Natural Resources and WRRI ■ Dr. Viney P. Aneja of North Carolina State University continues his project to begin describing all the paths of nitrogen (ammonia) volatilization, transport, transformation, and deposition at various kinds of swine and poultry operation and estimating the magnitude and frequency of loadings from these sources.

✓ ***Stable Nitrogen Tracers of Nitrogen Sources to Surface and Groundwaters near Animal Production Facilities*** (70157) August 15, 1996, to August 14, 1997—Funded by the N.C. Pork Producers; N.C. Department of Environment, Health, and Natural Resources, Division of Marine Fisheries; and WRRI ■ Dr. William J. Showers of North Carolina State University continues his project to use isotope science to measure the water quality impacts of animal waste as a source of nitrates to the Neuse River.

continued in shaded box on page 11

nutrient loading from a single watershed is expensive and time consuming even for an interdisciplinary group of research scientists. The task is beyond practical reality for policy makers and managers who need to make decisions about multiple watersheds with limited time and resources.

Water quality managers need new models that reflect the current understanding of the natural system but require input parameters that can be readily determined with a minimum of uncertainty.

To fill this need, a team of NCSU scientists will develop new watershed-scale models for predicting nutrient contribution based on their hypothesis that nitrogen loading at a watershed outlet is more affected by variations in hydrology and hydraulics than by variations in processes controlling nitrogen transformations. Rather than trying to model complex biological and biochemical nitrogen cycling processes, the scientists will lump these processes into simple empirical relationships that quantify the net change of nitrogen in the stream system. They will couple these lumped parameter models with models that simulate the variations in timing and intensity of storm events and the time required for drainage water to travel from field edge through conveyance systems to watershed outlets.

In the first year of the project, the scientists will develop two different lumped parameter models based on different approaches to representing nitrogen processing and will conduct field experiments on an existing instrumented watershed to determine the variability of the parameters used to describe the processes.

If they are successful in developing a workable lumped parameter model, the team will request a second year of funding to evaluate the models by comparing their predictions with field-measured data and with predictions of more complex process-based models. They will also evaluate the uncertainty of the lumped parameter models due to errors in parameter estimation and errors in model assumptions.

The research team includes Drs. R. Wayne Skaggs, George M. Chescheir, Devendra M. Amatya, and Glenn P. Fernandez of the NCSU Department of Biological and Agricultural Engineering and Dr. J. Wendell Gilliam of the NCSU Department of Soil Science.

Lumped Parameter Models for Predicting Nitrogen Loading from Lower Coastal Plain Watersheds (70162)
R. W. Skaggs, G. M. Chescheir, D.M. Amatya, G. Fernandez, and J.W. Gilliam
(Wayne_Skaggs@ncsu.edu)
North Carolina State University
June 1, 1997, to June 30, 1998
Funded by WRRI

Determining characteristics of fractured rock aquifers
continued

If numerical models can be developed that will yield estimates of both storativity and transmissivity from a transient flowmeter test, then a more economical and safer way of modeling groundwater flow and transport of contaminants in aquifers could be developed.

In this project, Dr. Zbigniew J. Kabala of the Duke University Department of Civil and Environmental Engineering will develop a theory of the transient flowmeter test and test interpretation methodology. In the first step, the theory will be developed for general layered porous media. Then it will be adapted for fractured rock aquifers such as are found in the N.C. Piedmont plateau. Dr. Kabala and his graduate student will evaluate the test in numerical experiments and in field tests at a site previously used for burial of low-level radioactive wastes where 15 unpumped monitoring wells are available.

An Improved Characterization of a Fractured-Rock Aquifer by the Transient Flowmeter Test (70165)
Zbigniew J. Kabala
(kabala@copernicus.egr.duke.edu)
Duke University
July 1, 1997, to June 30, 1998
Funded by WRRI and U.S. Geological Survey

CONTINUING RESEARCH

✓ ***Effect of Management Practices on Denitrification in Soils Fertilized with Lagoonal Swine Waste*** (70151) June 15, 1996, to August 31, 1998—Funded by WRRI and the U.S. Geological Survey ■ Dr. Stephen C. Whalen of UNC-Chapel Hill continues his project to identify field conditions under which microbes in soil most effectively convert complex forms of nitrogen into dinitrogen gas in order to determine which agricultural management practices are most likely to prevent export of nitrogen from fields treated with animal waste. In addition, he will examine the short- and long-term time trajectory for development and increase in microbial nitrogen transformations in fields treated with swine lagoon waste.

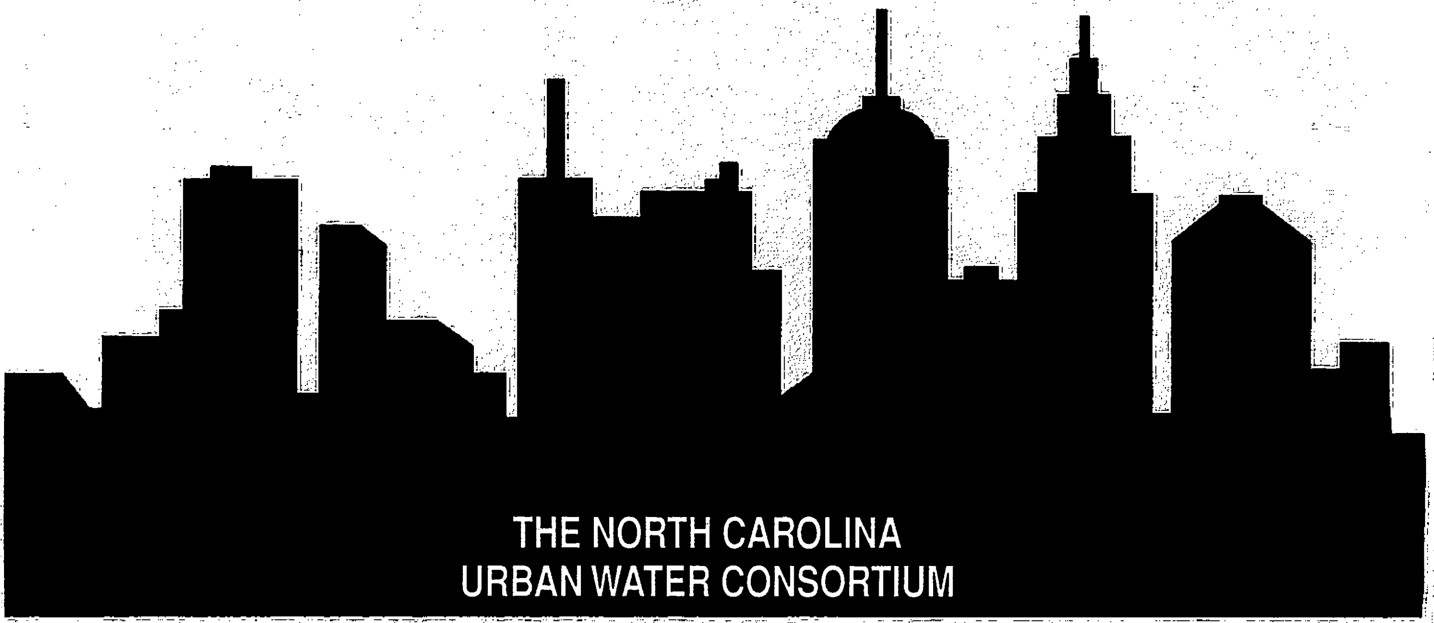
✓ ***Denitrification and Nitrification in Agricultural Soils Fertilized with Liquid Lagoonal Swine Effluent*** (50232) July 1, 1997, to June 30, 1998—Funded by the Division of Air Quality of the N.C. Department of Environment, Health, and Natural Resources ■ In a project related to the one described above, Dr. Stephen C. Whalen of UNC-Chapel Hill is examining the individual and interactive effects of environmental factors on denitrification in animal waste-amended agricultural fields and performing laboratory and field experiments to provide estimates of the annual gaseous nitrogen loss (N_2 and N_2O) to denitrification of liquid lagoonal swine effluent from spray fields. This study is part of an integrated project (See Characterization of Ammonia Emissions from Animal and Poultry Operations in North Carolina [50214]) to examine the fate of nitrogenous nutrients routinely stored in anaerobic swine waste lagoons. It will be of help to regulatory agencies in establishing BMPs and identifying needs for additional research on swine waste disposal.

✓ ***Control of Haloacetic Acid Formation in North Carolina Drinking Water*** (70155) June 15, 1996, to February 28, 1998—Funded by WRRI and the U.S. Geological Survey ■ Dr. Philip C. Singer of UNC-Chapel Hill continues exploring the possibility that elevating pH of coagulated and settled water prior to application of chlorine can control formation of haloacetic acids (a class of disinfection by-products) without significantly increasing formation of trihalomethanes (another class of disinfection by-products) or lowering the disinfection effectiveness of chlorine to unacceptable levels.

✓ ***A Decision Support System for Microbial and Disinfection By-Product Risk Analysis in North Carolina Water Supplies*** (70150) September 1, 1996, to October 31, 1997—Funded by WRRI ■ Dr. Douglas J. Crawford-Brown of UNC-Chapel Hill continues his project to develop an interactive computer-based Environmental Decision Support System that will allow water suppliers to select alternative assumptions to be used for assessing microbial vs disinfection by-product risk related to treatment options and to see how the assumptions affect the degree of confidence that can be placed in the assessment.

✓ ***Microbial Impacts of Animal Wastes on Water Resources*** (70152) June 15, 1996, to August 31, 1998—Funded by WRRI and the U.S. Geological Survey ■ Dr. Mark D. Sobsey of UNC-Chapel Hill continues his efforts to characterize and quantify the relative contributions of agricultural and commercial animal fecal wastes and human sewage effluents to levels of Cryptosporidium and Giardia in surface and ground waters in North Carolina. The purpose of the work is to provide a scientific basis for a quantitative assessment of the risk to human health and the environment from Cryptosporidium and other pathogens of agricultural animal origin in waters used for drinking water supply, recreation and shellfish raising. So far, analysis of replicate samples of cattle and swine lagoon influent and effluent has detected neither Cryptosporidium nor Giardia, and sampling of streams running through cattle and swine pastures and feedlots using BMPs has found no evidence of significant contribution of Cryptosporidium or Giardia from the animal operations.

✓ ***Protecting and Restoring Forested Stream Buffers in Existing Urban Residential Areas of Wake County*** (50216) October 1, 1996, to September 30, 1997—Funded by the Division of Forest Resources, N.C. Department of Environment, Health, and Natural Resources ■ Jeri Gray of WRRI and Rick Bailey of the Wake Soil and Water Conservation District wrap up a joint project aimed at providing information to urban landowners and local government officials in Wake County about the importance of forested riparian buffers for water quality and the importance of properly restoring riparian areas damaged by Hurricane Fran. A booklet, video, and call-in television program are products of the project.



In order to address research needs of specific groups, WRRI promotes partnership arrangements. One such partnership is the N.C. Urban Water Consortium. WRRI in cooperation with several of North Carolina's larger cities established the Urban Water Consortium to provide a program of research and development and technology transfer on water problems that urban areas share. Through this partnership, WRRI and the State of North Carolina help individual facilities and regions solve problems related to local environmental or regulatory circumstances.

The Consortium program is administered by the Institute. Participating cities support and guide the program through annual dues and enhancement funds and representation on an advisory board. Membership in the Consortium is limited to cities or special districts in North Carolina.

The program initially received support from the N.C. Department of Environment, Health, and Natural Resources and appropriations from the N.C. General Assembly. Current Consortium members are the Orange Water and Sewer Authority, Raleigh, Durham, High Point, Burlington, Winston-Salem, Charlotte, Greenville, and Greensboro.

Urban water research needs cover a broad range of topics. Problems addressed with Consortium support are described on the following pages.

Researchers shedding light on problems of algae in reservoirs

Drinking water plant managers in Piedmont North Carolina know that algae in their reservoir waters can cause problems. They know that algae can clog filters, contribute to the formation of disinfection by-products, and leave unpleasant tastes and odors in their finished water. Furthermore, algae may adversely affect drinking water quality by releasing toxins.

Because of the growing concern about algae, particularly toxic forms, and their possible effects on public health, the N.C. Urban Water Consortium has joined with the American Water Works Association Research Foundation to sponsor research that will shed light on the range of effects algae have on drinking water treatment and finished water quality. The research is being conducted by N.C. State University scientists Detlef Knappe, Sarah Liehr, JoAnn Burkholder and Howard Glasgow. It is also aimed at finding the best ways to treat raw water that contains algae, determining what can be done to control algae in reservoirs, and determining whether toxic forms of algae could threaten water supplies in the Piedmont. Work on this project began in December 1996.

To date, researchers have:

- collected information on other research through an ongoing literature review,
- worked on a method to determine algal biomass in raw, settled, and filtered water,
- begun investigating how organic matter released by algae affects the treatment process,
- begun evaluating how well conventional treatment removes algae and other particulate matter from water,

- begun a survey of treatment practices at Consortium member plants, and

- begun collecting samples and information to determine water quality and algae control practices at Consortium member reservoirs.

What the literature shows

Through the literature review, the investigators have found that when algae and blue-green algae are stressed they release large quantities of extracellular organic matter, which—depending on the kind of algae—may contain toxins or compounds that impart taste and odor to water. At least 18 genera of blue-green algae have been shown to be toxic, but toxicity varies widely. Poisoning of animals by blooms of freshwater blue-greens has been documented worldwide. While acute poisoning of humans by these organisms has not been documented, there are increasing reports of dermatitis and/or irritation from contact with freshwater blue-greens as people have more recreational contact with eutrophic waters. Some of the compounds that cause skin rashes have also shown to be tumor-producing, and chronic low-level exposure to these and other algal toxins have begun to be linked to immune system suppression.

Research into effects of algae on water treatment has linked increased turbidity levels in filtered water to elevated chlorophyll a concentrations in raw water. Indications are that in high concentrations, algae or extracellular organic matter released by algae interfere with particle destabilization in the coagulation process and, therefore, reduce filterability. Other researchers have identified elevated concentrations of dissolved iron or aluminum in filtered water as an early warning sign that the coagulation process has been adversely affected by soluble organic matter.

Studies have also shown that it is easier to remove algae from raw water when they are in their stationary growth phase, than when they are in their log growth phase.

Previous research has also revealed that algae, and more importantly the extracellular organic matter they release, can interact with chlorine to produce disinfection byproducts, some of which are suspected carcinogens. Furthermore, extracellular organic matter can serve as a substrate for the regrowth of microbial contaminants in water lines.

Studies have also shown that algae are stressed by the application of algicides to reservoirs, by chlorination prior to filtration, and by the physical process of withdrawing water from reservoirs.

Research indicates that there are problems with the most commonly used methods for controlling algae in reservoirs. Application of copper sulfate as an algicide stresses algae and induces production of extracellular organic matter, potentially including the release of toxins. Mixing (de-stratification, done to limit light and increase carbon dioxide levels) can increase inorganic carbon available for algal growth (although it could also shift species domination from blue-greens, which may be toxic, to greens). Finally, nutrient control may or may not be effective unless the ratio of nitrogen to phosphorous can also be controlled.

Developing a quick way to measure algae

If water managers have a quick and easy way to determine algal biomass in their source water, they may be able to adjust treatment methods accordingly to avoid problems. However, current quantification methods are costly and take too long to support a quick response. In this project, investigators are testing a process using a fluorometer to quantify chlorophyll a in flowing water. They are currently working on calibrating the fluorometer. They will then test it using raw water samples with concentrations of chlorophyll a determined by the standard EPA method. At the same time they will count algal cells and determine the presence of different algal species in samples in order to make comparisons between chlorophyll a levels and algal biomass.

Probing extracellular organic matter

Since extracellular organic matter (EOM) released by algae is known to affect treatment processes and the quality of finished water, the investigators are performing experiments to learn more about its role in the formation of disinfection byproducts (DBPs). They have spiked water from Falls Lake with EOM, dosed it with chlorine, and measured chlorine demand and the formation of trihalomethanes. Their initial experiments indicate that EOM greatly increases chlorine demand and the potential for DBP formation. They are now refining and repeating their experiments to produce some "hard numbers" on effects of EOM on DBP formation.

Evaluating removal of algae by conventional treatment

When high concentrations of algae are in raw water, water managers want to remove as much algal biomass as possible in the first step of the treatment process-coagulation and flocculation. In this project, investigators are trying to identify the optimum conditions for coagulation of algae. In a series of jar tests, they evaluated the effects of alum dose and pH on removal of turbidity, total organic carbon, dissolved organic carbon, and ultraviolet light absorbance in the presence and absence of algae. One important finding of these experiments was that the presence of algae did not seem to greatly affect percent removal of these commonly measured parameters even though large numbers of free algal cells remained in the settled water. This substantiates the need for the development of a direct method for the determination of algal concentrations in drinking water treatment plants.

As this two-year study continues, the investigators will:

- continue their ongoing work,
- study the effects of oxidants on the release and/or removal of EOM, taste and odor causing compounds, and toxins,
- evaluate dissolved air flotation for removal of algae from high turbidity waters,
- validate correlations developed from bench-scale studies at pilot-scale and full-scale plants, and
- initiate experiments to evaluate the effect of nutrients in reservoirs on the production of algal toxins.

Optimization of Treatment to Mitigate Impacts of Algae and Algae Control on Finished Water Quality (50215/7)
Detlef Knappe (KNAPPE@EOS.NCSU.EDU), Sarah Liehr, and JoAnn Burkholder
North Carolina State University
December 1, 1996, to November 30, 1998
Funded by the N.C. Urban Water Consortium and the American Water Works Association Research Foundation

Project offers insight into risk assessment process and risk from Cryptosporidium in drinking water

One of the thorniest problems facing managers of public drinking water utilities is that posed by the parasite Cryptosporidium. Almost ubiquitous in surface waters, this pathogen has been implicated in numerous recent outbreaks of water-borne disease, including the well-publicized 1993 Milwaukee outbreak that sickened nearly 400,000, hospitalized 4,000 and killed 40. The parasite is difficult to kill with common disinfection practices, and can be filtered out of water to reliable zero levels only by very expensive microfiltration techniques. One of the first steps in deciding how to address the problem of Cryptosporidium is knowing what kind of risk it poses in a specific water supply.

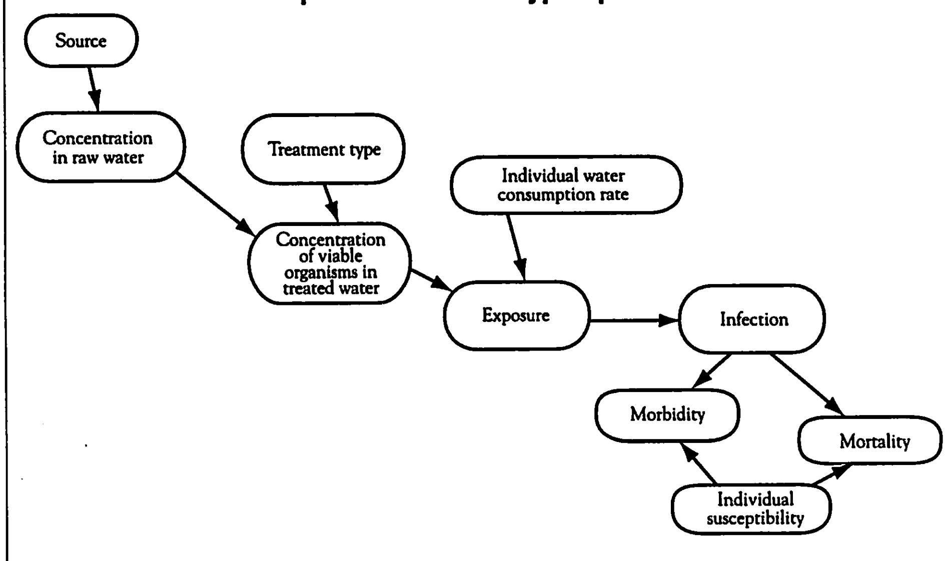
In this project, Kenneth H. Reckhow, director of WRRI, designed a conceptual model for assessing the risk that consumers of municipal drinking water in North Carolina face of infection from Cryptosporidium and the risk that immune-compromised consumers face of contracting a life-threatening illness from Cryptosporidium in drinking water. For her master's project in environmental management, Duke University graduate student Syril Director characterized uncertainties involved in Reckhow's conceptual model, then used a mathematical model representing the concept along with available "probabilistic" computer modeling programs to produce a probabilistic expression of Cryptosporidium risk for customers of several N.C. water utilities.

What is a risk assessment?

A risk assessment is a science-based estimate of the health risk a human population faces from being exposed to a particular substance. It combines information on the level of exposure to a substance with information on the toxicity of a chemical or virulence of a microbial contaminant to come up with some statement about what is likely to happened to humans who are exposed.

EXPOSURE + TOXICITY (OR VIRULENCE) = RISK

Conceptual model for Cryptosporidium risk assessment



Credibility in risk assessment

Identifying uncertainties

Because scientists never have certain knowledge about exposure or toxicity, risk may be characterized by a range of possible outcomes (e.g. "the risk could be as high as one additional case of disease X in 10,000 people or as low as no additional cases"). To come up with a reliable and creditable expression of risk, the risk assessor must identify uncertainties at each step in the risk assessment and take these uncertainties into account in the final estimates. For this project, Director examined each step in the model represented at the left and identified and modeled the uncertainties.

Uncertainty in assessing risk from Cryptosporidium in drinking water. To estimate how many Cryptosporidium oocysts (eggs) a consumer drinking water from any particular utility might consume in any day or year, it is necessary to know (1) the concentration of Cryptosporidium oocysts in the source water, (2) how much of it the treatment process removes and how much is left in finished drinking water, and (3) how much water a person typically drinks in a day.

In trying to get a reliable measurement of Cryptosporidium in source water, a risk assessor immediately comes upon a challenge: It is very difficult to detect and even more difficult to enumerate Cryptosporidium in water. They are microscopic and, even in high concentrations, are dispersed throughout large volumes of water. Further, there is no "litmus" test that will react only to them.

The first thing a technician analyzing a water sample for Cryptosopridium must do is capture all the cryptosopridium occysts from a sample of known quantity into a "supernatant." While there are standard procedures for doing this, it is not certain that these procedures actually capture every oocyst. So, to be honest about how accurate this first step of the analysis is, risk assessors may use a numerical range derived from statistical studies (of recovery rates from seeded samples), rather than a single number, to express a probable recovery rate of cryptosopridium occysts from the sample.

The next step in the analysis is to count the oocysts in the supernatant. An EPA-recognized immunofluorescence antibody test fluorescently labels the parasites so they can be seen and counted under a microscope, but the process also labels other particles. It is then necessary to microscopically distinguish the fluorescently labeled parasites from other labeled particles in the sample, and that is often nearly impossible to do. So, in this second step of measuring Cryptosporidium oocysts in source water, there is also uncertainty. Again, the risk assessor may use a range of values based on statistical studies (of accuracy in counting the parasite in seeded samples) rather than a single number to express the probable accuracy of oocyst counts.

Obviously, in the very early steps of the exposure assessment, the risk assessor already faces two serious areas of uncertainty. More will pop up at virtually every step. For instance, the exact extent to which any particular water treatment method removes or kills Cryptosporidium oocysts isn't known, and there's some uncertainty about how much tap water people actually consume in a day.

Moreover, when risk assessors reach the stage of assessing virulence of cryptosopridium, they face uncertainty about whether oocysts recovered from a specific water sample are all "viable"—that is able to cause illness, uncertainty about how many viable oocysts it takes to make any particular individual ill, and uncertainty about the seriousness of the illness in healthy and immune-compromised individuals.

To allow risk assessors to take all the many uncertainties about exposure and virulence into account, scientists have developed computer programs that generate probabilities or ranges of values for "parameters," or elements of a risk assessment model about which there is uncertainty. Using these programs along with risk assessment models, risk assessors can generate "probabilistic" expressions of risk.

Revealing assumptions. Mathematical models that are used to assess risk are by necessity simplified representations of a natural phenomenon (such as the rate of human infection by a pathogen). In simplifying phenomena enough to make calculations, modelers often make assumptions. A creditable risk assessment will always identify where assumptions were made and state what the assumptions were.

To mathematically represent the conceptual model designed by Reckhow, Director selected the "single-hit exponential" model, which had been derived from experimental data and was used to back-calculate oocyst concentrations causing the Milwaukee Cryptosporidiosis outbreak. However, she notes that the model assumes that each individual pathogenic particle ingested by a human is of equal virulence. Since scientists know very little about the infective capability of Cryptosporidium, this model could overstate the probability of infection from Cryptosporidium. Director also notes that in converting daily risk levels to annual risk levels, she assumed that there is no cumulative effect (such as development of immunity) from repeated exposures, and that if prior exposures do decrease sensitivity in a normally healthy individual, this assumption could result in overestimation of risk of illness.

Data. Even when a risk assessor scrupulously accounts for uncertainty and assumptions, insufficient data can raise questions about the reliability of a risk assessment. For this risk assessment, Director used data provided through U.S. Geological Survey monitoring of municipalities' water supply sources in the Research Triangle area. Most source waters were sampled twice, once in the fall or winter of 1994 and again between

continued

CONTINUING RESEARCH
SPONSORED BY THE
N.C. URBAN WATER CONSORTIUM

✓*Assessment of Trace Element Concentrations in Municipal Wastewater Treatment Plant Discharges in North Carolina* (50210) September 1, 1995, to June 30, 1998—Funded by the N.C. Urban Water Consortium

■ Drs. Philip C. Singer and Howard S. Wienberg of the University of North Carolina at Chapel Hill have found that strictly following recommended protocol and implementing quality assurance for wastewater effluent sample collection, handling and analysis will substantially reduce the number of instances of noncompliance with standards for mercury and cadmium. They have found that following protocol and enforcing quality assurance will reduce noncompliance for cyanide for most plants. However, they have also found that a few plants continue to show apparent high levels of cyanide in their effluents in spite of tight protocol and quality assurance. In a one-year continuation of this project, the scientists will investigate whether the current analytical methods employed for measuring cyanide are adequate and whether chlorination/dechlorination of wastewater may produce compounds that interfere with accurate measurement of cyanide in treatment plant effluent.

✓ *Evaluation of Ponds and Wetlands for the Protection of Public Water Supplies Continuation* (50211) January 1, 1996, to December 31, 1997—Funded by the N.C. Urban Water Consortium and the City of High Point.

■ Drs. Robert C. Borden and Sarah K. Liehr of North Carolina State University continue to examine the pollutant removal efficiency of stormwater detention ponds in the City of High Point's water supply watershed. They will use the results of their monitoring to calculate relative removal efficiencies of various stormwater control devices and to calibrate the lake water quality model MINLAKE for use in estimating season and long-term treatment efficiencies for each structure.

✓ *Evaluation of Pesticides in Water Supply Watersheds* (50218) April 1, 1997, to July 31, 1998—Funded by the N.C. Urban Water Consortium

■ For 16 months, Dr. Robert E. Holman of WRRI and Dr. Ross B. Leidy of NCSU collected water samples in water supply watersheds and conducted analyses for 11 pesticides: acetochlor, alachlor, aldicarb, atrazine, carbaryl, carbofuran, chlorothalonil, chlorpyrifos, methomyl, metolachlor, and 2,4-D. In more than 5,000 samples, the investigators found no traces of five of the targeted pesticides: acetochlor, alachlor, carbaryl, carbofuran, and methomyl. The only pesticide detected in raw water above the level that EPA has set for finished drinking water was atrazine. In phase II of the study, the investigators will attempt to further isolate the sources of atrazine through intensive field monitoring during the spring. Water plants will also be evaluated as to the timing and best treatment options to reduce the potential for pesticides to pass through the water treatment process.

✓*Evaluation of Wastewater Biosolids Compost for Production of Agronomic and Horticultural Crops* (50193) January 1, 1994, to December 31, 1997—Funded by the Charlotte-Mecklenburg Utility Department

■ Dr. James E. Shelton of North Carolina State University concludes his four-year project to identify and promote appropriate uses for compost made with wastewater "biosolids" by conducting demonstration and education activities for farmers, Cooperative Extension agents, and others.

✓ *Manual for Best Managemetn Practices for Compost Utilitization* (50227) March 1, 1997, to March 31, 1998—Funded by the Charlotte-Mecklenburg Utility District

■ Dr. James E. Shelton continues the effort to promote agricultural and horticultural use of composed biosolids by developing and producing a manual of use guidelines to be made available to producers through the Cooperative Extension Service and trade groups.

March and April of 1995. The concentration of Cryptosporidium oocysts per 100 liters was calculated using counts of "presumed" (that is, indicated by fluorescence) or confirmed oocysts in samples. However, because of all the uncertainties involved in detecting and measuring the parasite, a "detection limit" was calculated for each sample below which reported detection of the parasite should be considered unreliable. For all the samples except one, the reported concentrations were below the detection limits, meaning that the data available for this study allowed only an assessment of risk from source waters with Cryptosporidium concentrations below "detection limits."

Results of risk assessments for N.C. water supplies

Probabilistic risk assessments for N.C. source waters sampled indicated risk equal to or above EPA's recommended maximum annual risk of infection from potable waters of 1 case of infection in each 10,000 people. Since the most urgent concern about Cryptosporidium involves risk of illness in immune-compromised individuals, this project was designed to assess the risk of disease separately from the risk of infection. This assessment indicates that if infection can be equated to morbidity in immune-compromised individuals, then risk to these people may be as high as 1 in 10 on an annual basis.

In discussing the results of her analysis, Director notes that for the N.C. water supplies studied, the model predicts a "fairly significant background rate of Cryptosporidiosis in the healthy community." She notes that this prediction is consistent with epidemiological estimates.

Director says: "Although water utility and risk managers might be uncomfortable with the concept of a persistent background rate of disease associated with the consumption of treated waters, without sterilization or the installation of microfiltration systems, this phenomenon is likely unavoidable. For most individuals, natural immunity prevents this background incidence from becoming anything greater than a potential nuisance. However, it will be important to consider the potential for community concern in the communication of such risks to the public."

Uncertainty and Risk Analysis in Water Quality Modeling (50213)
Dr. Kenneth H. Reckhow, WRRI
August 1, 1996, to December 31, 1997
Funded by the N.C. Urban Water Consortium

STUDENT INTERN/ SCHOLARSHIP PROGRAM

WRRI coordinates three student intern projects and a scholarship program.

The N.C. Office of Waste Reduction supports seven interns who assist the staff during on-site audits and prepare reports on pollution prevention methods employed by industries. All graduating interns in this project have joined government or industry in the pollution prevention sector.

The N.C. Division of Land Resources, Land Quality Section and the N.C. Sedimentation Control Commission support one intern who works directly with the staff education specialist and two scholarships for university students in curricula related to erosion and sediment control.

The U.S. Geological Survey supports seven interns who work directly with the USGS District research staff on water resources related projects ranging from a literature review of nutrient contamination sources to maintaining a stormwater and rain gauge network.

UPCOMING WORKSHOPS AND CONFERENCES

During 1997-98, WRRI will sponsor or cosponsor the following:

September 1997

■ **9/23-24/97 Erosion and Sediment Control Design Workshop** *WRRI and the N.C. Sedimentation Control Commission and the N.C. Land Quality Section*

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TECHNOLOGY TRANSFER

WRRI disseminates information and promotes adoption of new technology and practices through publication of newsletters and technical completion reports on its projects and through sponsorship and co-sponsorship of conferences, workshops and seminars. The Institute has also established a World Wide Web page and is currently working to expand this aspect of its information and technology dissemination.

WRRI reports are distributed to libraries, and summaries of reports are published in the WRRI newsletter and distributed to interested research faculty, other state water institutes, and relevant government agencies. Single copies of publications are available to North Carolina residents at a cost of $4 per copy prepaid ($6 per copy if billed) and to nonresidents at a cost of $8 per copy prepaid ($10 per copy if billed). Send requests to WRRI, Box 7912, North Carolina State University, Raleigh, NC 27695-7912 or call (919) 515-2815. An updated listing of all WRRI publications, including technical reports, is published periodically and may be obtained by calling the Institute office.

WRRI produces three newsletters. The ***WRRI NEWS*** is published every other month and sent to nearly 3200 federal and state agencies, university personnel, multi-county planning regions, city and local officials, environmental groups, consultants, businesses and individuals. The *NEWS* regularly covers a wide range of water-related topics from current federal and state legislation and regulatory activities to new research findings and listings of water-related publications. The *WRRI NEWS* is available free of charge to residents of North Carolina. To be added to the mailing list, call or write WRRI. Email subscriptions to the *WRRI NEWS* are also available to anyone with an Internet address. To subscribe, send an email message to: listserv@ncsu.edu. In the message say: subscribe WRRI-NEWS your full name.

The ***Urban Water Consortium News*** is published annually and distributed to members of the Urban Water Consortium who use the newsletter to keep their constituencies (city councils, county commissions, etc.) informed about the activities of the consortium and about water-related issues affecting municipalities. The newsletter carries descriptions of research funded through the consortium as well as news about water-related projects undertaken independently by members, and state and federal programs and legislation.

The Institute also produces a newsletter, ***Sediments***, published by the N.C. Sedimentation Control Commission to provide information and assistance to the regulated community and to facilitate communication among personnel of state and local erosion and sediment control programs. This newsletter is free. To be added to the mailing list contact WRRI.

WRRI's World Wide Web homepage (http://www2.ncsu.edu/ncsu/CIL/WRRI) provides on-line access to the *WRRI News*; the WRRI Annual Program; a number of technical report summaries; the Water Resources Research Seminar Series schedule; information on workshops, conferences, calls for papers, and public hearings; and other items. Over the last year, additional report summaries and a directory of Water Resources Research Expertise in North Carolina universities were put on-line. Eventually, we expect to make full-text versions of technical completion reports and "discussion papers" related to water research topics available in postscript format and to establish a water resources research forum through our web page.

1997-98 Water Resources Research Seminar Series

Monday, October 20, 1997, Room 1132, Jordan Hall, NCSU Campus. "Geochemical Tracers of Ground-Water Movement between the Castle Hayne and Associated Coastal Plain Aquifers." *Assistant Professor Terri Woods, Department of Geology, East Carolina University*

Monday, November 17, 1997, Room 1132, Jordan Hall, NCSU Campus. "Atmospheric Emissions, Transport, Transformation and Deposition of Nitrogen compounds in the Neuse River Watershed." *Professor Viney Aneja, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University*

Monday, December 1, 1997, Ground Floor Hearing Room, Archdale Building, downtown Raleigh. "Optimization of Treatment to Mitigate Impacts of Algae Control on Finished Water Quality." *Assistant Professor Detlef Knappe, Department of Civil Engineering, North Carolina State University*

Tuesday, January 20, 1998, Room 1132, Jordan Hall, NCSU Campus. "History of Water Quality in North Carolina Estuarine Waters as Documented in the Stratigraphic Record." *Assistant Professor Sherri Cooper, Nicholas School of the Environment, Duke University.*

Tuesday, February 24, 1998, Ground Floor Hearing Room, Archdale Building, downtown Raleigh. "Biologically Mediated Nitrogen Dynamics in Eutrophying Estuaries." *Professor Hans Paerl, Institute of Marine Sciences, University of North Carolina at Chapel Hill.*

Tuesday, March 30, 1998, Room 1132, Jordan Hall, NCSU Campus. "Development of Methods of Estimating the Cost of Watershed Management Policies." *Professor David Moreau, Department of City and Regional Planning, University of North Carolina at Chapel Hill.*

Monday, April 20, 1998, Ground Floor Hearing Room, Archdale Building, downtown Raleigh. "Effectiveness of Four 'Best Management Practices' for Reducing Nonpoint Source Pollution from Piedmont Tobacco Fields." *Professor Carlyle Franklin, Department of Forestry, North Carolina State University.*

Tuesday, May 19, 1998, Room 1132, Jordan Hall, NCSU Campus. "Development of the Technical Basis and a Management Strategy for Reopening a Closed Shellfishing Area." *Associate Professor William Kirby-Smith, Nicholas School of the Environment, Duke University.*

WRRI Technical Committee

The Technical Committee, composed of university faculty, reviews and makes recommendations on research proposals and in other ways lends professional expertise to the Institute's programs.

Kenneth H. Reckhow, Director, Water Resources Research Institute (Chairman)
Michael D. Aitken, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill
James D. Bowen, Department of Engineering Technology, University of North Carolina at Charlotte
Mark M. Brinson, Department of Biology, East Carolina University
Stephen W. Broome, Department of Soil Science, North Carolina State University
Lawrence B. Cahoon, Department of Biological Sciences, University of North Carolina at Wilmington
Shoou-Yuh Chang, Department of Civil Engineering, North Carolina A&T State University
Robert R. Christian, Department of Biology, East Carolina University
B.J. Copeland, Department of Zoology, Norht Carolina State University
William L. Hinze, Department of Chemistry, Wake Forest University
Robert E. Holman, Associate Director, Water Resources Research Institute
Gregory D. Jennings, Department of Biological and Agricultural Engineering, North Carolina State University
George J. Kriz, Associate Director, Agricultural Research Service, North Carolina State University
Sarah K. Liehr, Department of Civil Engineering, North Carolina State University
Miguel A. Medina, Department of Civil Engineering, Duke University
Francisco San Juan, Department of Geosciences, Elizabeth City State University
V. Kerry Smith, Department of Economics, Duke University

UPCOMING WORKSHOPS AND CONFERENCES

continued

■ **9/25-26/97 Stormwater Quality & Watershed Management: Keeping Pace** *WRRI and the N.C. Chapter of the American Water Works Association*

October 1997

■ **10/28-29/97 Erosion and Sediment Control Design Workshop** *WRRI and the N.C. Sedimentation Control Commission and the N.C. Land Quality Section*

December 1997

■ **12/8-9/97 Nutrients in the Neuse River: Working toward Solutions** *WRRI and the N.C. Cooperative Extension Service*

January 1998

■ **1/27-28/98 Erosion and Sediment Control Local Programs Workshop** *WRRI and the N.C. Sedimentation Control Commission and the N.C. Land Quality Section*

February 1998

■ **2/10-11/98 Advanced Training: Erosion and Sediment Control Design Workshop** *WRRI and the N.C. Sedimentation Control Commission and the N.C. Land Quality Section*

March 1998

■ **3/10-11/98 Beginning Training: Erosion and Sediment Control Design Workshop** *WRRI and the N.C. Sedimentation Control Commission and the N.C. Land Quality Section*

April 1998

■ **4/1/98 Water Resources Research in North Carolina Conference** *WRRI*

- Requires DENR to coordinate an intradepartmental effort to develop scientific protocols to respond to fish kills, including (1) a plan of action to evaluate the impact of fish kills on public health and the environment, (2) responding to fish kills within 24 hours, (3) investigating and collecting data on fish kills, (3) summarizing and distributing fish kill information to agencies, scientists and other interested parties.
- Mandates revision of the general permits for animal waste management systems to make them more "flexible and practical" and to avoid conflicts with site-specific certified animal waste management plans. Mandates revision of the proposed time schedule for issuing the general permits. Extends to 2000 the deadline for poultry operations to comply with animal waste management plan testing and record-keeping requirements. Establishes schedule for bringing dairy farms under animal waste management rules and provides that, meantime, existing dairies are to continue to be deemed permitted as long as they are in compliance with a certified animal waste management plan or a special agreement with the EMC.
- Requires DENR to provide $600,000 to NCSU for odor control technology studies.
- Requires principal investigators of the following studies to make semi-annual progress reports to Environmental Review Commission and other commissions and advisory boards: (1) odor control technology, (2) sources of nitrogen through isotope markers, (3) groundwater impacts of lagoons, (4) atmospheric deposition of nitrogen in the Neuse Estuary, (5) alternative animal waste technologies.
- Requires DENR to use $400,000 of appropriated funds to establish a water quality monitoring program for the "Roanoke-Pamlico estuary system."
- Requires DENR to place in reserve $1,500,000 of 1997-98 fiscal year appropriations for the Cape Fear River Assembly, Inc. to be used for programs to monitor and improve water quality in the Cape Fear River. The Cape Fear River Assembly is to propose use of funds before encumbering them and the proposed use must be approved by (it appears), the Environmental Review Commission, the Joint Legislative Commission of Governmental Operations, and the Office of State Budget and Management.
- Requires DENR to use $850,000 of its appropriated funds for costs associated with development of "a regional wastewater collection, treatment, and disposal system that uses an innovative technology to reduce nutrient and organic loadings to surface waters." (Also requires DENR to provide $150,000 for wastewater infrastructure in Union County.)
- Requires DENR to develop and implement a program to monitor coastal fishing waters and to transfer money to the Shellfish Sanitation Branch to carry out the program.
- Requires DENR to evaluate septic tanks in the Neuse River basin, including hurricane damage and cost of repairing or replacing failing systems, and study development of guidelines for BMPs for septic tanks.
- Requires DENR to hold in reserve $1,000,000 and to use the funds to make up lost federal funding and budget shortfalls to the Division of Water Quality. The money can be used only when federal funding is cut and if receipts from permitting in 1997-98 are less than $2,950,000. Provides Division of Water Quality may receive funds received by DENR as federal indirect costs associated with the "106" water quality grant from EPA.
- Provides that $2,000,000 allocated in 1996-97 to the Lower Neuse River Basin Association does not revert and shall be used as grants to local governments to assist in fulfilling obligations under the Neuse River Nutrient Sensitive Waters Management Strategy if the EMC adopts one.
- Directs the Legislative Research Commission to study Oregon Inlet stabilization and to hold public hearing to take public input.
- Appropriates $7,030,600 for specific water resources development projects, including $828,600 in specific state-local projects.

S 516 An act to establish a state-administered lead-based paint hazard management program in lieu of having a federally administered program apply in this state. Requires certification and permit to perform lead-paint abatement in a child-occupied home except for homeowner performing work in own home. Sets up program in Department of Environment, Health, and Natural Resources to administer program.

S 550 An act to amend chapter 89C of the General Statutes to provide that the design of land application irrigation systems for animal waste management systems may be performed by irrigation design technical specialists and concerning agricultural best management practices.

S 812 An act to provide for special registration plates for supporters of the Great Smoky Mountains National Park. Provides for design and sale of special plate, if 300 applications are received. Money to go to Friends of the Great Smoky Mountain National Park for education, preservation and capital improvements of part of park in N.C.

S 947 An act to modify the burden of proof that must be satisfied to obtain a certification authorizing an interbasin transfer of surface waters, to direct the Environmental Review Commission to study issues relating to interbasin transfers, and to impose a temporary moratorium on certain interbasin transfers during the pendency of the study.

1998 ANNUAL NORTH CAROLINA WATER RESOURCES RESEARCH CONFERENCE

April 1, 1998, N.C. State University, McKimmon Center, Raleigh, North Carolina

CALL FOR PAPERS IN WATER RESOURCES

The meeting will highlight water resources research that is being conducted in North Carolina and provide an opportunity for researchers to meet and discuss their work with others interested in water research. University researchers, government agencies, industrial and agricultural representatives should attend this conference to gain current information on research that is addressing water resource issues.

If you are interested in presenting a paper at the annual conference, please call Robert Holman at WRRI (919/515-2815) for details or visit web site: http://www2.ncsu.edu/ncsu/CIL/WRRI/news/ja97wrrconf.html. Deadline for submission of abstracts is January 5, 1998. Notification of acceptance and session placement will be determined by February 1, 1998.

Digest

State Supreme Court upholds Water Supply Watershed Protection Act. In July the North Carolina Supreme Court handed down a decision upholding the constitutionality of the State's Water Supply Watershed Protection Act (WSWPA). The case in which the decision was rendered, Town of Spruce Pine v. Avery County, began when the Town of Spruce Pine in Mitchell County filed a complaint asking the court to direct the Avery County Commission to make a decision on the town's application to build a raw water intake on the North Toe River in Avery County. In its answer, Avery County alleged that Spruce Pine's action in selecting the intake site in Avery County was arbitrary and capricious and that the Water Supply Watershed Protection Act, which provides for zoning of watersheds, is unconstitutional because it unlawfully delegates legislative power to the Environmental Management Commission. A Superior Court judge granted a motion for summary judgment on the claim that the WSWPA was unconstituional, and the defendants' claim that the action of Spruce Pine was arbitrary and capricious was tried by a jury. The jury could not reach a verdict, and the judge granted the plaintiffs' motion for a directed verdict. The defendants did not appeal this order but did appeal the order regarding the WSWPA. The Court of Appeals, in a divided opinion, reversed the Superior Court and held that the WSWPA is unconstiutional because it delegates legislative power to the EMC without adequate guiding standards. Referring to Adams v. N.C. Department of Natural & Economic Resources, in which the State Supreme Court upheld the constitutionality of the Coastal Area Management Act, the Supreme Court in July reversed the Court of Appeals. In its decision, the court said "the classification of watersheds is a complex subject [and] . . . not something that the General Assembly can micro-manage." The judges ruled that in the WSWPA, the General Assembly provided "declarations of legislative goals and policies which an agency is to apply when exercising its delegated powers" as specific as the circumstances permitted when it provided for management of watersheds by controlling development density, performance-based alternatives, or a combination of both. Further, the court said, the General Assembly in the act provided procedural safeguards, including creation of the Watershed Protection Advisory Council and quarterly implementation reports to a legislative commission, that assured "the State retained as much control as was feasible over its legislative power."

DEHNR becomes DENR, maybe temporarily. The N.C. Department of Environment, Health, and Natural Resources (DEHNR, usually called "Deener") is no longer. By order of the General Assembly in the 1997 "budget bill," health programs formerly in DEHNR have been transferred to a new Department of Health and Human Services, leaving environmental protection and natural resource management in a new Department of Environment and Natural Resources (DENR). However, the Division of Environmental Health, which administers the on-site wastewater and public drinking water programs, has been left in DENR, but perhaps not permanently. The bill provides that on-site wastewater and drinking water programs may NOT be merged into the Division of Water Quality, and requires the Environmental Review Commission to study appropriate responsibilities relating to various water programs. According to DENR Public Information Officer Don Reuter, the new department's acronym is pronounced "Dinner." It may not matter, however, since DENR and Office of State Budget and Management are to study whether DENR should be split into two departments, one dealing with natural resources and one dealing with environmental protection and regulations.

Piedmont North Carolina Photographs by David H. Howells

Totten Center
UNC Botanical Garden
November-December 1997
Opening Reception 2-4 p.m.
November 2nd

The Triangle Land Conservancy has organized an exhibition of David Howell's magnificent black and white studies of Piedmont landscape for the UNC Botanical Garden. Greet Ginny Howells at the opening reception on November 2nd from 2-4 p.m.

The UNC Botanical Garden is on the 15-501 Bypass South.

Notecards featuring four of David's photographs are also available from the Triangle Land Conservancy (833-3662) and will be for sale at the reception.

Streambank stabilization BMP adopted to control sedimentation, nutrient inputs. The N.C. Soil and Water Conservation Commission has approved streambank stabilization for cost-sharing under the N.C. Agricultural Cost Share Program. For cost share purposes, streambank stabilization is defined as "use of bioengineering practices, native material revetments, channel stability structures, and/or the restoration or management of riparian corridors in order to protect upland BMPs, restore the natural function of the stream corridor, and improve water quality by reducing sediment to streams from streambank erosion and decreasing the delivery of nitrogen, phosphorus and other pollutants to the stream from adjacent pasture or cropland." Use of streambank stabilization as a BMP is limited to agricultural operations where the natural streambank has been severely damaged by livestock access or other activities associated with agricultural operations. A minimum set-back of 20 feet of undisturbed native vegetation or restored riparian area adjacent to the installed practice is mandatory. For additional information on this new BMP, contact your local Soil and Water Conservation District, or the N.C. Division of Soil and Water Conservation at (919) 733-2302.

UST inspections turn up leak detection violations. According to the U.S. EPA, a nationwide initiative in May to enforce leak detection requirements

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WRRI report available

WRRI has recently published a report on research for which it provided funding. Single copies of WRRI reports are available free to federal/state water resource agencies, state water resources research institutes, and other water research institutions with which exchange agreements have been made. Single copies of publications are available to North Carolina residents at a cost of $4 per copy prepaid ($6 per copy if billed) and to nonresidents at a cost of $8 per copy prepaid ($10 per copy if billed). Send requests to WRRI, Box 7912, NCSU, Raleigh, NC 27695-7912 or call (919) 515-2815, or Email water_resources@ncsu.edu.

Intrinsic Bioremediation of Gasoline-Contaminated Aquifers: Biodegradation Rate Measurement and Microbial Ecology (Report No. 308) July 1997

by Sreenivas Kota, Melody J. Hunt, Morton A. Barlaz, and Robert C. Borden
Department of Civil Engineering, North Carolina State University

The cost of pump-and-treat cleanup of groundwater contaminated by leaking underground petroleum storage tanks is staggering. Further, pump-and-treat is often not effective in meeting cleanup standards. More effective cleanup approaches are needed to manage the large number of sites contaminated by leaking underground storage tanks (USTs). Intrinsic bioremediation is a process in which contaminants are degraded by indigenous microbial populations. Where this approach can be used, it can save money over active approaches.

Research has shown that the primary groundwater petroleum contaminants—benzene, toluene, ethylbenzene, and xylene (BTEX)—do biodegrade under ambient conditions. However, the rate and extent of biodegradation are usually limited by the type and quality of electron acceptors. Oxygen is the preferred electron acceptor but is available in a very limited supply in the subsurface. Large amounts of ferric iron—Fe(III)—are present in the subsurface and could provide an enormous reservoir of electron acceptors for pollutant biodegradation. Unfortunately, little is known about the microbiology of BTEX biodegradation via iron reduction.

The goal of this study was to evaluate the significance of BTEX biodegradation at a contaminated site near Rocky Point, NC, where iron is thought to be a significant electron acceptor. Specific objectives were to (1) measure the rate and extent of BTEX biodegradation in laboratory scale microcosms designed to simulate ambient conditions at the site; measure the rate and extent of BTEX biodegradation in in-situ testers under natural conditions at the site; and (3) study the microbial ecology of the contaminant plume.

BTEX biodegradation rates under ambient conditions were measured in aquifer sediment recovered from three locations (source, mid-plume, and end-plume) at the site. In-situ biodegradation rates were measured using in-situ test columns. Two experiments were conduced, each by using two live columns and one abiotic column. In the first experiment, the columns were loaded with groundwater from one of the monitoring wells where the water contained all the dissolved hydrocarbons. In the second experiment, columns were loaded with anaerobic groundwater spiked with benzene. Two experiments were conducted to study the distribution of microorganisms in the contaminated aquifer. Populations enumerated included total microbes by acridine orange direct count, aerobic and anaerobic protozoa, iron reducers, and sulfate reducers. The objective of the first experiment was to evaluate spatial heterogeneity in closely spaced aquifer sediment samples from contaminated and pristine sections of the aquifer. In the second experiment, population distribution was measured in contaminated sediment samples spaced 0.3 m apart.

Conclusions of the study are:

- Destructive microcosms yield only one concentration measurement for each independent experiment (microcosm) and are poorly suited to generating the data required to fit a two-parameter model. Consequently, use of destructive microcosms, as specified in the USEPA protocol for estimation of anaerobic microbiological transformation rate data, is not appropriate when the lag period prior to the start of biodegradation is significant.
- Based on the laboratory microcosm and in-situ column experiments, benzene, toluene, ethylbenzene, and xylene isomers are anaerobically biodegradable under ambient subsurface conditions.
- A distinct order of biodegradation is often observed, with toluene being the most rapidly biodegraded compound.
- The more easily biodegradable compounds (toluene, o-xylene, m-xylene) appear to anaerobically biodegrade to low but detectable concentrations (0.1 to 0.4 µM) after which biodegradation slows or stops. It is not clear whether biodegradation of these compounds will continue once the more difficult to degrade compounds are depleted.
- Use of a simple first-order model does not adequately describe the anaerobic biodegradation of individual compounds in laboratory microcosms or in-situ columns. To accurately simulate the anaerobic biodegradation of individual compounds, a model that includes two variables will be required: (1) the lag period prior to biodegradation and (2) the rate of biodegradation.
- The lag period prior to the start of anaerobic BTEX biodegradation varies from compound to compound. Until the source of this variability is better understood, it will not be possible to use laboratory microcosms

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Water-related courses offered by N.C. universities Spring 1998

Duke University

Nicholas School of the Environment

ENV 242	Environmental Aquatic Chemistry
ENV 290	Physical Oceanography
ENV 298.06	Water Quality Sampling, Field Methods for Mgmt
ENV 312	Wetland Ecology and Management
ENV 356	Environmental Fluid Mechanics
ENV 234	Watershed Hydrology

For registration information call Ms Berti Belvin at (919) 613-8070. Non-degree students should contact the continuing education staff in the Duke admissions office (919) 684-6259.

Department of Civil and Environmental Engineering

CE 123L	Water Resources Engineering
CE 242	Environmental Aquatic Chemistry
CE 225	Dynamic Engineering Hydrology
EGR 24L	Introduction to Environmental Engineering

East Carolina University

Department of Geology

Geology 1550	Oceanography
Geology 6400/ 6401	Geochemistry

For course information, contact Scott Snyder, Chairman, at (919) 328-6360.

N.C. A&T State University

Department of Natural Resources and Environmental Design

AGEN 624 Water Resources Engineering
AGEN 714 Applied Hydrogeology
AGEN 602 Engineering Design
GEEN 660 Erosion and Water Quality Modeling

For course information, contact Godfrey A. Gayle, Chairman, at (910) 334-7543.

North Carolina State University

Department of Biological and Agricultural Engineering

BAE 472/572	Irrigation and Drainage
BAE 590W	Special Problems

Department of Chemical Engineering

ChE 575 Advances in Pollution Prevention

For course information, contact Michael Overcash (919) 515-2325.

Department of Civil Engineering

CE 280	Principles of Environmental Engineering
CE 381	Hydraulic Systems MeasurementsLaboratory
CE 382	Hydraulics
CE 383	Hydrology and Urban Water Systems
CE 374	Environmental Engineering Laboratory
CE 456	Air Quality
CE 480	Water Resources Engineering Project
CE 481	Environmental Engineering Project
CE 487	Coastal Engineering
CE 572	Design of Water and Wastewater Facilities
CE 577	Engineering Principles of Solid Waste Mgmt
CE 589	Special Topics in Civil Engineering - Water Resources Engineering
CE 591	Environmental & Water Resources Engr Smnr
CE 689	Advanced Topics in Water Resources Systems
CE 672	Advanced Water Treatment
CE 674	Chemistry & Microbiology for Env. Engrs II

For course information contact Robert C. Borden (919) 515-7665.

Department of Marine, Earth, and Atmospheric Sciences

MEA 100	Earth Systems Science ***New course
MEA 101	Geology I
MEA 110	Geology I lab
MEA 130	Introduction to Weather and Climate
MEA 135	Introduction to Weather and Climate lab
MEA 140	Natural Hazards and Global Change
MEA 200	Introduction to Oceanography
MEA 210	Introduction to Oceanography lab
MEA 220	Marine Biology
MEA 250	Introduction to Coastal Environments
MEA 251	Introduction to Coastal Environments lab
MEA 312	Physical Meteorology
MEA 314	Meteorology lab II
MEA 323	Earth System Chemistry
MEA 400	Earth Systems Modeling ***New course
MEA 430	Scientific Issues and Global Problems
MEA 460	Principles of Physical Oceanography
MEA 462	Methods in Marine Physics
MEA 467	Marine Meteorology
MEA 469	Ecology of Coastal Resources
MEA 493M	Coastal Issues and Scientific Concepts
MEA 520	Principles of Biological Oceanography
MEA 526	Air-Sea Interaction
MEA 560	Principles of Physical Oceanography
MEA 569	Physical Dynamics of Estuaries
MEA 572	Laboratory in Investigation of the Seabed
MEA 591B	Adaptations to the Marine Environment
MEA 592B	Surficial Processes
MEA 592C	NC Coastal Systems
MEA 592J	Cyclical Events in Earth History
MEA 663	Advanced Geophysical Fluid Mechanics

For course information contact Professor Donna Wolcott, Coordinator of Undergraduate Programs, at (919) 515-6207.

NCSU students may sign up for courses listed above through the TRACS system. Degree students at other universities participating in the interinstitutional program may sign up through interinstitutional registration. Non-degree students may sign up through the NCSU Division for Lifelong Education (919) 515-2261 (non-credit) or (919) 515-2265 (credit).

University of North Carolina at Chapel Hill

Department of City and Regional Planning

PLAN 236	Environmental Quality Planning
PLAN 232	Public Investment Theory and Techniques

For course information contact David Moreau, Chairman, at (919) 962-4756.

Department of Geology

GEOL 163	Applied Hydrology
GEOL 164	Geochemistry of Natural Waters

For course information contact Cathy Cash at (919) 966-4516

Curriculum in Marine Sciences

MASC 12	Marine Environment
MASC 101	Oceanography
MASC 104	Biological Oceanography
MASC 105	Chemical Oceanography
MASC 136	Coastal Processes
MASC 140	Biogeochemical Cycling
MASC 143	Biogeochemical Techniques
MASC 152	Marine Systems Modeling
MASC 156	Descriptive Physical Oceanography
MASC 206	Seminar in Oceanography
MASC 252	Ocean Circulation Theory
MASC 256	Seminars in Physical Oceanography

For course information, contact Jim Gray at (919) 962-3289.

Students enrolled at Duke and NCSU may register interinstitutionally. Contact the Registrar's Office at (919) 962-3954. Others should apply to UNC-CH's Evening College at (919) 962-1134.

University of North Carolina at Charlotte

Department of Geography

ESCI 4000-A01	Hydrologic Modelling in GIS
ESCI 4155-001	Fluvial Processes
ESCI 3240-001	Boundary-Layer Met/Climatology
ESCI 4150-001	Applied Climatology
GEOL 4145-090	Fundamentals of Hydrogeology

For course information contact Becky Guy at (704) 547-4268. Individuals wishing to enroll should contact the UNC Charlotte Office of the Registrar (704) 547-3487 for enrollment information.

University of North Carolina at Wilmington

Center for Marine Science Research

CHEM 475	Chemical Oceanography
CHEM 476	Chemical Analysis of Natural Waters
CHEM 377	Environmental Chemistry and Laboratory
CHEM 490	Aquatic Toxicology
GLY 150	Introduction to Oceanography
GLY 480/590	Surface Hydrodynamics
GLY 550	Marine Geology
BIO 238	Biology of the Sea
BIO 362	Marine Biology
BIO 457	Ichthyology
BIO 472	Marine Phycology
BIO 481	Marine Invertebrate Zoology
BIO 569	Advanced Oceanography

For course information contact the Center for Marine Science Research at (910) 256-3721 or the Dept of Biological Sciences at (910) 962- 3470.

CALL FOR PROPOSALS FOR WATER RESOURCES RESEARCH

Applications from faculty members of senior colleges and universities in North Carolina for grants under the Institute's Program for Fiscal 1999 will be accepted until December 12, 1997. No exceptions will be made to this cut-off date. All applicants will be notified of the review and evaluation process by April 15, 1998. The anticipated starting date for projects funded by the Institute is July 1, 1998, but some projects may be initiated as early as May 1 and others may have to be deferred pending the outcome of federal appropriation processes. Institute grants must be completed within a 12-month period. One 12-month renewal may be granted, but applications for renewal grants will be evaluated in the same manner as proposals for new projects.

The purpose of the Institute's program is to encourage research on water resource problems in North Carolina. Brief descriptions of focused problem areas and specific research topics are available from the Institute. Criteria that will be used to judge proposals are:

(1) the scientific quality of the proposed work;
(2) the need for results of the research in North Carolina;
(3) the probability that useful results can be obtained in one year;
(4) the potential for continued support from other funding sources; and
(5) the cost of the proposed work.

Special consideration will be given to proposals that satisfy all the above criteria and involve the use of Institute funds to match those from other agencies. Special consideration also will be given to young investigators and to investigators from colleges and universities that have received little funding from the Institute in recent years. As a general guide, requests for funds should not exceed $40,000 in direct costs. Any exceptions will require special justification.

Investigators are strongly encouraged, but not required, to submit pre-proposals to the Director of the Institute. Pre-proposals will be used to assess the feasibility and desirability of developing final detailed proposals.

Copies of instructions for preparation of proposals can be obtained from the Institute by calling or writing the Office of the Director, WRRI, Campus Box 7912, North Carolina State University, Raleigh, NC 27695-7912, Telephone (919) 515-2815.

WRRI report no 308 *continued*

or in-situ columns to accurately predict the time required for the field biodegradation of individual compounds.

- Among the microbial populations monitored, protozoa (aerobic and anaerobic) and iron reducers showed significant differences between the contaminated and pristine regions of the aquifer. However, the total bacterial populations were the same in both the pristine and contaminated regions of the aquifer.

- Spatial variability in microbial populations is not significant in closely spaced samples. But in samples separated by a distance of 0.30 m, the variability is significant.

- The presence of protozoa could indicate that they play a key role in the biological activity of the contaminant plume.

Digest *continued*

for underground storage tanks (USTs) turned up more than 3,000 facilities in violation and resulted in more than $1 million in fines. Owners of commercial USTs are supposed to have installed leak detection devices or are supposed to perform release detection periodically and keep records of the results. According to Burrie Boshoff, head of the N.C. Pollution Control Branch, North Carolina carried out its regular inspection program in May, inspecting 357 facilities; finding 171 in violation; and assessing more than $22,000 in fines. Boshoff said North Carolina participated in EPA's enforcement initiative by conducting a compliance assistance outreach effort. Owners of two or more tanks were given the opportunity to have an inspector visit and provide advice on actions needed to come into compliance. During the initiative, owners and operators of USTs installed before December 1988 were reminded that requirements for spill, overfill, and corrosion protection take effect in December 1998.

More TMDL settlements. Citizens and environmental groups recently scored more victories in lawsuits aimed at forcing EPA to enforce Clean Water Act requirements that states set total maximum daily loads for pollutants in impaired waterbodies. In April, EPA entered a settlement agreement with Defenders of Wildlife in which the agency promised to establish TMDLs for mercury in 13 river segments and lakes in Arizona if the state does not. In March, EPA entered into a consent decree with the Earthjustice Legal Defense Fund, representing 14 environmental and fishermen's groups, under which TMDLs will be established for elevated temperature and sediment in 18 Northern California salmon streams.

Stormwater Phase II rule postponed. Under a consent decree entered into by the U.S. EPA and the Natural Resources Defense Council, the agency was to have proposed a rule for implementing phase II of the NPDES stormwater requirements by September 1, 1997. However, the two parties have agreed to an extension of the deadline. Now EPA says it will publish the proposed rule in the Federal Register by November 25, 1997. Under the consent decree, a final rule is required by March 1, 1999.

North Carolina Precipitation/Water Resources

Rainfall (+/- average)

	July	August
Asheville	2.97" (-1.55")	1.37 (-3.32")
Charlotte	8.94" (+5.02")	1.10" (-2.63")
Greensboro	3.03" (-1.48")	1.97" (-1.91")
Raleigh	6.51" (+2.50")	1.01 (-3.01")
Wilmington	6.15" (-1.98")	2.86" (-4.08")

Streamflow

Index Station (CFS) (County, Basin)	July mean flow (CFS) (% of long-term median)	August mean flow (% of long-term median)
Valley River at Tomotla (Cherokee, Hiwassee)	178 (160%)	86 (69%)
Oconaluftee River at Birdtown (Swain, Tenn)	347 (104%)	192 (60%)
French Broad River at Asheville (Buncombe, FB)	1,790 (127%)	1,110 (82%)
South Fork New near Jefferson (Ashe, New)	365 (106%)	260 (86%)
Elk Creek at Elkville (Wilkes, Yadkin/Pee-Dee)	59 (93%)	--- ------
Fisher River near Copeland (Surry, Yadkin/Pee-Dee)	102 (68%)	61 (54%)
South Yadkin River near Mocksville (Rowan, Yadkin/PD)	239 (108%)	149 (75%)
Rocky River near Norwood (Stanly, Yadkin/Pee-Dee)	3,492 (922%)	294 (76%)
Deep River near Moncure (Lee, Cape Fear)	2,507 (624%)	194 (29%)
Black River near Tomahawk (Sampson, Cape Fear)	201 (47%)	332 (70%)
Trent River near Trenton (Jones, Neuse)	15 (17%)	11 (15%)
Lumber River near Boardman (Robeson, Lumber)	484 (80%)	759 (108%)
Little Fishing Creek near White Oak (Halifax, Pamlico)	79 (189%)	22 (50%)
Potecasi Creek near Union (Hertford, Chowan)	171 (448%)	--- --------

Groundwater

Index well (Province)	July depth below surface (ft) (departure from average for month)	August depth below surface (ft) (departure from average for month)
Blantyre (Blue Ridge)	28.05 (+3.10)	29.99 (+2.08)
Mocksville (Piedmont)	14.60 (+2.62)	15.32 (+2.22)
Simpson (Coastal Plain)	6.70 (-1.11)	8.15 (-2.81)

Source: U.S. Geological Survey's *Water Resources Conditions in North Carolina*

Conferences and workshops

Conference Announcement and Call for Papers: WORKING WITH COMMUNITIES EIGHTH ANNUAL SOUTHERN APPALACHIAN MAN AND THE BIOSPHERE (SAMAB) CONFERENCE, November 5, 6, &7, 1997, Holiday Inn Sun Spree, Gatlinburg, TN. Abstracts must be received no later than September 30, 1997. For information contact: SAMAB Annual Conference, 1314 Cherokee Orchard Rd., Gatlinburg, TN 37738. Phone: 423/436-1701. FAX: 423/436-5598 Email: samab@ix.netcom.com.

The N.C. Section of the American Water Works Association and the N.C. Water Environment Association will hold their **77TH ANNUAL CONFERENCE** at the Adams Mark Hotel/Benton Convention Center in Winston-Salem, NC, November 16-19, 1997. For information, write NC AWWA & WEA, P.O. Box 11322, Raleigh, NC 27604.

The U.S. Section, Permanent International Association of Navigation Congresses (PIANC) and The North Carolina State Ports Authority will present **THE MARITIME INDUSTRY IN TRANSITION: ISSUES, CHALLENGES, AND SOLUTIONS FOR THE 21ST CENTURY** October 28-30, 1997, Wilmington, NC. For registration and additional information call the Office of the U.S. Section, PIANC at (703) 428-6286 or FAX (703) 428-8171.

The Urban Land Institute and the U.S. EPA will present **PARTNERS FOR SMART GROWTH CONFERENCE** December 2-4, 1997, at the Renaissance Harborplace Hotel in Baltimore, MD. For information call ULI at 1-800-321-5011 or email smartgrowth@uli.org.

The American Geophysical Union and others will present **APPLICATION OF GIS, REMOTE SENSING, GEOSTATISTICS AND SOLUTE TRANSPORT MODELING TO THE ASSESSMENT OF NONPOINT SOURCE POLLUTANTS IN THE VADOSE ZONE** October 19-24, 1997, at the Mission Inn in Riverside, CA. For information contact Ellyn Grossman, Meetings Manager, American Geophyscial Union at (202) 462-6910 or EGrossman@Kosmos.agu.org.

The University of Texas at Austin Department of Civil Engineering will present **RIVER AND FLOOD PLAIN HYDRAULICS USING HEC-RAS** October 13-17, 1997, at the J.J. Pickle Research Campus in Austin. For information contact Continuing Engineering Studies at (512) 471-3506 or visit http://ceswww.utexas.edu.

The American Water Resources Association will hold its **ANNUAL CONFERENCE ON WATER RESOURCES & SYMPOSIUM ON CONJUNCTIVE USE OF WATER RESOURCES: AQUIFER STORAGE & RECOVERY** October 19-23, 1997, at the Sheraton Long Beach Hotel in Long Beach, CA. For information contact AWRA at (703) 904-1225 or email: awrahq@aol.com.

NASA, NOAA and others will present **SYMPOSIUM ON CLIMATE VARIABILITY, CLIMATE CHANGE, AND WATER RESOURCE MANAGEMENT** October 26-29, 1997, at Colorado Springs, CO. For information visit web site http://civil.colorado.edu/climate or contact Ken Strzepek at the University of Colorado at (303) 492-7111 or strzepek@colorado.edu

The Energy Division of the N.C. Department of Commerce will present **ALTERNATIVE FUEL VEHICLES CONFERENCE AND EXHIBITION** December 2, 3, and 4, 1997, at the Adam's Mark Hotel in Charlotte, NC. For information contact the Energy Division at (919) 733-1898 or visit http://energy.state.nc.us.

The **NORTH AMERICAN LAKE MANAGEMENT SOCIETY** is holding its **17TH INTERNATIONAL SYMPOSIUM** December 2-6, 1997, at the Hyatt Regency Hotel in Houston, TX. NALMS will offer CEUs that can be applied to Lake Management Certification. For information, call the conference office at 303/781-8287.

Duke Center for Environmental Education continuing education

The Center for Environmental Education's continuing education office at Duke University's Nicholas School of the Environment is offering the following courses during the 1997-98 academic year. For additional information contact Bonnie Britt at (919) 613-8082 or britt@duke.edu.

- ✓ Medicine for the Third World Traveler—Oct 23-26, 1997
- ✓ Identification and Delineation of Jurisdictional Wetlands (to be scheduled)
- ✓ Implementation of the National Environmental Policy Act on Federal Lands and Facilities—Nov 3-7, 1997
- ✓ Socioeconomic Impact Analysis under NEPA—Nov 19-21, 1997
- ✓ Making the NEPA Process More Efficient: Scoping and Public Participation—Feb 18-20, 1998
- ✓ New Advances in Ecological Risk Assessment—March 1998
- ✓ Project Management: Translating Ideas into Implementable Projects—Mar 16-20, 1998
- ✓ Forest Appraisal-Mar 23-27, 1998
- ✓ Current and Emerging Issues in Managing the NEPA Process—April 1998
- ✓ Land Conservation Strategies—Apr 6-10, 1997
- ✓ Cumulative Effects Assessment—May 1998
- ✓ Landscape History and Ecosystem Change—June 1998

Nutrients in the Neuse River: Working toward Solutions

December 8-9, 1997, at the New Bern Sheraton Hotel New Bern, NC

This is a technical conference on the Neuse River for local, state, and federal officials, scientists, educators, river users, landowners, nutrient managers, agribusiness, industry, fisheries and citizen groups.

For additional information contact Greg Jennings with the Cooperative Extension Service at NCSU. Phone: 919/515-6795. Email: greg_jennings@ncsu.edu. Or visit website http://www.bae.ncsu.edu/people/faculty/jennings/

Publications

The N.C. Cooperative Extension Service and others have published a special edition of the newsletter, *Neuse Letter*, to provide information on the Neuse River Basin Nutrient Sensitive Waters Management Strategy. To receive a copy contact your local Cooperative Extension Office or write Mitch Woodward, Wake County Extension Center, 4001 (E) Carya Drive, Raleigh, NC 27610 or mwoodwrd@wake.ces.state.nc.us.

The N.C. Cooperative Extension Service has produced a series of fact sheets to help rural homeowners and farm families protect their drinking water wells and the ground and surface waters of North Carolina from petroleum fuels, hazardous waste, septic systems, pesticides, fertilizers and livestock waste. Called "Home*A*Syst" and "Farm*A*Syst," these materials provide tools to help individuals assess behaviors and structures (e.g. septic systems) around their homes and farmsteads that can cause pollution and then to take action. The programs, which may include delivery of the materials in a training setting, are currently being made available to all county Cooperative Extension Service offices. To find out about availability of the Home*A*Syst and Farm*A*Syst programs in your county, call your Cooperative Extension Service office. Find the phone number under county government in you local directory.

Web sites

Dr. JoAnn Burkholder and her laboratory staff have established a web site to provide current information on Pfiesteria-related fish kills and fish disease outbreaks, safety guidelines, and links to scientific papers and other web pages about Pfiesteria: http://www2.ncsu.edu/unity/lockers/project/aquatic_botany

North Carolina Water Resources Association

NCWRA

North Carolina Section of the American Water Resources Association

Luncheon and Forum Schedule

Nov. 3, 1997	Water Allocation: Lake Gaston
Feb 9, 1998	Safe Drinking Water Act in N.C. Information
Apr 13, 1998	Stream Restoration
Sept 14, 1998	Water Quantity Issues in N.C.
Nov 9, 1998	Nutrient Management

All luncheon/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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