Bios & Abstracts for the
NC Forum on Nutrient Over-Enrichment – May 29 & 30, 2012

PANEL

Jacqueline A. Jarrell, P.E.

Jacqueline Jarrell has been with Charlotte Mecklenburg Utility Department for over 20 years. As the Superintendent of the Environmental Management Division, she is responsible for the overall management of the operation and maintenance of five wastewater treatment facilities consisting of a total capacity of 123 Million Gallons per Day (MGD) with the largest plant permitted at 64MGD. Two of these plants provide for biological nutrient removal. She is also responsible for the related Residuals Program producing over 90,000 wet tons/ year, and the Industrial Pretreatment Program with approximately 60 Significant Industrial Users. Jackie has been very involved in a number projects and programs related to environmental and energy management initiatives for her Division and Utilities. This includes the development of a Combined Heat and Power (CHP) project at one of the McAlpine Wastewater Management Facility to produce over 1.5 MW of power.

Jackie is the current chair of the NC Water Quality Association. She has been very active with NC AWWA-WEA serving as Chair Elect this year, the Water Environment Federation Utility Management Committee and Utility Management Program Symposia. Jackie holds a B.S. Engineering from University of North Carolina Charlotte. She is a NC registered professional engineer and holds a Biological Wastewater Grade II OIT. Jackie lives in Charlotte with her husband and two children.

Grady McCallie

Grady McCallie started as the NC Conservation Network's Policy Analyst in December 2000. Mr. McCallie holds a law degree from the University of California at Berkeley (1993), and a BA in History and Economics from Yale University (1990). Before joining the NC Conservation Network, he worked for the Chesapeake Bay Foundation (1994) in Annapolis and the National Wildlife Federation in Washington, D.C. (1994-2000), as a wetlands policy analyst and lobbyist. He has also worked and written on agricultural conservation, water quality, and water quantity issues.

Darryl D. Moss

Mayor Moss was appointed to the Environmental Management Commission in 2007. He is currently the mayor of the City of Creedmoor and is the vice-chairman of the National League of Cities Advisory Board. Mayor Moss graduated from the University of North Carolina at Chapel Hill in 1980 and is currently a Senior Account Executive with BlueRange Technology.

Stephen T. Smith

Steve Smith has been a member of the N.C. Environmental Management Commission since 2005 and Chairman since 2008. He holds a B.A. from East Carolina University and a J.D. with honors from the University of North Carolina at Chapel Hill where he was a member of the Law Review. He is a partner in the law firm of McMillan & Smith in Raleigh, N.C. He is listed in Best Lawyers in America and the Top 100 Lawyers in North Carolina. He enjoys hiking and back-packing, including having hiked the southern half of the Appalachian Trail in one-week stretches, as well as various northern sections including climbing Mt. Katahdin (the northern terminus) four years ago.

Bios & Abstracts for the
NC Forum on Nutrient Over-Enrichment – May 29 & 30, 2012

MODERATOR

Richard Whisnant

Richard Whisnant is Professor of Public Law and Government at the UNC-Chapel Hill School of Government. He holds degrees from Harvard University (J.D. *cum laude* and Masters in Public Policy) and from the University of North Carolina at Chapel Hill (B.A. in philosophy with highest honors). From 1993 to 1998, he was General Counsel to the N.C. Dept. of Environment, Health and Natural Resources. He served as law clerk to the Hon. Sam J. Ervin, III, United States Court of Appeals for the Fourth Circuit, and as an editor of the Harvard Law Review. He has practiced environmental law in the private sector as well as on behalf of public interest environmental law firms. He is past President of the Conservation Trust of North Carolina and has founded and served on several other nonprofit boards. Richard's publications include Rule Making in North Carolina (2005), Cleanup Law of North Carolina (2003) and Local Government for Environmental Policymakers (2002), as well as North Carolina's model Phase II, Universal, and Jordan watershed stormwater ordinances. He was the principal investigator for the North Carolina legislature's Water Allocation Study in 2007-11 and for an interdisciplinary team looking at operational flexibility of dam operations in the Roanoke River basin for the bi-state 216 Study of Kerr Dam. His current writing focuses on the "water wiki," http://water.unc.edu , an interactive guide to water management in the southeastern U.S. He is an experienced whitewater paddler and an aspiring old-time musician.

SPEAKERS - ALPHABETICALLY

SUCCESSFUL DEVELOPMENT/APPLICATION OF NUTRIENT/SEDIMENT ENRICHMENT CRITERIA DRIVING CHESAPEAKE BAY RESTORATION—25 YEARS OF EXPERIENCES

Rich Batiuk

U.S. Environmental Protection Agency Chesapeake Bay Program, Annapolis, Maryland

Rich Batiuk is the Associate Director for Science at the U.S. Environmental Protection Agency's Chesapeake Bay Program Office located in Annapolis, Maryland. In his 27 years with EPA and the Chesapeake Bay Program partnership, he has led the integration of science into multi-partner decision-making. On a daily basis, Rich has responsibility for providing basinwide monitoring network coordination, model simulation and analysis, information technology and data sharing, web-based and geographical communication, programmatic implementation effectiveness and efficiency evaluation, and watershed implementation plan programmatic and technical support to the Bay Program partners and stakeholders. This work is accomplished through multiple teams of very talented and extremely dedicated colleagues at the Bay Program Office. He is now focused on helping lead efforts to use EPA's December 2010 publication of the watershed-wide Bay TMDL pollution diet to help state and local partners accelerate on-the-ground implementation of the nutrient and sediment reduction actions to restore local waterways and the Bay. He received his B.S. in Environmental Science from the University of New Hampshire in 1984 and his M.S. in Environmental Toxicology from American University in Washington D.C. in 1985.

Abstract

With roots as far back as 1985, the Chesapeake Bay Program partners—DE, DC, MD, NY, PA, VA, WV, EPA, and other federal and local agencies—have a multi-decadal history of developing and then adopting a suite of nutrient/sediment enrichment water quality criteria into the four tidal water jurisdictions' water quality standards regulations. These partner-approved water quality criteria, published by EPA in 2003, started out as a set of "habitat requirements" in the late 1980s. Through the 1990s, additional research and an ever increasing base of monitoring data supported development of a series of technical syntheses of the latest scientific understanding by the scientific and management communities. Specific commitments within the Chesapeake 2000 Agreement laid out a roadmap for the partnership to reach agreement on and support adoption of a set of Chesapeake Bay water quality standards that all seven watershed jurisdiction could agree to and fully support. The resultant Delaware, District of Columbia, Maryland, and Virginia Chesapeake Bay water quality standards regulations, adopted in 2004-2005, were entirely consistent across a common set of five tidal water designated uses. All four jurisdictions adopted consistent use-specific protective criteria, criteria assessment procedures, and listing/delisting decision making protocols. Since their initial publication in 2003, EPA and its jurisdictional partners has published a series of addenda to the Chesapeake Bay criteria and designated uses, which were then adopted by the four jurisdictions' into their water quality standards regulations. These Chesapeake Bay water quality standards formed the basis for the December 2010 Chesapeake Bay TMDL—a basinwide pollution diet being undertaken collectively by the 17 million watershed residents.

SUSTAINABILITY AND ANCILLARY ENVIRONMENTAL BENEFITS OF NUTRIENT CONTROL PRACTICES

Clifton F. Bell
Brown & Caldwell, Virginia Beach, VA

Clifton Bell is the Technical Leader for Watersheds and TMDLs with Brown & Caldwell. He began his career with the U.S. Geological Survey (1992-1997), and has led water quality management projects in Arizona, Virginia, Alabama, Georgia, California, Florida, and the Carolinas. Much of Clifton's project work involves nutrient science and policy, and he is currently a leader of the North Carolina Water Quality Association's efforts to develop long-term solutions to nutrient-related challenges. Since 2000, Clifton has served as the chief technical consultant to the Virginia Association of Municipal Wastewater Agencies, and led the development of the *BMP Benefit Planner* for nutrient management on a watershed scale. Clifton is also co-PI of an ongoing Water Environment Research Foundation project on the use of models to set site-specific nutrient criteria. He is a licensed professional engineer and certified professional geologist.

Abstract

Under Clean Water Act drivers, watershed management plans are created to achieve specific water quality goals in streams, lakes, reservoirs, or estuaries. However, BMPs intended to protect water quality have other environmental effects that can be positive or negative. Practices that achieve the same nutrient load reduction may be very different with regard to sustainability metrics such as cost, energy use, carbon sequestration, and greenhouse gas (GHG) emissions. Similarly, nutrient control

practices have very different effects on ecosystem services such as wildlife habitat, flood hazard mitigation, soil quality, and public health protection.

This presentation will present the results of recent research into the sustainability and ancillary environmental benefits of nutrient control strategies. Results demonstrate that point source nutrient controls have a relatively high cost-effectiveness at certain levels of technology, but tend to score more poorly on sustainability metrics at the limit of technology, as higher energy and chemical usage is required to achieve relatively modest additional reductions. Agricultural practices such as conservation tillage, cover crops, and buffers have widespread ancillary benefits including wildlife habitat, improve soil quality, and reduced soil erosion. Nutrient management planning (i.e., reduced fertilizer application) is a highly cost-effective practice with relatively few ancillary environmental benefits, with the exception of reduced GHG emission associated with N_2O. Urban stormwater retrofits are among the least cost-effective nutrient control practices, but do provide critical ancillary benefits include flood hazard mitigation and improved aesthetics.

MAINE'S APPROACH TO INTEGRATE CAUSAL AND RESPONSE INDICATORS OF EUTROPHICATION

Thomas J. Danielson
Maine Department of Environmental Protection, Augusta, Maine

Tom Danielson is a Biologist with the Maine Department of Environmental Protection and formerly was an Ecologist for U.S. EPA headquarters. His work focuses on biological monitoring and nutrient criteria for fresh surface waters. Tom earned a PhD in Ecology from the University of Maine, 2 Master degrees from Duke University in Environmental Management & Public Policy, and 2 Bachelors degrees from the University of Massachusetts (Wildlife Ecology & Finance).

Abstract

Maine has developed a draft nutrient rule for fresh surface waters that combines limits for phosphorus and environmental response indicators. The combination of causal and response indicator criteria provides more robust and comprehensive assessments of the waterbody condition than relying solely on causal indicators. Maine avoided issues of independent applicability by constructing draft nutrient criteria that merge nutrient and environmental response indicator limits. The proposed limits for phosphorus and some response indicators are tiered with different expectations for lakes (Class GPA) and several classes of streams and rivers (Classes AA, A, B, and C). A simple decision framework guides the process of determining attainment of nutrient criteria based on monitoring and assessment results. The draft rule provides the ability to set site-specific criteria for phosphorus, nitrogen, and carbon as needed and provides flexibility in implementing water quality management programs to minimize the costs of remedial actions. Maine is in the early stages of developing marine nutrient criteria.

Bios & Abstracts for the NC Forum on Nutrient Over-Enrichment – May 29 & 30, 2012

STORMWATER RETROFITTING IN URBAN AREAS: GETTING THE MOST BANG FOR YOUR BUCK

Kathy M. DeBusk
North Carolina State University, Raleigh, NC

Ms. Kathy DeBusk received her B.S. and M.S. degrees in Biological Systems Engineering from Virginia Tech, where her research involved evaluating Low Impact Development strategies and their effectiveness in addressing urban stormwater quality and quantity concerns. She joined Dr. Bill Hunt's Stormwater team at NC State University in June 2008 as an Extension Associate, where she conducted research on various stormwater management practices, helped teach numerous workshops and trainings and was heavily involved in extension outreach and public education projects related to stormwater. Major projects Kathy was involved in included a feasibility and cost assessment of urban stormwater retrofits, development of the Jordan/Falls Lake Stormwater Load Nutrient Accounting Tool and a study equating bioretention outflow to natural stream interflow. In 2011 Kathy chose to continue her education by pursuing a doctorate degree in the Biological & Agricultural Engineering department at NC State under Dr. Hunt. Her PhD research focuses on the water quality aspects of rainwater harvesting systems and enhancing the stormwater management capabilities of these systems. Kathy is a member of the American Society of Civil Engineers, American Society of Agricultural & Biological Engineers, American Rainwater Catchment Systems Association, the National Society of Professional Engineers and the Professional Engineers of North Carolina. She also serves on the ASCE-EWRI Rainwater Harvesting Technical Committee and as an alternate for the Jordan Lake Scientific Advisory Board.

Abstract

New regulations in the state of North Carolina require all municipalities within the Jordan and Falls Lake watersheds to reduce nitrogen and phosphorus loadings to the lake by establishing stormwater control measures (SCMs) for new and existing development. It is anticipated that these new regulations will be emulated in many urban areas across the state of North Carolina and perhaps in other parts of the United States. As such, it is important to understand the feasibility, both physically and economically, of implementing such practices.

FLORIDA NUMERIC NUTRIENT CRITERIA: LESSONS LEARNED – TECHNICAL ISSUES

Douglas J. Durbin
Cardno ENTRIX, Riverview, Florida

Dr. Durbin is a Technical Director, Vice President and Senior Principal with Cardno ENTRIX, and a member of the firm since 1992. He has a broad educational background in the sciences, with particular focus on the disciplines of zoology, aquatic ecology, and ecosystems analysis. His Masters work centered on the effects of urbanization and land use changes on fish communities, and his doctoral research involved the development of microcosm systems to simulate aquatic ecosystem dynamics. Dr. Durbin has designed, managed and conducted numerous studies on streams, lakes, springs, wetlands and estuaries, encompassing floral and faunal assessments, as well as physical and chemical analyses. His investigations have focused on freshwater, brackish and marine aquatic systems, addressing impacts resulting from human activities and identifying appropriate compensation for impacts. His efforts have

included the development of water quality criteria, stormwater impact assessment and management, establishment of domestic and industrial wastewater effluent limitations, the evaluation, permitting and environmental management of various waterfront and coastal development projects, and sampling and analysis of fish, invertebrate and algal populations. He contributed technical information during the public comment process for the U.S. Environmental Protection Agency's numeric nutrient criteria for Florida. Dr. Durbin is the only individual to serve on both the Florida Numeric Nutrient Criteria Technical Advisory Committee (TAC) and the Statewide Stormwater Treatment Rule Development TAC to the Florida Department Environmental Protection. He has testified in legal proceedings in multiple areas of expertise, including general ecology, lake, stream and estuarine ecology, ichthyology, microbiology, limnology, environmental permitting, water quality and data analysis.

Abstract

In spite of frequently pointing out that it was responsible for contributing a very sizeable fraction of the water quality data in the EPA STORET database, the State of Florida encountered a wide array of difficulties in charting a quantitative course to the establishment of Numeric Nutrient Criteria for its lakes, streams and springs. As more and more hurdles were encountered, some even commented that Florida was essentially being punished as a result of its large investment in water resource data collection. With more than 7,500 lakes, 11,000 miles of flowing waters, and many hundreds of springs, the ability to lump all members of each waterbody type together seemed unreasonable, but determining how to separate them into meaningful groups was a daunting challenge.

Some of the lessons learned from the decade-long analytical process were:

- Clear definition of water body classes, and specific descriptions of the Designated Uses for each class, can be very valuable when establishing nutrient criteria.
- There is not a bright line separating the benefits provided by nutrients to aquatic systems from the drawbacks of excess nutrients.
- Stressor-response relationships may not be as simple and clear from analytical results as they are in conceptual frameworks, and nutrient effects can be nearly impossible to separate from other ecological factors, or may not even exist in some aquatic systems.
- Physical conditions can play a far greater role in the ecological condition of some water bodies than nutrient levels.
- One size does not fit all - Nothing beats a site-specific approach, but it takes a lot of time and money, and every water body has to be assessed.

NUTRIENT MANAGEMENT IN NORTH CAROLINA: THE PATH TO HERE

Richard "Rich" Gannon
North Carolina Division of Water Quality, Raleigh, NC

Rich Gannon is currently the Supervisor of the Nonpoint Source Planning Program with the NC Division of Water Quality where he supervises the development and implementation of watershed, regulatory nutrient restoration strategies and Administers EPA's Section 319 Nonpoint Source Grant program for NC. Previously he was a Wetlands Biologist in central Florida where he implemented wetlands and stormwater regulations for 10 years, including 6 years with the Southwest Florida Water Management District. Rich has a B.A. in Biology from the University of South Florida and a Master of Environmental

Management and Water Resources from Duke University. He enjoys raising two grandsons and outdoor sports that require a helmet.

Abstract

For the last several decades North Carolina has instituted a series of progressive, science-based, watershed-specific nutrient management strategies addressing cultural eutrophication. These strategies have both informed and evolved in response to supporting legislation. The Division's successful response to large-scale algal blooms in the Chowan River in the 1970's set a strong example for all subsequent initiatives through: rigorous evaluation of water quality data and research on eutrophication dynamics; development of watershed nutrient budgets; water body response modeling; evaluation of the effects of management alternatives; and coordinated management actions. The Chowan initiative also precipitated foundational elements that have supported all subsequent nutrient management in the state: adoption of a chlorophyll *a* standard in 1979; establishment of a state agriculture cost share program in 1984; enactment of a statewide phosphate detergent ban in 1988; and determination of achievable point source technology limits. Subsequent strategies have benefited immensely from this groundwork, allowing them to add increasingly comprehensive, flexible and adaptive rules supported by full stakeholder collaboration and evolving accounting tools.

AQUIFER HYDRAULICS, AND THE MULTI-DECADE LEGACY OF NON-POINT-SOURCE POLLUTION

David P. Genereux
North Carolina State University, Raleigh, NC

Dr. Genereux is Associate Director for Research in the Water Resources Research Institute (WRRI) of UNC, and a Professor in the Dept. of Marine, Earth, and Atmospheric Sciences at N.C. State University. He holds a bachelor's degree in geology and chemistry from the University of Delaware and graduate degrees (M.S. in civil engineering and Ph.D. in hydrology) from the Massachusetts Institute of Technology (MIT). After a post-doc at MIT's Department of Civil and Environmental Engineering, Dr. Genereux began his faculty career at Florida International University (FIU) in Miami. At FIU he held joint appointments between the Dept. of Geology and two research centers, the Drinking Water Research Center (1992-1997) and the Southeast Environmental Research Center (1997-2000). In 2000 Dr. Genereux came to N.C. State, where he carries out research and teaches undergraduate and graduate courses in hydrogeology. His research focuses on the interaction of groundwater and surface water, watershed hydrology, and chemical/isotope hydrology, and has been funded by the National Science Foundation, U.S. Department of Agriculture, U.S. Department of Energy, U.S. Army Research Office, and other sources. Since Sept. 2009, he also oversees the WRRI research program. He has been an associate editor for scientific journals (Water Resources Research and the Journal of Contaminant Hydrology), and has served on grant program panels at the National Science Foundation, U.S. Environmental Protection Agency, and U.S. Department of Agriculture.

Abstract

A portion of the nitrogen (N) applied to the land surface in agricultural watersheds finds its way into aquifers with groundwater recharge. Some of this N is lost from groundwater systems by denitrification (conversion to N_2, the principle gas in the atmosphere), but most of the rest is ultimately discharged to streams and other surface water by groundwater seepage. Because groundwater systems are large, they have the potential to store large quantities of N and other non-point-source pollutants. Also, their

large size and relatively small input (recharge) per year lead to slow groundwater flow rates, meaning that groundwater systems can be responsible for large lag times between the release of N at the ground surface and the appearance of that N in surface water. Insights into these storage and lag time processes have come from the combined use of N measurements and age-dating tracers (dissolved chemicals that indicate how long groundwater has been in the ground) in coastal plain aquifers, especially for the "unconfined" aquifer (the aquifer immediately below the ground surface, that is not "confined" at depth beneath a low-permeability layer). Studies have shown the mean transit time through these aquifers, from recharge to discharge, is on the order of a few decades. Because the bulk of water in streams and rivers is discharged from groundwater systems, decades-long transit times in groundwater have important implications for understanding N concentrations in streams and rivers, and their potential response to changes in N release rates and management practices in watersheds. At any given moment, the groundwater discharge supplying water to coastal plain streams has ages ranging from a few years to several decades. Thus, at any given time, the N concentrations of streams and rivers represent the legacy of past, not just present, N use and management. This is a predictable consequence of the hydraulics of groundwater flow in unconfined aquifers (though of course other factors such as denitrification also affect the flux of nitrate from groundwater to surface water). This suggests that persistence and patience on a decadal time scale may be important when evaluating the effects of N and land-use management practices on surface water quality, specifically because of the multi-decade time scale for "flushing" the relevant groundwater systems.

EPA'S PERSPECTIVE ON NUTRIENT MANAGEMENT

Ellen Gilinsky
Office of Water, US Environmental Protection Agency, Washington, D.C.

Dr. Gilinsky is the Senior Policy Advisor in the Environmental Protection Agency's Office of Water. Ellen is a Past President of the Association of State and Interstate Water Pollution Control Administrators (now known as the Association of Clean Water Administrators -ACWA). Ellen came from the Virginia Department of Environmental Quality where she served as the Director of the Water Division since September 2004. As Water Division Director Ellen's responsibilities included oversight of all agency regulatory and non-regulatory water related activities. Prior to serving as the Director of the Water Division, Ellen served for five years as Virginia's Manager of the Office of Wetlands, Water Protection and Compliance, where her responsibilities included oversight of the statewide wetland and water withdrawal permit program, and the development of new policies, guidance and regulations for wetlands. Additionally, Ellen has served in leadership positions in the private sector with Earth Tech, Law Engineering and Environmental Services, Inc., and Resource International, LTD. She is also an Affiliate Associate Professor at the Center for Environmental Studies at Virginia Commonwealth University, and previously served as an Adjunct Faculty member with VCU's Department of Biology. Ellen holds a Doctorate Degree in Zoology from the University of North Carolina and a Bachelors Degree in Biology from the University of Pennsylvania.

Bios & Abstracts for the NC Forum on Nutrient Over-Enrichment – May 29 & 30, 2012

NUTRIENT REGULATION FOR RIVERS AND LAKES: GETTING IT RIGHT POST USEPA SCIENCE ADVISORY BOARD REVIEW

John C. Hall
Hall & Associates, Washington D.C.

John Hall is the founder of Hall & Associates. Mr. Hall practice specializes in the resolution of complex water, air and hazardous waste issues through application of state of the art scientific analysis, legal advocacy and innovative regulatory implementation. He is a nationally recognized expert on water quality criteria and standards, NPDES permitting, compliance issues, and coalition building. Mr. Hall represents industries, municipalities, and associations throughout the country and has been a persistent advocate for common sense and cost-effective environmental regulation. He has authored over 100 articles, many published in peer-reviewed journals, regarding various aspects of environmental permitting, impact assessment and compliance.

Mr. Hall received his B.A. degree in mathematics from St. John's University in 1978 and his M.S. degree in Environmental Engineering from Manhattan College in 1980. He obtained his law degree from George Washington University in 1984. Mr. Hall is a member of the District of Columbia and Virginia bars, and is admitted to practice before various appellate courts.

Abstract

In 2009 EPA's Science Advisory Board (SAB) chastised EPA for seeking to promote the use of scientific methods to develop nutrient criteria that were not based on scientifically defensible "cause and effect" relationships. These methods generally failed to address impairment thresholds, the biological significance of impacts and the realities of nutrient limitation and growth saturation. The SAB noted that adoption of such criteria could lead to misdirected resource allocation and fail to provide the intended level of environmental protection. Unfortunately, since the SAB review, EPA has continued to promote the use of simplified methods to develop nutrient criteria that do not address the technical concerns raised by the SAB. EPA has also begun to promote concepts such as "independent applicability" to impose both TP and TN reduction, even in waters that do not exhibit nutrient impairment. State agencies have sought relief from the arbitrary imposition of nutrient requirements via political processes such as federal oversight hearings. This is all an unfortunate turn of events. This presentation will review the technical issues raised by the USEPA SAB and discuss concerns with EPA's latest regulatory approaches that will misdirect state and local resources. The presentation will end with a review of various evaluation procedures and adaptive management methods that have worked effectively to address nutrient impairments in lake and stream environments in other states.

WHO CARES IF THE WATER ISN'T FISHABLE, SWIMMABLE OR DRINKABLE? THE CONSEQUENCES OF INACTION

Bill Holman
Duke University, Durham, NC

Dr. Holman is Director of State Policy at Duke University's Nicholas Institute for Environmental Policy Solutions. He has extensive experience in legislative and administrative policy making at the state level.

He served as Governor Jim Hunt's Secretary of the Department of Environment & Natural Resources from 1999 – 2000 and as an Assistant Secretary from 1998 – 1999. He worked as Executive Director of the NC Clean Water Management Trust Fund – a $100 million per year clean water financing program – from 2001 – 2006. Holman chairs the NC State Water Infrastructure Commission (SWIC). He was appointed to the SWIC by Senator Marc Basnight and reappointed by Senator Phil Berger. Governor Bev Perdue appointed Holman to the Science Advisory Panel on Offshore Energy in 2009. Holman serves on the Board of the Environmental Research Institute of the States (ERIS). His current projects at the Nicholas Institute include state water allocation policy, transition of water utilities to new business models, innovative strategies to improve protection of drinking water supplies including Falls Lake and other supplies in the Upper Neuse watershed, and assisting state and local governments in planning for and adapting to climate change and sea level rise. Holman and Amy Pickle teach a State Environmental Policy Making class for Nicholas School and Sanford School students during the spring semester. Holman graduated magna cum laude with a BS in biology from NC State University in Raleigh in 1978. He lives in Raleigh with his wife Stephanie Bass and dog Sylva. He completed hiking the Appalachian Trail from Maine to Georgia in 1975.

Abstract

Water is critical to public health, environmental quality and the economy of North Carolina, but it is undervalued. Water pollution caused by excess nutrients and sediment is the primary threat to water quality and quantity in the State.

The Environmental Management Commission has adopted major rules and regulations to reduce nutrient pollution in the Tar-Pamlico River Basin, Neuse River Basin, Upper Cape Fear/Jordan Lake River Basin, Upper Neuse/Falls Lake River Basin, and other watersheds. These rules provide significant benefits and impose significant costs on the public. The rules require upstream communities to make investments to protect the water of their downstream neighbors.

Are the benefits of these rules worth the costs? Do we need to make these investments in protecting water quality and quantity? Who cares if the public can't swim or fish in Falls Lake or Pamlico Sound? What are the consequences of inaction?

NUTRIENT CONTROL FUNDING OPTIONS FOR LOCAL GOVERNMENTS

Jeffery A. Hughes
University of North Carolina School of Government, Chapel Hill, NC

Jeff Hughes joined the School of Government in 2002. Jeff currently serves as director of the Environmental Finance Center. He has more than 20 years of experience in assisting communities address the finance and policy challenges related to the provision of environmental services and programs. Hughes is the author of numerous reports, guides, and articles on environmental finance and environmental policy analysis subjects. He works with a range of state and national organizations that focus on utility and environmental issues, and he holds a seat on the NC water operator's certification board and has served as an expert witness to the EPA Environmental Finance Advisory Board. He is an active member of Council of Infrastructure Finance Authorities (CIFA) and the American Water Works Association (AWWA).

Abstract

Communities have a range of methods for funding nutrient control improvements with each method leading to different impacts on how costs are allocated throughout the community. Hughes will provide a brief overview of the legal options open to NC communities and will present several real world examples ranging from the "tried and true" to truly innovative.

AN APPROACH TO NUTRIENT REMOVAL BASED ON PRACTICAL TECHNOLOGIES, THEIR RELIABILITY, AND ECONOMICS

S. Joh Kang
Tetra Tech Inc., Ann Arbor, MI

Dr. Kang is a registered Professional Engineer (P.E.) with over 30 years of technical leadership and project management experience in water and wastewater treatment. He specializes in energy optimization and nutrient removal. He has written over 40 peer-reviewed papers, two technical manuals on nutrient removal, and numerous reports for public and private clients. Several papers deal with nutrient removal/recovery and energy optimization and self-sufficiency in wastewater treatment in the U.S. Based in Ann Arbor, MI, he is the Director of Water Infrastructure at Tetra Tech.

Abstract

This presentation will address the practical levels and associated costs that can be achieved by current nutrient removal technologies. The merits of nutrient trading to share burdens between point and non-point sources will be discussed. The use of flow-based permitting with multiple discharge seasons will be proposed as a way of matching technologies with the needs of the receiving water body, leading to substantial energy savings.

ASSESSING COSTS AND BENEFITS RELATED TO IMPLEMENTING NUTRIENT CRITERIA TO IMPROVE AND MAINTAIN WATER QUALITY

Mary Jo Kealy
CH2MHILL, Wilmington, DE

Dr. Kealy has over 30 years experience as a professional economist, including in academia, government (U.S.EPA) and consulting, while specializing in valuation of environmental amenities and other non-market goods and services. Her experience in the valuation of environmental amenities and ecological services includes: cost-benefit analysis, risk-benefit analysis, and sustainable return on investment analysis, Habitat Equivalency Analysis (HEA), and Net Environmental Benefit Analysis (NEBA). She applies these tools in a wide-range of applications as follows: project selection, land asset management, water resource management, managing natural resource assets for sustainability, NEPA documentation, regulatory compliance (e.g., NRDA, CWA, RCRA), FERC licensing, and permitting. She is involved in several on-going water resource and natural resource allocation projects, and facility siting and alternative selection projects involving diverse stakeholder interests (including tribal interests), ecological values, and incentive-based solutions. Examples include Utah nutrient water quality benefit-cost analysis and sustainable return on investment analysis, City of Damascus ecological services

protection/sustainability implementation plan, multiple facility siting projects in Wyoming, benefit-cost analysis of water re-use technologies, valuation of green infrastructure CSO controls, and net environmental benefit analysis of remediation alternatives for a former mine. She is currently a Senior Principal Technologist with CH2MHill.

Abstract

Significant documentation of the harmful effects of nutrients on many surface water bodies—and in particular on several major, highly visible water bodies receiving nutrient loads from very large geographic areas (such as the Great Lakes, Gulf of Mexico, and Chesapeake Bay)—is available. Nearly all states, including Utah, have targeted a number of water bodies for nutrient-driven total maximum daily load (TMDL) studies. However, reducing nutrient loadings can be costly. Before embarking on the path of establishing statewide nutrient criteria, it is prudent to first assess those costs along with anticipated improvements in water quality and resultant economic benefits. This is accomplished by measuring the changes in economic welfare caused by a proposed action and involves comparing the level of market and non-market economic activity *without* the action (i.e., baseline condition) to the level of market and non-market economic activity *with* the action. Benefit-cost analysis proceeds by first identifying the effects of the action. On the cost side of the ledger are higher costs of treating wastewater discharges, implementing stormwater and non-point source best management practices, and other compliance and administrative costs. The benefits are all generated by the water quality improvements that result from reducing nutrient loads. When water quality improves, so does the value that people place on water-based recreation activities (e.g., fishing, waterfowl hunting, boating, and swimming) near shore recreation activities (riparian green-way activities such as walking and wildlife observation, picnicking by the water). Property values of waterfront locations are sensitive to the water aesthetics. The costs of treating drinking water and industrial process water can be sensitive to surface water quality as can aquatic life. To some extent, the quality of life of citizens is tied to the quality of the surface waters in their care and some residents are willing to pay to improve and protect their state's water resources and steward them for future generations to enjoy. The purpose of economic benefit-cost analysis is to inform decisions to increase the value of resources to society by weighing the economic costs and benefits of the alternatives. This presentation will summarize the state's approaches toward assessing the beneficial and cost categories and results to data and discuss the implications for implementing nutrient criteria.

A FRAMEWORK FOR DEVELOPING REGIONAL NUTRIENT CRITERIA FOR WADEABLE STREAMS

Ryan S. King
Baylor University, Waco, TX

Dr. King is an Associate Professor of Biology at Baylor University in Texas, where he directs research in the Aquatic Ecology Lab and the Baylor Experimental Aquatic Research (BEAR) stream mesocosm facility. King earned a PhD in Ecology from Duke University and held a previous position as a research ecologist at the Smithsonian Environmental Research Center in Maryland. His research is broadly focused on aquatic ecosystem structure and functioning. He integrates aquatic community ecology, landscape ecology, biogeochemistry, and ecological statistics to address complex issues relevant to natural resource management. He has particular expertise in stream and wetland ecosystem response to nitrogen and phosphorus enrichment.

Abstract

Streams present a variety of unique challenges for the development of scientifically defensible, numerical nutrient criteria. I review a host of factors that may influence stream ecosystem responses to nutrient enrichment. I also present a framework for selecting an appropriate study design, physical, chemical, and biological measurements, and data analyses using a multi-year field study of wadeable streams in Texas as an example. The case study highlights the significance of seasonal variability of stream flows in controlling biological responses to nutrients as well as the value of in situ and mesocosm experiments for validating field responses.

SATELLITE AND AIRCRAFT SENSORS - MAPPING AND MODELING OF WATER QUALITY PARAMETERS AND NUTRIENT LOADS USING REMOTE SENSING.

Siamak Khorram
North Carolina State University and University of California at Berkeley

Dr. Khorram is a Professor of Remote Sensing and Image processing. He holds a joint faculty appointment at the University of California at Berkeley and is the Professor and Founder of the Center for Earth Observation at North Carolina State University. He received MS. in Engineering and another MS in Ecology from the University of California (UC) at Davis. He received a Ph.D. under a joint program from the University of California at Berkeley and Davis with emphasis on Remote Sensing and Image Processing. He holds patents (pending final approval) in Data Fusion techniques as applied to imagery from various payloads and platforms. He has served as the Major Professor for over 30 Ph.D. and MS students. He is the author of over 200 publications in peer-reviewed journals, conference proceedings, and major technical reports. He is a member of several professional and scientific societies. He has taught undergraduate and graduate courses as well as short-courses and workshops in remote sensing, photogammetry, and digital image processing. He has delivered Keynote speeches in the International Symposium on Computers and Communications in 2008 in Morocco and 2010 in Italy.

Abstract

Water is the foundation of life on Earth and provides a wide range of social, economic, and recreational activities. Protecting water quality is critical for the well being of our society. Water quality is impacted by natural processes and episodic events and the anthropogenic factors such as changes in land use practices, urban development, agriculture, animal farming, etc. Rivers, streams and materials contained in them that flow to the coasts are linked to changes in coastal water quality.

Remote sensing has been used successfully for mapping water quality parameters such as chlorophyll a, suspended solids, turbidity, nutrient load, pollutants, and in certain cases salinity for over 3 decades. This technology has evolved in terms of better spectral and spatial resolutions to provide specific answers for water issues. There are certain advantages and certain pitfalls associated with the use of remote sensing for water quality and related issues.

This talk is designed to present case studies of remote sensing of water quality and address some basic questions such as:

- What can remote sensing tell us on water quality and related issues such as land use practices, impervious surface areas, stream buffers, sedimentation, nutrient loads, pollutants, and eutrophication?
- How reliable the mapping, modeling, and monitoring of these issues can be when they are studied using remotely sensed date?
- What are the advantages and what are the pitfalls?
- How reliably we can map non-point and nutrient sources such as nitrogen and phosphorus?
- How is the shallow waters handled?
- What satellite and aircraft sensors provide the best data sources for such purposes and what are the latest and planned satellites?
- Has remote sensing technology been oversold?

FLORIDA NUMERIC NUTRIENT CRITERIA LESSONS LEARNED – POLICY AND PROCESS

Scott I. McClelland
CDM Smith, Inc, Tampa, FL

Mr. McClelland is Vice President of CDM Smith, Inc. and has worked for 36 years in the environmental and regulatory fields, including almost 9 years with the Florida Department of Environmental Protection. His experience includes TMDL study and implementation, stormwater funding studies and implementation, stormwater master planning, MS4 NPDES permitting and compliance, water quality and quantity modeling, water quality assessments, wasteload allocation, and nonpoint source impact studies.

Mr. McClelland has also supported FDEP as a member of various Advisory Committees:

- Impaired Water Technical Advisory Committee (TAC), to help develop the Impaired Waters Rule for the selection and prioritization of 303(d) impaired waters in Florida.
- Designated Uses and Classification Refinement Policy Advisory Committee (PAC) to help revise the classification system for Florida waters.
- Numeric Nutrient Rule TAC formed by FDEP to help prepare numerical criteria for nutrients in Florida.

Abstract

After an 11-year process including significant data analysis, federal promulgation of criteria, and multiple legal proceedings, the Florida Department of Environmental Protection finally produced numeric nutrient criteria applicable to Florida streams, lakes, springs and some estuaries. Problems that lead to the lengthy process included state activities took too long for local environmental interests (leading to litigation), EPA did not even follow its own guidance, and EPA did not give much weight to either state or elected officials. For nutrient management, these experiences lead to a better understanding of the policy, process, implementation strategy and even designated uses. This presentation provides a summary of "lessons learned" during this 11-year experience related to nutrient management policy and process.

Some of the lessons to be discussed are:

- Management of nutrient should start with the downstream-most waters such as estuaries and lakes/reservoirs.
- The state should adopt an aggressive but collaborative restoration policy.
- Local restoration programs should be promoted and encourages rather than controlled.
- Overall planning for restoration should be integrated, considering water, wastewater, groundwater and stormwater from all sources.

NUMERIC NUTRIENT WATER QUALITY CRITERIA: RECONCILING WEIGHT-OF-EVIDENCE WITH INDEPENDENT APPLICATION

Robert Miltner
Ohio Environmental Protection Agency, Groveport, Ohio

Robert Miltner is employed by the Ohio Environmental Agency to monitor and assess the water resources of Ohio. He has a keen interest in identifying sustainable land-use patterns for aquatic resource integrity, and has published on the relationship between suburbanization and biotic integrity. Bob is also involved in deriving water quality standards based on empirical relationships observed in field data, notably for nutrients, and more recently for dissolved ions. He has recently published the results of his field research tracing the causal pathway between nutrient enrichment and the condition of biological communities in rivers and streams.

Bob received his Bachelor of Science degree in Natural Resources from The Ohio State University, and earned his Master of Science degree from the University of North Carolina Wilmington.

Abstract

Water quality standards for most pollutants are predicated on well-defined dose-response relationships such that when measured or projected concentrations exceed a given standard, harm to aquatic life or degradation of beneficial uses is likely. From this premise, it follows that measured exceedences of the water quality standard can be used independently to infer loss of a beneficial use, and projected exceedences of the standard demonstrate a reasonable potential to cause non-attainment. This basic paradigm is an essential organizing principal behind programmatic and administrative implementation of the Clean Water Act, especially with respect to permitting, identifying impaired waters, and the formulation of restoration plans. Although this has been a generally successful approach for the last thirty years, nutrients represent a special challenge because they violate the premise of a well-defined dose-response relationship. Axiomatically, novel approaches are needed for both defining the relationship between nutrients and beneficial uses, and implementation of a resulting standard within existing legal and administrative frameworks. Ohio has developed a multimetric index called the Trophic Index Criterion (TIC) that helps reconcile these approaches. Because the TIC is formulated on empirical evidence, and blends multiple lines of evidence, it can be used to position a given waterbody against an enrichment gradient, thereby serving most obviously as a definitive identifier of nutrient impairment, but also as a herald of impairment to invoke independent application or support reasonable potential when necessary.

Bios & Abstracts for the NC Forum on Nutrient Over-Enrichment – May 29 & 30, 2012

ACCOUNTING FOR AGRICULTURAL PROGRESS AT THE WATERSHED SCALE

Deanna L. Osmond
NCSU, Raleigh, NC

Dr. Osmond received her undergraduate degrees in Agronomy and Anthropology from Kansas State University and an MS in Soils from NC State University. After working for US Agency for International Development, she obtained her PhD from Cornell in Agronomy and for the past 20 years has worked at the interface of nutrient management and water quality at NC State University.

Abstract

Accounting for agricultural progress at the watershed or river basin scale is important for different reasons. In some watersheds, source reductions from the different pollutant contributors are mandatory. Thus the accounting serves to indicate progress. In other watersheds, accounting serves to relate changes in agricultural practices to measured water quality. To account for agricultural progress, agricultural management and changes to agricultural systems must be delineated both spatially and temporally. There are many issues and challenges associated with the collection of agricultural information. Practices funded by the US Department of Agriculture cannot be shared. Although geospatial techniques are available to determine structural conservation practices, management practices will remain elusive. Different techniques of varying costs can be used to obtain conservation practice information but the more detailed the scale, the more expensive the process. Accounting for agricultural practices is just the first step, however. Biophysical considerations, such as lag time of pollutant transport, and changes in pollutant source must also be considered when accounting for nutrients at the watershed scale. As the size of the watershed increases, the more difficult the task of accounting for agricultural progress at the watershed scale. Challenges of accounting for agricultural progress at the watershed scale will be presented using examples from the National Institute of Food and Agriculture Conservation Effects Assessment Project, regulated river basins in North Carolina, and the Chesapeake Bay

CONTROLLING NUTRIENT OVER-ENRICHMENT ALONG THE FRESHWATER TO MARINE CONTINUUM WILL LIKELY REQUIRE BOTH NITROGEN AND PHOSPHORUS REDUCTIONS: LESSONS LEARNED FROM NORTH CAROLINA ESTUARIES AND AROUND THE WORLD.

Hans W. Paerl
University of North Carolina at Chapel Hill, Institute of Marine Sciences, Morehead City, NC

Dr. Paerl is Kenan Professor of Marine and Environmental Sciences at the University of North Carolina's Institute of Marine Sciences, located in Morehead City, NC. His research includes; nutrient cycling and primary production dynamics of aquatic ecosystems, environmental controls and management of harmful algal blooms, and the effects of man-made and climatic nutrient enrichment and hydrologic alterations on the water quality of inland, estuarine and coastal waters. His studies have highlighted the importance and ecological impacts of atmospheric nitrogen deposition on estuarine and coastal eutrophication. He heads up the Neuse River Estuary Modeling and Monitoring Program, ModMon (www.unc.edu/ims/neuse/modmon) and a ferry-based water quality monitoring program, FerryMon (www.ferrymon.org), which employs environmental sensors to assess near real-time ecological condition

of the Pamlico Sound. In 2003 he was awarded the G. Evelyn Hutchinson Award by the American Society of Limnology and Oceanography for his work in these fields and their application to interdisciplinary research, teaching and management of aquatic ecosystems, and in 2011 he received the Odum Lifetime Achievement Award from the Estuarine and Coastal Research Federation for his work on the cause and consequences of eutrophication and harmful algal blooms in estuarine and coastal waters.

Abstract

Regionally and globally, more than 75% of the human population lives in coastal watersheds, which in recent decades have experienced unprecedented changes in the urban, agricultural and industrial landscape. Coastal watersheds also support the fastest rate of population growth. These activities have accelerated nutrient (nitrogen; N and phosphorus; P) discharge along the freshwater to marine continuum in coastal watersheds and have promoted eutrophication, harmful algal blooms, hypoxia and habitat degradation. Phosphorus input reduction has been the "holy grail" for controlling upstream freshwater eutrophication, based on early findings (starting in the 1960's) that many freshwater systems, such as lakes and reservoirs, could be improved by managing phosphorus alone. The assumption was that natural biological nitrogen fixation can relieve nitrogen concerns. Accordingly, in an effort to control algal blooms in freshwaters, North Carolina enacted Phosphorus input controls, starting in the 1980's with wastewater Phosphorus reductions, a Phosphate detergent ban and Phosphorus-based best management practices. Recent research however has shown that the need for reducing Nitrogen inputs is far more common than previously assumed along the Nitrogen-sensitive freshwater to estuary to coastal continuum. These findings, accompanied by a worldwide expansion of Nitrogen based fertilizers, intensive animal operations, urban wastewater, septic systems and atmospheric fossil fuel emissions has led to a Nitrogen "glut" that is now threatening water quality uses. Nutrient over-enrichment has caused imbalances in the natural ratio of Nitrogen and Phosphorous. Furthermore, nutrient-saturated conditions, climatic changes, and more intense tropical cyclones and droughts have challenged our understanding of the nutrient delivery to our nutrient-sensitive waters further complicating approaches to management solutions. Phosphorus only nutrient reductions have impacted the types and magnitudes of downstream algal bloom responses. In the Neuse River system, Phosphorus reductions initiated in the 1980's without parallel nitrogen reductions were accompanied by accelerated eutrophication in the more saline, Nitrogen-sensitive downstream estuary. This points to the need to consider nutrient management on the continuum scale (i.e. upper watershed to the coast), because nutrient input controls for protecting water quality in upstream systems can strongly influence downstream water quality responses. This concept that has led to the recent evolution of dual nutrient (Nitrogen & Phosphorus) reduction strategies for the Neuse and other lakes, rivers and estuaries worldwide examples of which will be discussed.

APPROACHES TO NUTRIENT CRITERIA DEVELOPMENT: PRINCIPAL APPROACHES AND CASE STUDIES

Michael Paul
Tetra Tech, Inc., RTP, NC

Dr. Paul of Tetra Tech, Inc. is an aquatic ecosystem ecologist/biogeochemist with more than 18 years of experience in the research and management of aquatic ecosystems. His work, which has included teaching, research, and public policy, has focused on the ecology of freshwater ecosystems, especially streams. His technical skills and experience include nutrient cycling and biogeochemistry and water

quality standards development. He has directed assessment and criteria work for several states and federal government agencies, has led workshops on assessment and analysis across the nation, and has co-authored USEPA guidance on the statistical analysis of bioassessment data, the design, sampling and analysis of bioassessment for large rivers, and the application of stressor-response analysis for nutrient criteria development. In addition to criteria, Dr. Paul has frequently been called upon to set site specific targets for nutrient and sediment TMDLs to protect aquatic life uses. Dr. Paul currently co-manages the national nutrient criteria support center for EPA Office of Science and Technology. Dr. Paul has authored more than 30 peer reviewed scientific papers, proceedings, and book chapters and more than 30 technical reports/guidance documents. He lives in Carrboro, North Carolina with his wife and daughter and spends as much of his free time on the water or in the woods as he can.

Abstract

A variety of approaches for deriving nutrient criteria were proposed in EPA Nutrient Criteria guidance which are generally organized into the following principal themes: modeled reference conditions, stressor-response relationships, scientific literature, and mechanistic modeling. In states across the nation, each of these approaches has been applied singly or in combination under a multiple line of evidence approach. This talk reviews the technical elements of these four principal approaches, provides examples using case studies from across the country, and comments on advantages and disadvantages of each.

DRINKING WATER SOURCES – TASTE & ODOR PLUS??

Michael E. Richardson
Cape Fear Public Utility Authority, Wilmington, NC

Michael E. Richardson has over 35 years experience in drinking water treatment and distribution. Mike has served several different water utilities in NC in various progressive supervisory roles over his career. He is currently responsible for two water production facilities, source water pumping and water storage facilities for the Cape Fear Public Utility Authority.

Mike was awarded the very distinguished George Warren Fuller Award by the NCAWWA-WEA in 2010. Mike is also the past recipient of the Outstanding Operator of the Year Award from the NC Waterworks Operators Association, the Tom Flowers Award by the Southeast Section of the NC Waterworks Operators Association and is a member of the Select Society of Sanitary Sludge Shovelers (5-S). Mike is the only person to have served as the leader of all three major water Associations in North Carolina, NCAWWA-WEA, NC Rural Water Association, and NC Waterworks Operators Association. He has served each Association in many additional leadership roles on committees and task groups as well as has taught in various water operator training schools for over twenty years.

Mike received his Associate Degree in Environmental Engineering in 1975. He is married, has two grown children and eight grandchildren.

Abstract

Taste and odor in drinking water have always been an issue for the water operator. Customers desire to have their tap water clear and having no noticeable odor or unusual taste. Treatment has been focused

on achieving these factors over the years to minimize and eliminate as much as possible the taste and odor issues.

Now, the potential detrimental health effects of the consumption of water affected by algal blooms have been of significant concern to the suppliers of water. As analytical techniques for the detection of cynotoxins have improved, the high frequency of occurrence of these potentially hazardous compounds in drinking water world-wide has become apparent.

Algal toxins in surface waters with potential as drinking water sources are widespread. The list is growing as we test over a wider range for toxins. It is therefore of great importance to develop reliable drinking water treatment strategies for a range of algal toxins. New viable treatment techniques for cynotoxins, in particular oxidation, UV irradiation, activated carbon adsorption, and biodegradation are available to assist with handling the toxin effects in drinking water.

What are the new effects of the algal blooms that we are yet to determine and how will these affect how we treat our drinking water? Is the impact of climate change causing more occurrences? Does the nutrient enriched environment of our rivers, streams and lakes contribute to the increased algal bloom problem? All these questions are yet to be answered. The age old problem of taste and odor in drinking water is still a problem for the water suppliers and now we have an even more complex issue to deal with…cynotoxins.

NUTRIENTS AND LAKES: CONDITIONS AND ISSUES TO CONSIDER WHEN SETTING STANDARDS

Kenneth J. Wagner
Water Resource Services, Inc., Wilbraham, MA

Dr. Wagner holds degrees from Dartmouth College (AB) and Cornell University (MS and PhD). He has over 30 years of experience working on a variety of water resources assessment and management projects, focusing on lakes and reservoirs, but extending to the streams and watersheds that drain to them. In 2010 he started Water Resource Services, a small company with a focus on water supply protection and lake management consulting. He is a former President of the North American Lake Management Society and the current Editor in Chief of Lake and Reservoir Management, a peer-reviewed journal.

Abstract

Nutrients include phosphorus and nitrogen, plus a variety of other elements that are essential to life but can cause problems in aquatic environments when overabundant or at undesirable ratios to each other. We can't ignore other nutrients, but phosphorus tends to control productivity in freshwater lakes. Increased phosphorus in freshwater lakes leads to more algae and more algae leads to dominance by cyanobacteria, which is undesirable for almost any use but especially impairs consumptive and contact recreation uses. Inputs of phosphorus (and other nutrients) increase rapidly when watersheds are developed into urban areas or for agricultural use, increasing inputs by an order of magnitude even at moderate levels of change from natural conditions. Traditional means of mitigating those inputs are not capable of providing more than about a 2/3 reduction, and tend to provide a 50% decrease on average. New or coming improvements to mitigative means can increase removal rates somewhat, but the 90%

decrease necessary to offset order of magnitude increases in loading are not expected. Setting standards to protect lakes with less developed watersheds has definite merit, but enforcing such standards for lakes in highly impacted watersheds will force large expenditures without any guarantee of success.

Because there are other factors (e.g., depth, flushing, settling, light, temperature and grazing) besides nutrients that affect lake response to nutrient inputs, and because temporal and spatial variation can be substantial within a lake, a single standard is unlikely to properly reflect needed management for more fertile systems, and a set of standards should be developed to link conditions to designated uses. This is workable where sufficient data are available, but deciding which standard to apply in each case can be challenging. To do this most effectively and fairly, uses must be prioritized or there must be an established process for compromise where the applicable standard for one use conflicts with optimal benefits for another use. Compliance should be defined based on some minimum number of values over a relevant timeframe, and may be best as non-significant difference from the expected distribution of values. Set standards near the low end of the range expected to support a designated use, but provide a reasonable process for adjusting upward when proper data are presented that support such a shift; recognize that naturally fertile systems exist, and that not all lakes must support all uses. Beyond nutrient standards, there is strong justification for an impervious surface standard for watersheds. In-lake management methods may be necessary to meet use goals and should not be given less attention that watershed management approaches.