Nutrient TMDL Workshop

February 15 – 17, 2011

New Orleans, LA

Meeting Summary

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Prepared for:

U.S. Environmental Protection Agency

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Contents

Meeting Summary

The Nutrient TMDL Workshop was held in New Orleans, Louisiana, February 15 – 17, 2011. The purpose of this workshop was to bring together U.S. EPA and State staff in the Section 303(d) program to discuss and exchange ideas related to nutrients. Key topics of the workshop included:

- Nutrient criteria development
- Assessing and listing waters impaired by nutrients
- Methods of nutrient TMDL development
- Setting nutrient targets
- Implementation
- Multi-jurisdictional TMDLs, specifically related to nutrients

A summary of each presentation from the workshop in presented in this meeting summary. Appendix A contains the workshop agenda. Presentations can be accessed at http://www.tetratech-ffx.com/NOLAnutrient_workshop/ until Fall 2011.

Any feedback related to this workshop or its content can be provided to:

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Overview Session 1 – Programmatic and Scientific Background

Nutrient Effects on Aquatic Ecology, Recreation and Drinking Water Supply: Nutrient and Key Response Indicators

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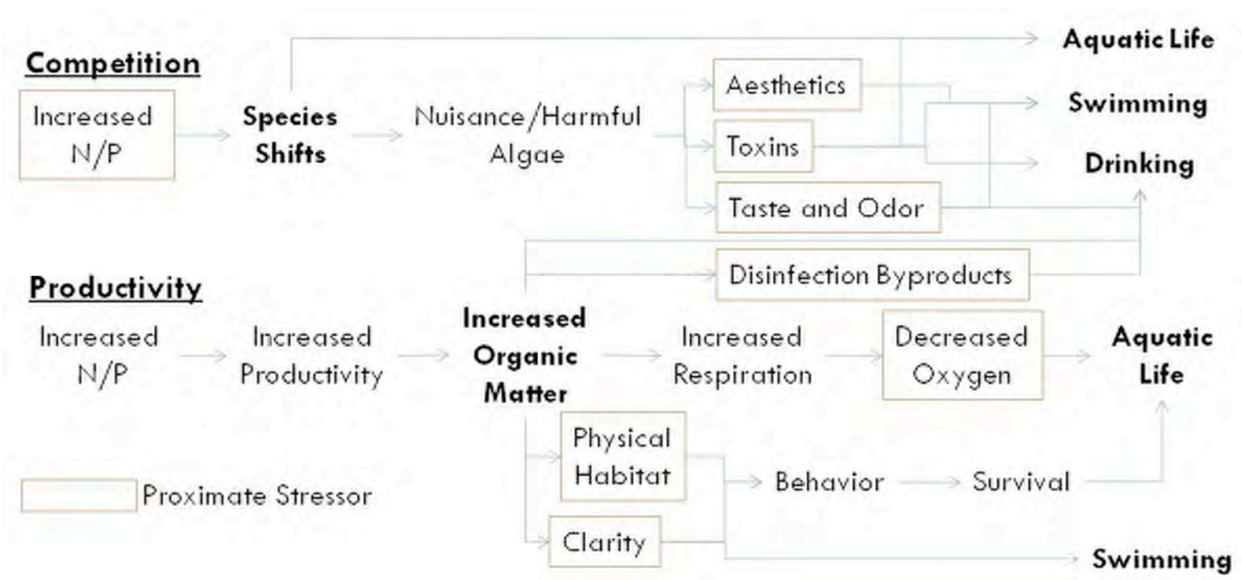
Nitrogen and phosphorus are a natural part of all ecosystems and all organisms rely on nutrients to grow and carry out the many functions that provide the goods and services upon which we rely. Nutrient enrichment alters this in ways that affect the principal uses these waterbodies serve: support of aquatic life, recreation, and consumption. This talk briefly reviews the role of nutrients in natural systems, their natural cycles, the way that enrichment affects these common, core uses, and the way we characterize the stressors and responses. The talk will highlight some of the lesser known responses of aquatic systems to nutrient enrichment, some of the latest scientific understanding regarding important pathways, and novel techniques being used to measure nutrients and evaluate their impacts.



Nutrients and the Clean Water Act 303(d) Listing and TMDL Program

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A review of Clean Water Act Section 303(d) program basics, national statistics on nutrient-related listings and TMDLs; summary of approaches used to identify waters impaired by nutrients; summary of approaches used to develop water quality targets for nutrient TMDLs; and ongoing program activities and direction are presented.

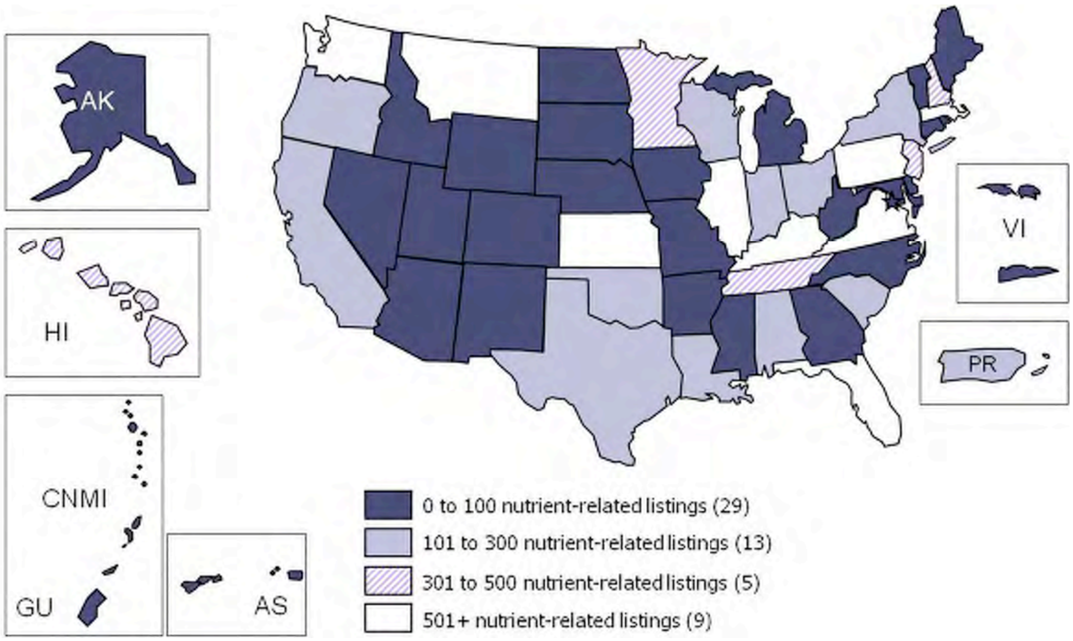

Figure 1. Number of Clean Water Act Nutrient-related Impaired Waters by State.

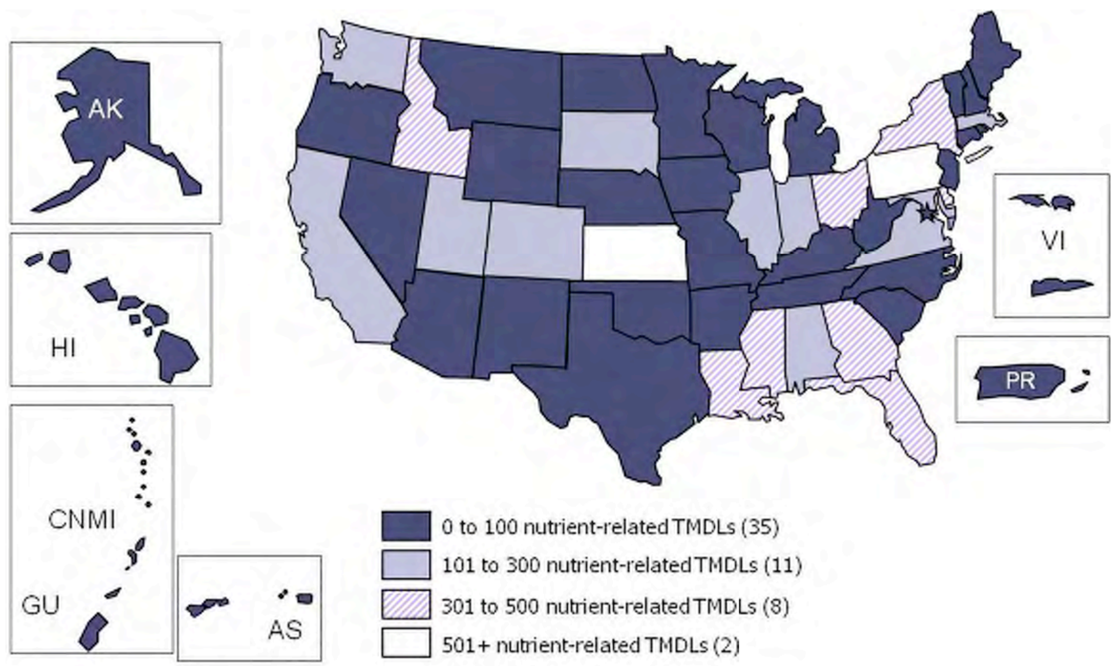

Figure 2. Number of Clean Water Act Nutrient-Related TMDLs by State.

Overview Session 2 – Nutrient Criteria Development

Nutrient Criteria: National Overview/Recent Developments/Look to the Future

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The status of numeric nutrient criteria development in the county is presented below. This talk reviewed the history of the national nutrient criteria program and ecoregion criteria recommendations. Multiple approached for establishing numeric nutrient criteria are presented including: classification; reference conditions; stressor-response; scientific literature and expert judgment; mechanistic models; and using multiple lines of evidence. The results of the Inspector General's 2009 report which concluded that U.S. EPA needs to accelerate adoption of numeric nutrient water quality standards and develop a corrective action plan are presented.

http://water.epa.gov/scitech/swguidance/waterquality/standards/criteria/aqlife/pollutants/nutrient/index.cfm

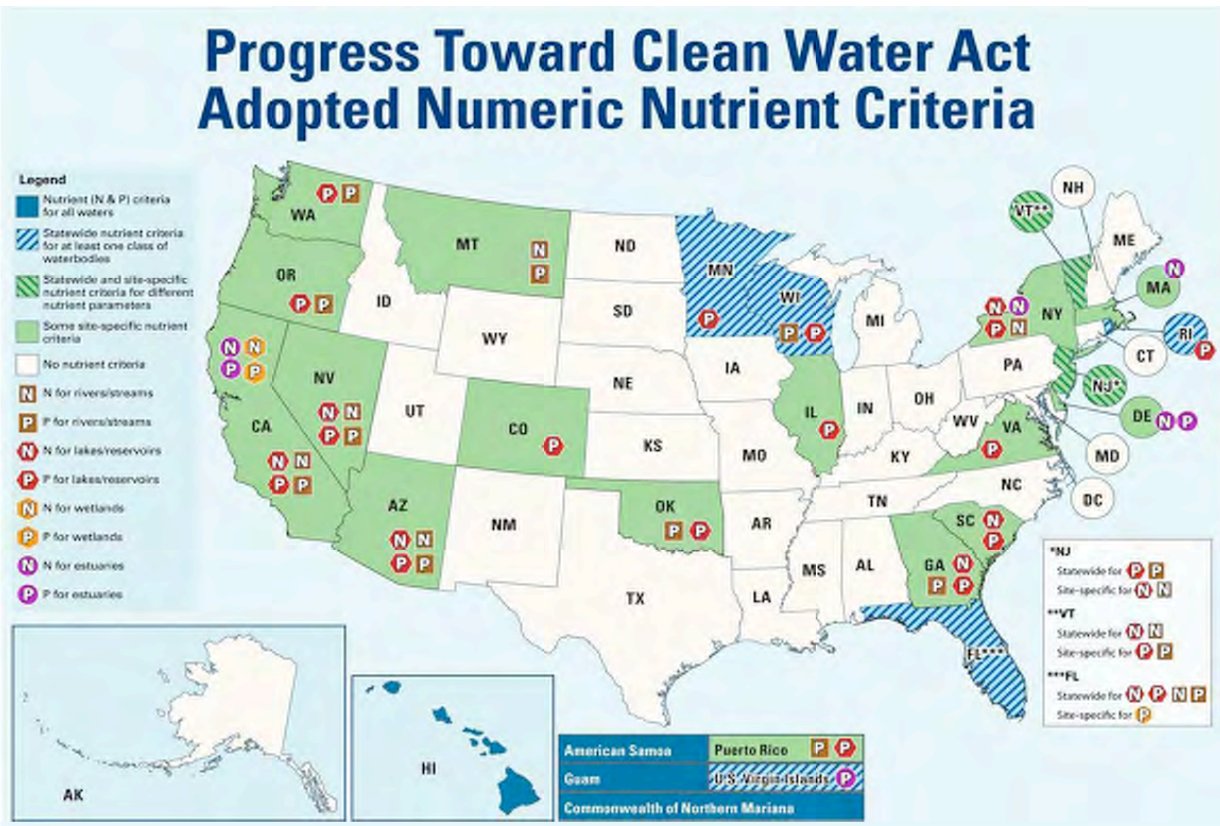

Figure 3. Status of numeric nutrient criteria, Feb 2011.

Overview of EPA's Promulgated Numeric Nutrient Criteria for Florida's Streams, Lakes and Springs

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In August 2008, a coalition of environmental groups, represented by EarthJustice, filed suit against the Environmental Protection Agency (EPA) for their failure to establish numeric nutrient criteria (NNC) in the State of Florida. The lawsuit alleged that the 1998 Clean Water Action Plan created a mandatory duty to develop NNC. However EPA rendered this point moot by issuing a “determination” in January 2009 that NNC were required in Florida to implement the Clean Water Act. EPA then worked with EarthJustice on a settlement agreement, which was entered as a Consent Decree and which established a schedule for the establishment of NNC for fresh waters by October 2010 (later revised to November 2010) and for marine waters by October 2011 (later revised to August 2012).

EPA promulgated numeric nutrient criteria (NNC) for Florida's lakes, streams, and springs on November 15, 2010, and the presentation will provide background information about the criteria, summarize the criteria, discuss procedures for establishing Site-Specific Alternative Criteria (SSACs), including the adoption of nutrient TMDLs as SSAC, and give the Florida Department of Environmental Protection's perspective on the criteria.

http://www.dep.state.fl.us/water/wqssp/nutrients

Listing Session 1 – Assessing and Listing Nutrient Impairments

Results of the National Survey

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The National Aquatic Resource Survey (NARS) is a statistically-valid characterization of the "health" of the nation's waters with documented confidence. NARS is designed to answer national questions and support decision-making. The following key messages were identified:

- Excess nutrients are widespread which is related to decreased biological health in our streams and lakes
- Multiple monitoring designs needed to provide data to protect and restore our waters
  - Statistical surveys provide us with information on the extent of water quality problems and national issues that require broad attention
  - Targeted monitoring allows us to locate specific problems and actions needed to protect/restore those waters.
- Integration of NARS data and 303(d) listing information suggests we don't know where all of our nutrient impacted waters
- We should continue to invest resources in:
  - our monitoring and assessment programs to identify impaired waters; and
  - actions to reduce nutrients throughout our watersheds.

Listings Based on Narrative Water Quality Criteria

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Selected information from watershed branch in-house survey's of RPA regions related to nutrient listings are presented. The basis for nutrient listings on 303(d) lists were identified through a written survey which provided input on 35 states. In order of frequency of use, numeric water quality criteria for dissolved oxygen; biosurveys; threshold values from EPA or State guidance for trophic state index, phosphorus, nitrogen, or chlorophyll-a; and numeric water quality criteria for phosphorus, turbidity/clarity, nitrogen, and chlorophyll-a were the most frequently used approaches for identifying nutrient impairments.

Stressor Identification

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For many biologically impaired waters, the cause of impairment is unknown. Causal Analysis/Diagnosis Decision Information System (CADDIS) is an online application that helps users conduct causal assessments of stream biological impairment. CADDIS is based on using a strength of evidence framework for stressor identification. Information on specific stressors, data analysis methods, etc. are provided as well as tools for data analysis and literature evaluation. Case studies are also included.

http://www.epa.gov/caddis

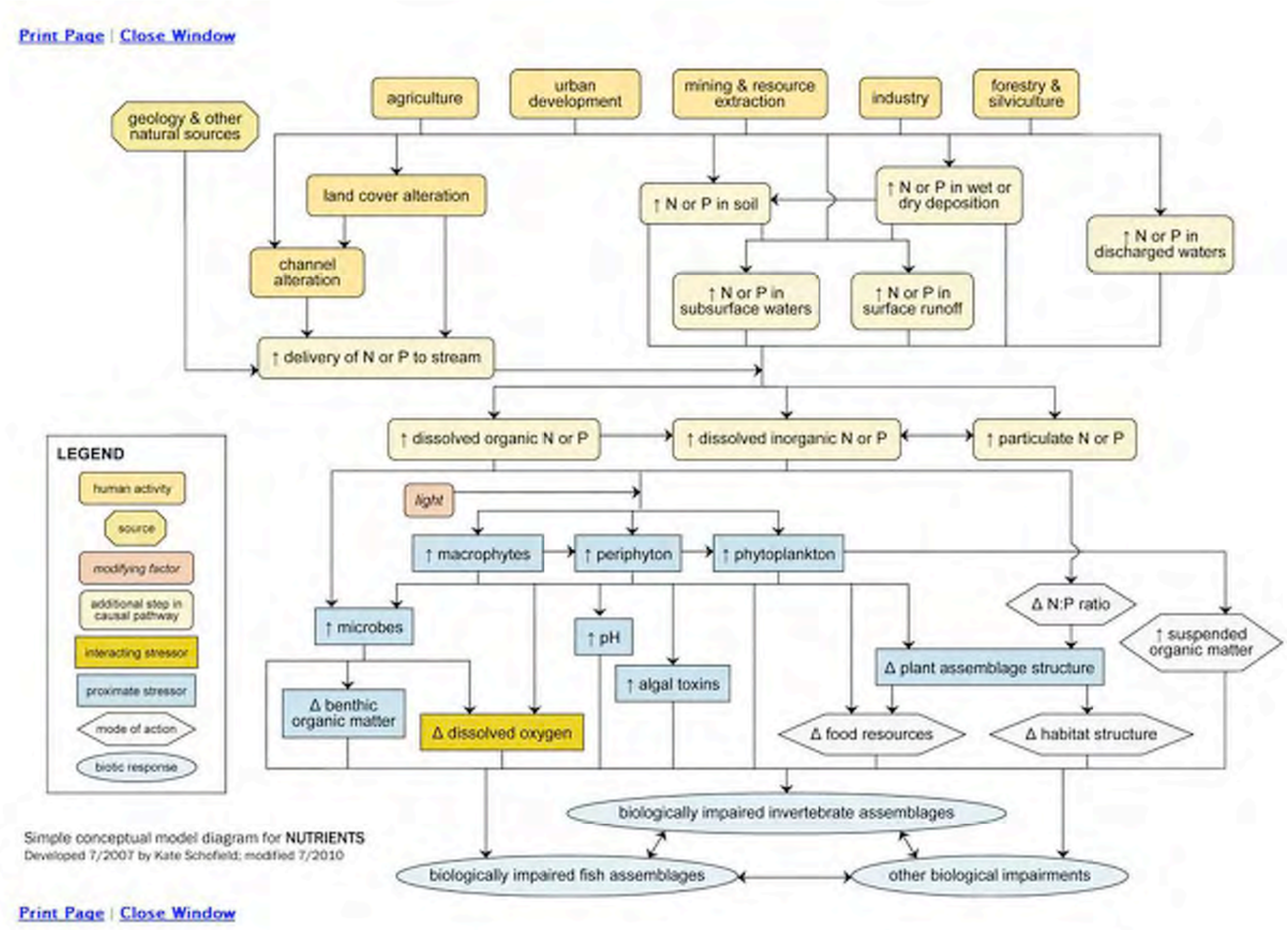

Figure 4. Nitrogen and phosphorus, CADDIS conceptual diagram.

TMDL Session 1 – Overview of the Existing Methods for Nutrient TMDL Development

Overview of Findings from Compendium of Nutrient TMDLs

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In an effort to better understand common practices for identifying impaired waters and developing total maximum daily loads (TMDL) for nutrients, the authors initiated several information gathering activities. The research was conducted through surveys and interviews with Regional Environmental Protection Agency (EPA) staff responsible for approving Clean Water Act (CWA) Section 303(d) lists and TMDLs and through analysis of the national database on listings and TMDLs. This effort will help document the application of current practices and provide examples of how states have addressed nutrient pollution in 303(d) listings and TMDLs. The goal of this effort is to provide practitioners with additional tools that would better enable them to face the challenge of managing excess nutrients in waterbodies across the country in the future. This presentation summarizes some of the relevant findings of this project and provides examples of the application of current practices in approved nutrient TMDLs.

Quantitative Prediction of Effects of Nutrients on Key Response Indicators and Use

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There are many different approaches that can be used to quantitatively link nutrient targets to key response variables. These approaches should relate stressors to response variables, consider aquatic life use support, consider downstream uses, and should be usable to determine impairment. Common methods include expert solicitation, statistical methods using regional or ecoregion data, reference conditions, regression analysis, and mechanistic modeling. The pros and cons of each method are described.

TMDL Session 2 – Setting Nutrient Targets

Developing Nutrient Concentration Targets from Narrative Criteria

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Selected information from watershed branch in-house survey's of RPA regions related to nutrient listings is presented. Methods to translate narrative water quality criteria to nutrient targets were evaluated through a written survey of EPA regions representing 27 states. The following translation methods were identified:

- Water quality target for phosphorus or nitrogen value taken from state-issued guidance document(s)
- Used EPA recommended criterion for phosphorus or nitrogen as water quality target
- TMDL-specific derivation of water quality target for phosphorus or nitrogen
    - Modeled phosphorus or nitrogen water quality target from state--issued guidance value for a response indicator
    - Based phosphorus or nitrogen water quality target on reference waterbody conditions
    - Based phosphorus or nitrogen water quality target on stressor-response correlation

Setting Water Quality Targets for Phosphorus and Nitrogen

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An array of stressors can affect uses, especially aquatic life, in waterbodies and identifying the responsible stressor(s) can be difficult. EPA has been developing techniques for use in stressor identification and causal analysis, including models for nutrients. Once nutrients are identified as a cause, the goal becomes setting appropriate goals to restore and protect those uses. Some of the techniques used for causal analysis are similarly applicable for identifying water quality targets for TP and TN. This talk reviews techniques for setting nutrient targets to protect uses, including an overview of new USEPA guidance on stressor-response methods for setting nutrient targets.

Pennsylvania Nutrient TMDLs – Using a Weight of Evidence Approach

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In June, 2008 EPA Region 3 established 5 nutrient TMDLs for Consent Decree waters in PA. As PADEP does not have numeric nutrient criteria, a TMDL endpoint was developed using multiple lines of evidence. Of the 17 lines of evidence used, lines included distribution based approaches, a modeled reference condition, stressor-response based evidence and literature values.

All EPA documents including TMDL reports, TMDL endpoint documents and response to public comments documents can be found on Region 3's website:

http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/GooseCreekNutrient/index.html

http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/IndianCreekNutrient/index.html

http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/PaxtonCreekNutrient/index.html

http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/SawmillRunNutrient/index.html

http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/SouthamptonCreekNutrient/index.html

Michigan Approach to Setting Nutrient Targets Based on Biological Impairments

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Nutrients are major pollutants in many of Michigan's lakes and streams, causing severe impairments in some water bodies and requiring the development of nutrient Total Maximum Daily Loads (TMDLs). When a lake or stream does not meet Water Quality Standards (WQS), a TMDL must be developed to determine the amount of a pollutant that can enter a water body and still meet WQS. The state of Michigan, with the help of researchers from Michigan State University, has developed a novel ecosystem-specific approach using biological thresholds and predictive modeling (BTPM) to establish site specific targets for nutrient impaired waters. The main components of the BTPM framework are: (1) to predict each ecosystem's „expected nutrient concentration' in the absence of human effects using a predictive model, (2) to identify important biological thresholds along a nutrient gradient (i.e., biological [BIO] benchmarks), (3) to determine each ecosystem's current nutrient concentration, and (4) to use the above information to derive a nutrient target for the ecosystem using the BTPM framework. The nutrient targets can serve as phosphorus goals in the development of nutrient TMDLs. Michigan has piloted this approach in a nutrient TMDL for Bear Lake, a small shallow lake in the northern lower peninsula. This presentation will outline the steps used in developing the nutrient target for Bear Lake following the BTPM approach, and the challenges faced in developing the TMDL.

Michigan Department of Environmental Quality, Water Bureau, 2008. Total Maximum Daily Load for Phosphorus for Bear Lake, Muskegon County.

Soranno, P. A., K. Spence-Cheruvelil, R. J. Stevenson, S.L. Rollins, S.W. Holden, S. Heaton, and E. Torng. 2008. A Framework for Developing Ecosystem-Specific Nutrient Criteria: Integrating Biological Thresholds with Predictive Modeling. Limnol. Oceanogr. 53(2):773-787.

Identification of Nutrient Concentrations and Enrichment Indicators for Application in a Weight- of-Evidence Based Nutrient Water Quality Standard for Ohio

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Nutrient pollution is recognized as one of the leading causes of impairment to surface waters in Ohio. To facilitate restoration of impaired waters, and protection of those currently meeting their designated use, target nutrient concentrations and benchmarks for associated enrichment indicators were identified based on results of a 4-year study. The nutrient study examined links between primary nutrients, abundance of benthic algae, dissolved oxygen concentrations and condition of fish and macroinvertebrate communities. Retrospective analyses of Ohio EPA's biological and water quality data were used to help place the results of the nutrient study into context. Consistent with results in the published literature, change points in abundance of benthic algae occurred at very low nutrient concentrations; however, those concentrations did not necessarily equate to harmful levels with respect to fish and macroinvertebrate communities, owing to the complex relationship between nutrient concentrations and manifestations of enrichment. Dissolved oxygen concentrations proved a better indicator of locally consequential enrichment. A multifaceted criteria is proposed that incorporates targets for primary nutrients, benchmarks for secondary enrichment indicators, and biological performance.

Development of Biologically Based Total Maximum Daily Loads for Nutrients in the Upper Midwest

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As part of NAWQA's Major River Basins study, biological indicators were used to study water quality impairments dues to nutrients. Algal, invertebrate, and fish taxa and community attributes that best reflect the effects of nutrients were determined along a gradient of low to high nutrient concentrations in wadeable Midwestern streams. Nutrient data collected from 64 sampling sites that included reference, agricultural and urban influences were used to represent the nutrient gradient within the Central and Western Plains (CWPE) Diatom Ecoregion (Cornbelt and Northern Great Plains Nutrient Ecoregion), and the Glacial North (GNE) Diatom Ecoregion (the Mostly Glaciated Dairy Region and the Nutrient Poor Largely Glaciated Upper Midwest and Northeast Nutrient Ecoregions). Sites were classified into low, medium, and high nutrient categories based approximately on the 10^{th} and 75^{th} percentiles of total nitrogen (TN) and total phosphorus (TP) concentrations for sites within each Diatom Ecoregion.

There were significant breakpoints for nutrients and multiple biological attributes within the CWPE and GNE ecoregions. The findings suggest that the range in breakpoints for TN and TP from the GNE can be used as oligotrophic and eutrophic boundaries whereas breakpoints for TN and TP from the CWPE suggest nutrient saturation and can only determine eutrophic boundaries for rivers and streams in these ecoregions. The TN and TP breakpoints from this study will be useful for developing target loads for biological TMDLs (1) to prevent further negative impacts on biological communities in Indiana and other Midwestern streams, and (2) in Midwestern states that do not have water quality standards for nutrients.

Concurrent Session 1A – TMDL Modeling Applications

Nutrient Modeling Overview

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This talk presented an overview of available water quality models including: USGS regression, SPARROW, GWLF, SWMM, SWAT, and HSPF. The various advantages of each model are described and important considerations in model selection are discussed. In addition, modeling protocol and example applications are described.

Table 1. Comparison of various water quality models

MODEL	Time Step	Spatial Scale	Water Quality
USGS Regression	Annual	Large basins	Nutrients
SPARROW	Annual	Large basins	Sediment, Nutrient, Pesticides
GWLF	Monthly	HUC12, 8	Sediment, Nutrient
QUAL2E	Steady-St.	Water body	TN, TP, NH_3, DO, Chlorophyll a, Pathogens
WASP	Hourly	Water body	TN, TP, NH_3, DO, Chlorophyll a, TSS, Toxics
SWMM	Sub-Daily	Small basins	Sediment, Nutrient, Pesticide, Metals, BOD
SWAT	Daily	M-L basins	Sediment, Nutrient, Pesticide, Metals, BOD
HSPF	Sub-Daily	M-L basins	Sediment, Nutrient, Pesticide, Metals, BOD

Using Load Duration Curves in Nutrient TMDLs

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Dependable tools are needed, which promote effective communication between analysts, planners and implementers, so that actions will lead to measurable water quality improvements. Over the past several years, basic hydrology and flow duration curves have been used to support the development of TMDLs. Flow duration curve analysis identifies intervals, which can be used as a general indicator of hydrologic condition (i.e. wet versus dry and to what degree). Duration curves help refine assessments by expanding the characterization of water quality concerns, linking concerns to key watershed processes, and prioritizing source evaluation efforts. The extended use of monitoring information using duration curves offers an opportunity for enhanced targeting, both in field investigation efforts and implementation planning.

Duration curves provide another way of presenting water quality data, which characterizes concerns and describes patterns associated with impairments. This framework can help elevate the importance of monitoring information to stakeholders, which in turn can encourage locally driven data collection efforts (e.g. through watershed groups, conservation districts, point sources). As an assessment and communication tool, duration curves can also help narrow potential debates, as well as inform the public and stakeholders so they become engaged in efforts to improve water quality. This presentation will provide a brief overview on the duration curve approach followed by a focused discussion on the applicability of the method to support development of nutrient TMDLs. Several examples will be used to illustrate how the duration curve framework can be used to identify patterns associated with nutrient concerns and focus efforts to develop meaningful TMDL allocations.

Water Quality Modeling – Technical Applications Using Mechanistic Models

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Mechanistic models are commonly used to simulate the effects of nutrients on biological conditions. There are numerous variables and processes that are represented in typical eutrophication models as described in Figure 5 which is a representation of the WASP model. Several of the processes are described in detail, and an example of mechanistic modeling on the Nuese River is provided.

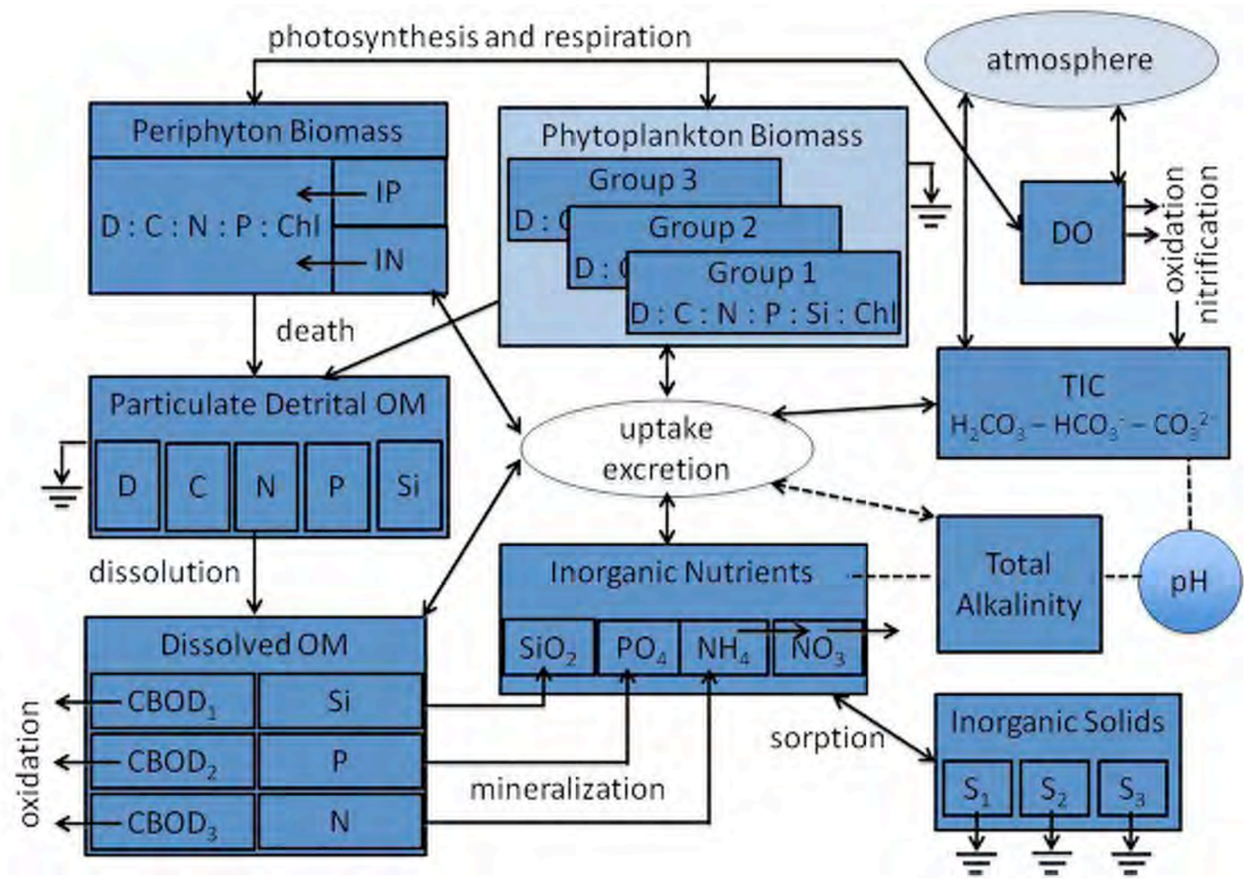

Figure 5. Variables and processes included in the WASP model.

Nutrient TMDLs for Reservoirs with Limited Data: Assessing Uncertainty Using Monte Carlo Simulation

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Rocky and Tom Steed Lakes are two small- to mid-sized reservoirs in rural southwest Oklahoma. They have conservation pool storages of 4,210 and 88,970 ac-ft, respectively, with average depths of 12 and 15 feet. Data indicate that the two lakes do not stratify consistently during summer months. The two lakes are designated as sensitive water supply (SWS) lakes and are on Oklahoma's 303(d) list due to high Chl-a levels (long-term averages of 45 and 24 µg/L, respectively). Oklahoma DEQ is developing TMDLs for these two lakes aiming to reduce the Chl-a level in the lakes to below 10 µg/L, the Oklahoma water quality standard for SWS lakes.

Due to its wheat and range dominated agricultural landscape, SWAT was chosen for estimating nutrient loadings to the lakes. Because there is no stream water quality monitoring in the lake watersheds, the

SWAT model is calibrated against two water quality monitoring stations in the larger HUC-8 watershed that encompasses both lakes and their watersheds. Lake morphometric data are limited to lake volume and surface area only for Rock Lake while bathymetric data are available for Tom Steed Lake. There are between 40 and 67 measurements of Chl-a and nutrients spanning over 6 years from 6 sampling points on each lake (between 1~2 samples per site per year). Such data limitation prevented the application of more detailed water quality models such as EFDC for the lakes. As a result, the Corps of Engineers' BATHTUB statistical reservoir model was chosen to simulate lake Chl-a responses to nutrient loadings from the watershed.

After BATHTUB is calibrated against the long-term averages of water quality measurements for total P, total N, Chl-a, and Secchi depth, a sensitivity analysis is conducted on 18 model input and calibration parameters to identify the 5 most sensitive ones influencing the modeled Chl-a level in each lake. Two model parameters, non-algal turbidity and the calibration factor for Chl-a, are shown to be sensitive for both lakes. A Monte Carlo uncertainty analysis is then conducted based on assumed normal distributions of the 5 most sensitive parameters and the Latin Hypercube sampling technique. Twenty thousand (20,000) Monte Carlo simulations are run for each lake to reach numerical stability. The simulation result is a probability distribution indicating the probability of the lake being at any given Chl-a level in response to a targeted watershed load reduction, given the variability of the 5parameters. Initial execution of the methodology showed that there was a 75% probability that Rocky Lake would have a Chl-a level ≤ 10 µg/L if the N and P load reductions from the lake watershed was set to achieve an average lake Chl-a at 9 µg/L (an explicit 10% MOS). For Tom Steed Lake, the probability is 50%. Further exploration of the application of the uncertainty analysis in setting the TMDLs, including the MOS, is still on-going.

Concurrent Session 1B – State Approaches to Nutrient TMDLs

Nutrient TMDLs Issues in Kentucky

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Kentucky currently has a narrative nutrient limit that restricts discharges of nitrogen, phosphorus, carbon, and contributing trace elements based upon the scope of the problem; the geography of the affected area; and relative contributions from existing and proposed sources. Biologists must interpret this narrative to determine whether a waterbody is impaired for nutrients. This is done by first determining that the waterbody is not supporting the Aquatic Life Use, then examining the biological and physiochemical data and field observations to determine that nutrients are a cause of the impairment. Although numerical nutrient criteria are under development, in the past, the link between the Aquatic Life Use and nutrient impairment was not well established. This made TMDL development difficult because the nutrient target was not known or standardized.

Kentucky currently relies on outside entities to model nutrient impairments and develop TMDLs based upon nutrient targets, a resource intensive endeavor. To date, five TMDLs for nutrient impaired waterbodies have been approved, all prior to 2001. Kentucky hopes that simpler methods than modeling can be identified to produce meaningful nutrient TMDLs; however, staff are preparing for in-house modeling of nutrients via training opportunities.

Although only five TMDLs have been produced, Kentucky does have several nutrient TMDLs under development by outside entities. The main challenges associated with development of the nutrient TMDLs are data gaps and lack of standardized numerical nutrient targets. Data gaps include lack of continuous or near continuous flow measurements and limited knowledge of karst behavior for modeling purposes, limited information on frequency, magnitude, and duration of CSO and SSO events as well as nutrient concentrations in these discharges, no measured data on event mean concentrations for different land uses, and unknown boundary conditions for modeling purposes.

In Kentucky, implementation of fixes for impaired waterbodies can occur independently of TMDL development via Watershed Based Plans. Challenges associated with implementation of nutrient targets include undetermined nonpoint source loadings, which allow stakeholders to deny their responsibility and point fingers at other groups; limited enforcement of the KY Agriculture Water Quality Act, which requires nutrient management plans; and costly BMPs or facility upgrades.

Nutrient TMDL Development and Implementation in New Mexico

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Plant nutrients are essential for proper functioning of ecosystems. However, nuisance levels of algae and other aquatic vegetation can develop rapidly in response to nutrient enrichment when other factors (e.g., light, temperature, substrate, etc.) are not limiting. The relationship between nuisance algal growth and nutrient enrichment in stream systems has been well documented in the literature. Unfortunately, the nutrient concentration that constitutes "excess" is difficult to determine due to site-specific variables such as temperature, canopy shading, and turbidity which control the response of a given aquatic system.

Currently, the State of New Mexico has a narrative nutrient criterion to determine impairment, which states:

> *"Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state" (NMAC 2007).*

This narrative criterion can be challenging to assess because the relationship between nutrient concentrations and use attainment is variable between ecoregions, watersheds, and reaches. In addition, distinguishing nutrients from "other than natural causes" can be expensive, time consuming, and difficult to determine. With recognition of the pervasiveness and severity of nutrient-related problems, the need to accurately monitor and assess nutrient impairment and develop effective TMDLs for impaired waters is clear. Quantitative translators are necessary to accurately assess waters of the state, provide TMDL targets for impaired waters, and calculate wasteload allocations for NPDES permits. This presentation provides an overview of New Mexico's approach to nutrient assessment, TMDL development, and implementation. In addition, several pertinent case studies will be discussed.

New Mexico's Nutrient Webpage: http://www.nmenv.state.nm.us/swqb/Nutrients/

Nutrient Assessment Protocol for Wadeable, Perennial Streams:
ftp://ftp.nmenv.state.nm.us/www/swqb/MAS/Protocols/E.pdf

Examples of Nutrient TMDLs:

1. Cimarron River Watershed TMDLs (Section 5 – Plant Nutrients)
    a. Cieneguilla Creek (Angel Fire WWTP)
    b. Cimarron River (Springer WWTP)
2. Jemez River Waterhsed TMDLs (Section 5 – Plant Nutrients)
    a. Jemez River (Jemez Springs WWTP)
3. Rio Hondo Watershed in Lincoln County (Section 5 – Nutrients)
    a. Rio Ruidoso (Ruidoso/Ruidoso Downs WWTP)

North Carolina Nutrient TMDLs: Integrating State and Federal Programs

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North Carolina (NC) primarily addresses nutrient impairment through its chlorophyll-a numeric water quality standard. This presentation will provide background on the chlorophyll-a standard and the history of nutrient TMDL development in NC. The presentation will include a general example of how nutrient TMDLs are developed in NC and explain how NC has integrated state and federal programs to ensure implementation by all sources. Finally, proposed changes to the current standard and state regulatory efforts to prevent waters from becoming impaired will be discussed.

Los Angeles Area Lake TMDLs

"Simple" TMDLs developed using the NNE BATHTUB model.

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EPA is under a consent decree that requires development of TMDLs for hundreds of waterbody pollutant combinations in the Los Angeles area by March 2012. To meet the consent decree deadline, EPA is establishing many of these TMDLs broken up into projects that encompass many pollutant waterbody combinations. One of these projects includes nine lakes impaired by algae, ammonia, chlordane, copper, dieldrin, DDT, eutrophication, lead, organic enrichment/low dissolved oxygen, mercury, odor, PCBs, pH and/or trash.

The overall effort includes 33 TMDLs covering nine lakes but only the nitrogen and phosphorus TMDLs in eight lakes will be discussed here. Due to lack of time and resources these nutrient TMDLs are being developed in a simplified way with often only one summer and one winter data set. Chlorophyll *a* is used as an indicator of algal density and a target of 20 μg/L is set in these TMDLs to protect beneficial uses. To simulate the impacts of nutrient loading on each impaired lake, the Nutrient Numeric Endpoints (NNE) BATHTUB model was calibrated to lake-specific conditions. This model was then used to generate site-specific nutrient loadings required to attain the chlorophyll *a* target at each lake. Limited data currently indicate Echo Park Lake, Peck Road Park Lake, Santa Fe Dam Park and the southern lake system of El Dorado Park Lakes are meeting the chlorophyll *a* target. EPA is assigning responsible jurisdictions in these lakes' wasteload and load allocations based on existing loading of nitrogen and phosphorus to those lakes. Lake Calabasas, Legg Lakes, Lincoln Park Lake, Puddingstone Reservoir and the northern lake system of El Dorado Park Lakes are assigned mass-based wasteload and load allocations based on the NNE BATHTUB model outputs. During the first public comment period, concerns were raised by many stakeholders about wanting to transition to using reclaimed water to supplement lake levels instead of potable water. To incorporate some flexibility alternative wasteload allocations are being included in the TMDLs. Responsible jurisdictions receiving required reductions have the option to submit a request to the Regional Board for alternative concentration-based wasteload allocations along with a Lake Management Plan detailing how the water quality standards, chlorophyll *a* target and the concentration-based wasteload allocations will be achieved by improved lake management practices. These jurisdictions can receive alternative concentration-based wasteload allocations not to exceed 1.0 and 0.1 mg/L total nitrogen and total phosphorus, respectively. For lakes not currently attaining the chlorophyll *a* target, these TMDLs include reductions of 45% to 71% for total nitrogen and 23% to 62% for total phosphorus depending on the lake.

Expressing Load Allocations for Nutrient TMDLs with Direct Linkage to Implementation Tools

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The development of TMDLs has historically focused on the wasteload allocation often leaving a vague load allocation encompassing multiple sources of nutrients and sediment. Permitted point sources receive individual waste load allocations while the load allocation is a lumped number representing loads from agriculture, non-permitted urban, background, and undeveloped areas including wetlands, forests, and grasslands. Without breaking out the load allocation, TMDL developers are unable to provide guidance on where to target with nonpoint management practices. For the majority of nutrient impairments, improvements in water quality are unlikely not to occur unless nonpoint reductions can be realized. Even when this breakout occurs, often it is done at the watershed scale with reduction goals expressed through the watershed modeling. The results of the watershed modeling are often expressed in a delivered load that accounts for fate and transport phenomena that often does not translate to the field scale tools used for implementation.

In Wisconsin, TMDLs are being developed that breakout the load allocation by sector and source area. The loads are then linked to edge of field loads that better match the implementation tools used by local conservation agencies, NRCS, and other implementation partners. Wisconsin is currently developing tools to help target specific watersheds and fields within those watersheds. This process will be conducted during the implementation planning for the TMDL. Wisconsin has several ongoing pilot projects looking at sediment and phosphorus loading through very detailed surveys. Using information gathered from these projects, techniques are being developed to help identify and target critical areas without time-consuming and detailed surveys.

Link for Wisconsin's field scale nutrient management tool: http://www.snapplus.net/

Link for Wisconsin Buffer Initiative which outlines an implementation strategy for water quality improvement: http://www.soils.wisc.edu/extension/nonpoint/wbi.php

Link to pilot project:
http://www.nature.org/wherewework/northamerica/states/wisconsin/files/pecatonica_river_fact_sheet.pdf

Concurrent Session 2A – Technical and Regulatory Issues in TMDL Development

Linking Nutrients and Sediment Oxygen Demand, Souris River TMDL

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Most dissolved oxygen impairments are related to excessive nutrients, so writing a TMDL with a nutrient target of the State water quality standard or guideline and linking it to dissolved oxygen through appropriate literature and research studies is a fairly straight forward process. This is how North Dakota develops dissolved oxygen TMDLs for lakes and reservoirs. When nutrient standards do not exist, as is the case for North Dakota rivers and streams, a more in-depth look into the processes that drive the reduction in oxygen is needed. When personnel and resources are limited, subcontracting analysis of data, especially large amounts of historical data, can be an effective use of funds if managed properly. Recognizing potential players in both the TMDL and implementation phase processes early on will greatly increase the success of conservation measures in the future, as will recognizing that differing perspectives on the causes of impairments does not mean common goals cannot be met.

As an example of these concepts, I will discuss the recently completed Souris River Dissolved Oxygen TMDL, a TMDL that presents unique challenges as the watershed crosses an international boundary. A North Dakota State University graduate student was provided funding to analyze historical data collected on this reach of the Souris River from 1991 to present, as well as to collect additional data to fill in data gaps identified in the analysis of the historical data. This sampling and analysis suggested that sediment oxygen demand was the major process leading to the dissolved oxygen impairment. There are also challenges to the stakeholder involvement process which include local, state, federal, and international interests. The flow of the river is controlled by releases from two reservoirs located upstream in Canada, which are controlled by long standing international agreements. The local Soil Conservation District came to the North Dakota Dept of Health with concerns regarding eutrophication (bad smell, fish kills) and was involved in some of the sample collection. The downstream end of the reach is at the boarder of Lake Darling, which is part of the Upper Souris National Wildlife Refuge and part of a three reservoir US Fish and Wildlife Service complex located along the Souris River. At the upstream end of the reach, just across the US border with Canada, the Saskatchewan Watershed Authority recently completed a watershed plan that identified many of the same concerns expressed in North Dakota, but with different thoughts on the sources of pollution. We will be working with all the involved groups as we move forward towards an implementation plan.

A copy of the Souris River Dissolved Oxygen TMDL can be found at:
http://www.ndhealth.gov/WQ/SW/Z2_TMDL/TMDLs_Completed/B_Completed_TMDLs.htm

Cutler Reservoir's Phased TMDL for Nutrients and Dissolved Oxygen

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The overall goal of the TMDL process is to restore and maintain water quality in Cutler Reservoir and the Bear River and their associated watersheds to a level that protects and supports the designated beneficial uses (secondary contact recreation, warm water game fish, waterfowl habitat and agricultural water supply). The Bear River/Cutler Reservoir watershed exemplifies many of the complex difficulties faced in attempting to manage water quality on a watershed basis. Although watershed-based planning is recognized as a scientifically sound approach, the reality is complicated by the many political and jurisdictional entities which control different sectors of the watershed. The Bear River/Cutler Reservoir Advisory Committee (BRCRAC) was formed in 2004 and brought together all the stakeholders to devise a strategy to restore water quality in the basin. In February 2010 a Phased TMDL was submitted and approved by EPA. The difficulties and decisions reached in an effort to make progress will be presented. The presentation also discusses an adaptive management strategy and monitoring plan, designed to quantify the linkage between nutrients and dissolved oxygen for the Cutler Reservoir complex.

The Bear River / Cutler Reservoir TMDL document can be viewed with all appendices at:
http://www.waterquality.utah.gov/TMDL/index.htm#approved

Convergence of the Clean Water Act and a Federal Civil Works Project – the Central and South Florida Project Canals

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This presentation will describe the convergence of the Federal Clean Water Act's (CWA) goals with the primary goals of one of the country's largest Federal civil projects – the Central and Southern Florida (C&SF) Project. The C&SF Project was adopted by the U.S. Congress in 1948 and the U.S. Army Corps of Engineers (the Corps) built the massive flood control plumbing system stretching from just south of Orlando to Florida Bay. Currently, over 1,600 miles of canals are artificially operated by the C&SF's state sponsor, the South Florida Water Management District, and the Corps. The C&SF canals' primary uses are to provide flood protection and water supply for over seven million people and the natural environment. These artificially managed canals are also held to the same CWA goal of "protection and propagation of fish, shellfish, and wildlife and recreation" similar to natural systems including America's Everglades. Thus, stakeholders are facing complex decisions on how the canals fit within the CWA and can still meet their original intent. A case study, the Hillsboro Canal, will be presented to guide the audience through the evolution of the CWA's TMDL process in Florida. Since 1999, the 303(d) listing and TMDL development process has evolved due, in part, to a federal consent decree and the state's own Florida Watershed Restoration Act. Adding to the complexity, the U.S. Environmental Protection Agency will be proposing numeric nutrient criteria for the canals due to another federal consent decree. The complexities of these CWA components being applied to canals will be discussed in the context of watershed restoration priorities within South Florida where the largest environmental restoration project in the nation, the federal and state Comprehensive Everglades Restoration Plan, is underway.

Concurrent Session 2B – TMDL Implementation

Addressing Uncertainty in TMDL Implementation

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The United States Environmental Protection Agency (USEPA) is promoting through regulation and guidance a watershed approach for not only addressing water quality impairments, but also for protection of high quality water resources. The watershed approach discussed in this paper is limited to the development and implementation of nutrient Total Maximum Daily Load's (TMDL) Load Allocations. Three major limitations associated with using the watershed approach to address nutrient TMDL Nonpoint Source (NPS) loading reductions are the availability of suitable water quality data, the reliance on models and the ability to accurately track implementation. The limitation associated with suitable water quality data is governed by both the volume of data available and its quality. Addressing both the complexity of NPS load assessment (volume, timing, source, form) and linkage of load assessment to observed water quality conditions requires collection of robust datasets, and the failure to do so creates uncertainty in watershed level decision making. It is well known that our inability to adequately account (measure/estimate) for the various components of NPS loading at a particular point in time and location is a result of natural system variability and sampling error involved in the collection of water quality data. The use of these data in modeling performed to guide decision making further compounds the uncertainty associated with the initial data collection. While there are also a number of approaches (models) being promoted to estimate and evaluate the impact of implementation of nutrient NPS controls, they each have their uncertainty associated with them. Addressing both the complexity of nutrient NPS load reduction efforts (load, timing, form) and linkage of load reduction to observe able improvements in water quality conditions requires utilization of a combination of linked management and environmental datasets, and the failure to do so creates uncertainty in watershed level evaluations. Presently, a two-stage framework is being promoted to address this uncertainty under the watershed approach. This framework covers data collection, its application to models the use of modeling results in decision making and estimating the impact of the implementation efforts. USEPA has partially established through regulation how managers are to address some aspects of uncertainty in TMDLs. This presentation will address how uncertainty is needs to be in developing implementation approaches, as well as tracking implementation of nutrient TMDL implementation plans. As part of the presentation, recommendations will be made on to factor uncertainty issues into reasonable assurance approaches.

Development of a Water Quality Trading Framework in Wisconsin for Phosphorus

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In Wisconsin, many of the impaired waters listed for nutrients are blended waters with phosphorus loads coming from both point and nonpoint sources. Often the point source contributions may only account for a fraction of the total loading. For example, in the Rock River TMDL, analysis was conducted taking the

WLA = 0 and water quality standards were not met in the receiving waters. To address the impairments nonpoint pollution reductions are needed.

Water quality trading can provide a cost-effective and environmentally sound local solution to improving water quality. Economic benefits include allowing dischargers to take advantage of economies of scale and treatment efficiencies that vary by source and scale. Environmental benefits include achieving water quality objectives more quickly, encouraging collaboration of both point and nonpoint sources in addressing water quality concerns, and providing collateral benefits such as improved habitat and ecosystem protection. From a social standpoint, trading helps foster dialog at the watershed scale and helps create incentives for water quality improvement.

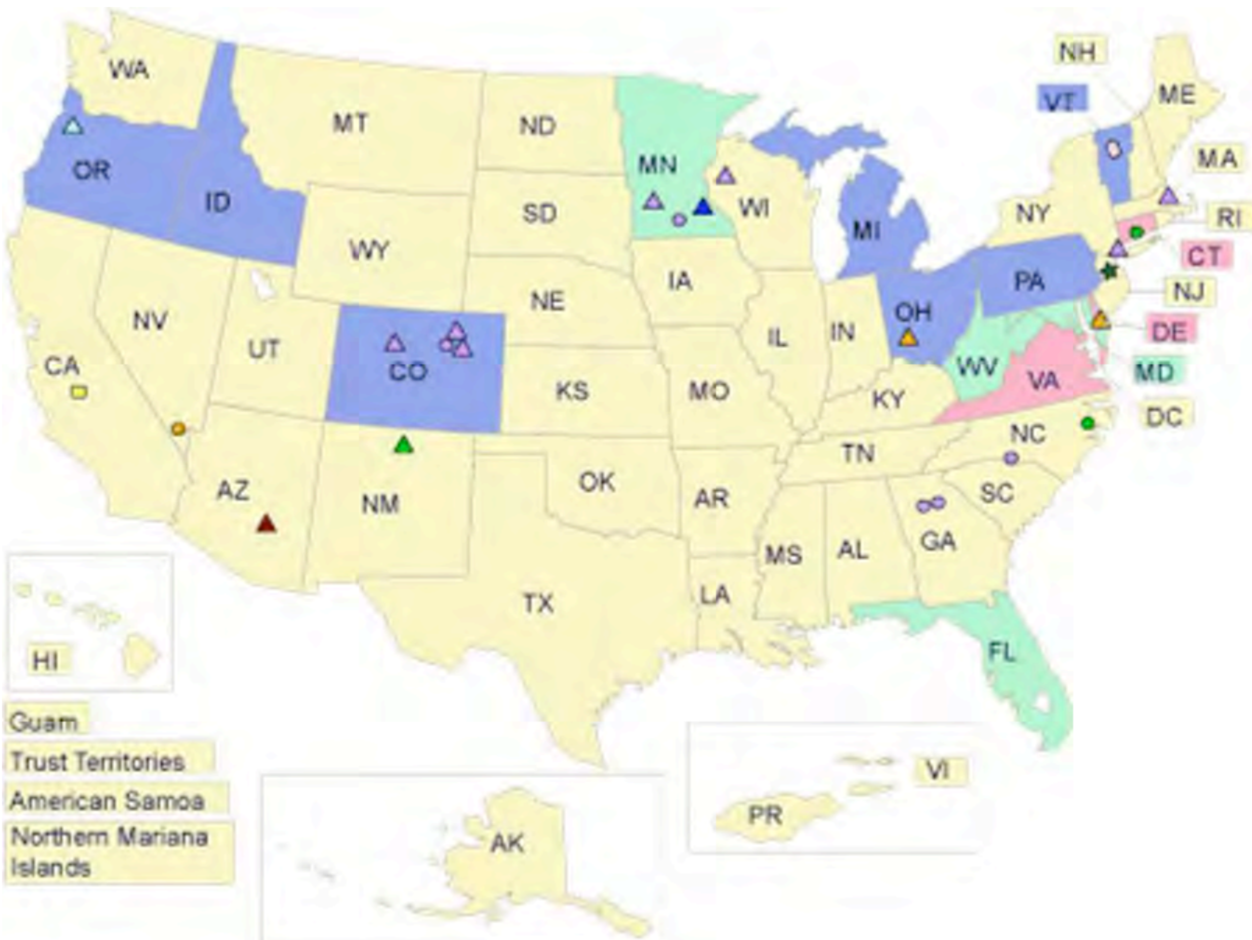

Figure 6. Exiting trading programs reviewed by Wisconsin.

Grand Lake St. Mary's Lake Restoration

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Grand Lake St Marys, in west-central Ohio, is Ohio's largest inland lake occupying approximately 21 square miles. Located in Mercer and Auglaize Counties it was constructed in 1837 as a feeder lake to the Miami and Ohio Canal. The lake is now home to a state park and serves as the public drinking water supply for the city of Celina. The lake is shallow and has a drainage area of 312 square miles. The land use in the watershed is predominately agriculture with over two-thirds of the farms having livestock operations. The watershed has the highest density of livestock per acre in Ohio with more than 3.5 million laying hens, 165,000 turkeys, 80,000 hogs, 8,600 dairy cows and 11,000 beef cattle. Documented sources of water quality impairments within the six primary tributaries entering the lake, include hydromodification, elimination of riparian vegetation, sediment and nutrient loading from agriculture. At five times the level associated with as hypereutrophic, in lake concentrations indicated the lake is extremely hypereutrohpic, Water quality continues to decline, there have been cyanobacteria (toxic blue-green) blooms over the past two years. Recreational and fish advisories have been issued for the lake. A number of other algae toxins have been reported including microcystin, anatoxin, saxitoxin and cylindorspermospin. With USEPA's assistance, OEPA is overseeing the development and implementation of a Lake Management and Watershed Implementation Plan for the Grand Lake/St. Mary's.

The watershed management portion of the plan is being built off the foundation provided by existing Action Plan and Beaver Creek TMDL The integrated watershed management plan will update the proposed implementation actions in the existing documents based upon progress to date, new information and expansion of the effort to include previously not drainage areas and include tributary treatment systems including treatment trains and in-stream alum doser demonstration projects;. The new plan will outline actions needed for improving water quality within Grand Lake St Marys as well as Wabash River.

The other major focus is on lake management practices and methods that if implemented will improve water quality conditions and potentially reduce occurrences of recreational advisories for skin contact due to blue-green algae related mycrocystin in and around public recreational areas of the lake. At a minimum, the lake management portion will include a combination of practices such as: shoreline stabilization; channel aeration and/or circulation; alum treatment projects, solar-powered circulators in and around beach and marina or boat-launching areas; and lake management education and outreach activities. The dual tracked plan will lead to attainment of water quality standards once fully implemented.

Implementation Session

Point Source Reduction Strategies

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A key question faced during TMDL development is “How low can the nutrient (P and N) limits be set for wastewater facilities?” This presentation will discuss the available wastewater (point source) nutrient removal technologies, their reliability, and their expected nutrient removal capacity. Examples of wastewater treatment facilities that meet low nutrient limits in the United States will be provided. The presentation will also cover the science of nitrogen and phosphorus removal from wastewater and will conclude with an assessment of future trends in wastewater nutrient removal technology.

Implementation Strategies for Reducing Nonpoint Source Nutrient Impacts

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Reducing the impacts of nonpoint sources of nutrients is extremely challenging, yet critical to improving water quality in rivers, streams and lakes. Identifying critical areas and selecting appropriate management actions are always difficult yet even these challenges are often dwarfed by the difficulty of actually implementing effective actions. Mr. Gibson will share considerations for successful implementation with a focus on those actions and practices that effectively reduce the impacts of nutrients on surface water quality. Whether it is reducing nutrients at their source or improving a stream’s capacity for assimilating existing nutrient loads, this presentation features specific examples from Ohio’s successful Section 319 and Surface Water Improvement Fund grant programs that are proving effective at addressing this challenging problem.

Source reduction measures for nutrients will always be a staple in the toolbox used to improve water quality in rivers and streams. However, emerging practices such as natural channel restoration to restore stream function as a nutrient reduction tool are exhibiting promise in reducing the influence of nutrients. Green stormwater practices such as rain gardens, green roofs and pervious pavement are also showing considerable promise as local municipalities and urban landowners begin to redevelop areas and retrofit outdated stormwater management practices. This presentation highlights several of the tools that are fast becoming available to watershed coordinators and others for reducing nutrient impacts.

eRAMS – A Tool to Integrate Point and Nonpoint Source Reduction Strategies

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The environmental Risk Assessment and Management System (eRAMS)technology is a comprehensive support system that enhances decision makers' capacity to target conservation practices for sediment, nutrient and pesticide control. The tool can incorporate economic, environmental and management criteria in the decision making process at the watershed scale. eRAMS provides a web-based participatory GIS platform and requires no software installation by the end users. Users can access all components of the platform online at www.eramsinfo.com. The tool works across spatial scales from farmland to watersheds and daily or larger time steps (e.g., monthly, seasonal, or annual). The tool is fully compatible with other commonly used databases/GIS technologies, and thus, takes advantage of readily available data. Since these capacities are implemented and maintained on the host server, users will not be required to master the complicated underlying algorithms. Ultimately, watershed stakeholders across the U.S. will be able to use this targeting tool for conservation planning and implementation of watershed plans.

Multi-Jurisdictional Efforts

Update from the Gulf of Mexico Alliance and the Mississippi River/Gulf of Mexico Nutrient Task Force

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The Gulf of Mexico Alliance.
In 2006, the governors of the five Gulf states (Alabama, Florida, Louisiana, Mississippi, and Texas) established the Gulf of Mexico Alliance. In March 2006, the Gulf of Mexico Alliance (GOMA), released the *Governors' Action Plan for Healthy and Resilient Coasts*. A succeeding five-year *Governor's Action Plan II* was released in June 2009. The Alliance is organized into six Priority Issue Teams: Coastal Community Resilience; Ecosystem Integration and Assessment; Environmental Education; Habitat Conservation and Restoration; Reducing Nutrients and Nutrient Impacts; and Water Quality.

As expressed in *Action Plan II*, the Gulf Alliance Nutrients Team is focusing its efforts in the following four action areas: (1) Characterizing Nutrients and their Impacts, (2) Supporting State Development of Nutrient Criteria, (3) Reducing Hypoxia, and (4) Implementing Nutrient Reduction Activities.

The Mississippi River/Gulf of Mexico Nutrient Task Force.
In June 2008, the Mississippi River/Gulf of Mexico Nutrient Task Force released the *Gulf Hypoxia Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin 2008*. The Task Force, currently co-led by the U.S. Environmental Protection Agency (USEPA) and the Mississippi Department of Environmental Quality (MDEQ), consists of state environmental and agricultural/conservation agencies within the Mississippi/Atchafalaya River Basin (MARB) as well as federal agencies whose missions deal with agricultural, conservation, and water quality-related issues. A key component of the *Gulf Hypoxia Action Plan (GHAP)* calls for the development of state nutrient reduction strategies for those states with significant contributions of nitrogen and phosphorus to the Gulf.

Multi-Jurisdictional TMDLs – Chesapeake Bay and Others
An update on the effort to develop a National Policy Memorandum

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The purpose and progress of developing a National Policy Memorandum related to development of multi-jurisdictional TMDLs (MJTMDLs) is presented. The purpose of the memorandum is to provide TMDL practitioners with recommendations on making assumptions about pollutant loadings at jurisdictional boundaries, developing MJTMDLs that must consider varying water quality standards; determining the legal and geographical limits for the assignment of Wasteload Allocations (WLAs); defining the expectations for incorporating Reasonable Assurance (RA) into the final TMDL; coordinating TMDL schedules and implementation goals across multiple jurisdictions, and coordinating the outreach and public review process. This presentation includes definition, legal basis, and challenges associated with MJTMDLs. Recommended U.S. EPA approaches to multi-jurisdictional TMDLs and the Chesapeake Bay TMDL are presented.

Closing Remarks

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Closing remarks included the following observations and themes:

1. There are numerous challenging issues related to nutrient impairments in the aquatic environment.

2. There are a variety of approaches that states and others are using to characterize nutrient impairments and develop TMDLs.

3. There are likely many impairments that are not being identified due to the type of assessment methods being used.

4. Implementation of nutrient TMDLs is ongoing and we are seeing successes. It is important to keep an open mind and understand that the cost of delay or of inaction can be significant.

5. There are a variety of intangibles that are important when using CWA tools to address nutrients:
   a. Uncertainty
   b. Implementation issues (needs beyond the CWA)
   c. Limited regulatory authority
   d. Limited budgets

6. There are new tools to support addressing nutrient impairments. Technology might not be the final answer but seeing new tools and new twists on old tools are proving useful.