Preliminary Draft Plan for Development of Nutrient Criteria in Maryland

Contact:
Mr. Joseph Beaman or Richard Eskin, Ph.D.
TARSA
Maryland Department of the Environment
1800 Washington Blvd, Ste 540
Baltimore, MD 21230-1718
jbeaman@mde.state.md.us
reskin@mde.state.md.us
410-537-3572

Background

Assessments of state waters have found that nutrient pollution, excess amounts of nitrogen and phosphorus, is one of the most common violations of water quality standards. Although in many States, including Maryland, nutrient pollution, also called "eutrophication," is addressed by narrative standards, the effects of nutrient pollution described below clearly demonstrate degraded water quality and nonattainment of the Clean Water Act goal "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" [CWA §101(a)].

- In deeper lake or estuarine areas nutrient pollution results in high chlorophyll levels reduced light penetration, and conditions in which submerged aquatic vegetation, a critical habitat component, cannot grow;
- In shallow streams nutrient pollution encourages the growth of excess periphyton growing on rocks degrading habitat, and leading to changes in the benthic community and trophic structure of the stream;
- Algal blooms caused by the high nutrient levels die, decompose, and use up oxygen in bottom waters, destroying habitat and resulting in fish kills;
- By perturbing the natural communities nutrient pollution can alter the natural chemistry of aquatic systems by excessive photosynthesis/respiration activities that result in high pH and widely varying dissolved oxygen levels;
- Create odors and esthetically unpleasing situations when excess algae caused by the nutrient pollution eventually die; and
- Some species of algae are toxic or release toxic substances. During bloom conditions facilitated by high nutrient concentrations, this can result in mortality to aquatic life.

With recognition of the pervasiveness of nutrient-related problems, and the need to develop Total Maximum Daily Loads (TMDLs) for the impaired waters, quantitative criteria become more important. This document provides a draft plan, open to public comment, for developing those criteria.

The Difficulties

Nutrients are essential for properly functioning ecosystems. The problem comes when they are present in excess. Unfortunately, just what concentrations constitute an "excess" is a difficult determination to make because nutrient concentrations vary widely and interact with many other

biological and physical conditions to cause a continuum of undesirable effects, from very minor to major impairments, depending on other factors. For example, nutrient concentrations that would not cause a problem in rapidly flowing waters or under cloudy conditions can create major blooms in periods of bright, prolonged sunlight and low flows that provide maximum light for photosynthesis and minimum dispersion of the algae. Similarly, in some circumstances higher nutrient concentrations (also called "eutrophic" conditions) may be desirable to manage a lake for a warm water fishery such as bass, but may not produce water quality suitable for other recreational activities such as swimming.

Closely tied to nutrient impacts are goals for chlorophyll, because as indicated above, the excess nutrients promote excess algae containing chlorophyll and reducing water clarity. Thus, chlorophyll and water clarity can be other measures of nutrient impacts. Nutrients, i.e., nitrogen and phosphorus are considered the stressor indicators, and chlorophyll and clarity are considered the effects indicators. Clarity is generally reduced as nutrients and chlorophyll increase. Sediments suspended in water contribute to a reduction in water clarity, but these inorganic particles also carry nutrients, particularly adsorbed phosphorus.

Other key factors that must be addressed in defining nutrient criteria include: geographic regions, waterbody types, seasonality, and designated uses.

Geographic regions

Different areas of the State have different nutrient concentrations depending on native soil types, groundwater hydrology, and land use (agriculture vs forest vs urban), and thus, different criteria may be necessary in different areas, based on local or regional conditions. In Maryland, three separate sets of criteria are proposed, one for each geographic "ecoregion." These ecoregions are based on geology and geography, and are consistent with the areas known generally as the coastal plain (Eastern Shore), piedmont (Central Maryland), and mountains (Western Maryland).

Waterbody types

Different water body types, i.e., rivers and streams, lakes and ponds, wetlands, and estuaries have different critical conditions at which nutrient concentrations become problematic, producing habitat degradation through eutrophication. Since the nutrients and critical conditions vary greatly between waterbody type, each category will require different criteria.

Seasonality

For some potential quantitative nutrient related criteria such as chlorophyll, seasonal expectations and impacts may vary widely.

Designated uses

The Clean Water Act requires that States designate a "use" for each water body, e.g., support of fish and aquatic life, or recreation (swimming and fishing), and determine the criteria necessary to support that use.

Objectives and Process

The plan presented below, presents a draft approach for developing nutrient criteria in Maryland to support the various uses, in the different water body types in each ecoregion. There are three

major stages to this process. The first is the development of this plan, with public participation, to determine the approaches and priorities. The second is the actual development of the criteria, again with public participation. The third and final step is the promulgation of the criteria into regulation in accordance with Maryland's Administrative Procedures Act. Staff work to date will be modified in the future by additional public review and participation in the Nutrient Criteria Development Plan revision and refinement.

The outline below for the draft plan closely follows an outline provided by EPA for consistency between States in the nutrient criteria development plans.

I. Nutrient Criteria Development Process

The Maryland Department of the Environment (MDE), the agency responsible for developing and eventually promulgating the criteria, recommends the approach that most closely ties nutrient concentrations to actual biological impacts.

A. Conceptual Approach

EPA offers three approaches to the development of the nutrient criteria: (1) Use the EPA approach to criteria development (Technical Guidance Manual), or (2) Use EPA's 304(a) Criteria Recommendations, or (3) Use another scientifically defensible method.

MDE met with technical staff in other State and federal agencies and determined that the EPA approach recommending a percentile of measured concentrations is not clearly and specifically linked to aquatic life use support, and is not the best approach for criteria development. Rather criteria should be set in relation to the designated use and biological impacts. Therefore, Maryland will use other "Scientifically Defensible Methods" for development of nutrient criteria in the different categories of water bodies, having determined that this is most consistent with Maryland's needs, good science, and the intent of the water quality standards. Option 3 most directly ties nutrient concentrations to actual impacts, provides for Maryland specific approaches using Maryland and regional data, and is the most scientifically defensible approach.

Within option 3 there are three possible methods: (1) Empirical approaches (i.e., directly measured relationships between nutrient indicators and impacts, (2) Loading Models, and (3) Cause and Effect Based Studies/Relationships. Maryland will mostly use the first and third methods, depending on the type of water body, but will consider using loading models in some cases. Loading models are used extensively in development of TMDLs, but may not be the first choice in development of criteria because of uncertainties in some assumptions. Loading models may be a good tool to corroborate conclusions reached by the other methods.

The application and implementation of the Cause and Effect based relationships has already begun in the Chesapeake Bay estuary where nutrient impacts are well documented. Draft water clarity and dissolved oxygen criteria, as well as aquatic life-based designated uses have been proposed and public and peer review comments are being evaluated. We have agreement from EPA headquarters that the Chesapeake Water Quality Model will serve to calculate the nitrogen and phosphorus loads that will be protective of the new designated uses that are being proposed concurrently with the new criteria.

For lakes, ponds, and impoundments, nitrogen does not appear to be a critical nutrient and therefore the Department would develop criteria for phosphorus (TP and orthophosphate), clarity (Secchi depth) and chlorophyll *a* first, probably based on empirical relationships established by Carlson (1977), Carlson and Simpson (1996), and Vollenweider (1968).

Following extensive literature review and conversations with subject experts, the Department will pursue the development of nutrient criteria for free-flowing streams and rivers using a multimetric periphyton index of biotic integrity (PIBI). The protocol is similar to that in Barbour et al., 1999. In wadeable streams, periphyton speciation metrics, rapid periphyton surveys, biomass assessment (chlorophyll *a*, AFDM, cell density and biovolume) and concurrently collected nutrient data will be combined with stream assessments from the Maryland Biological Stream Survey (MBSS), nutrient data collected by the MDE field staff, and data from the MidAtlantic Integrated Assessment (MAIA) for rivers and streams to examine statistical relationships between nutrient concentrations, periphyton metrics and support of aquatic life. Ecological conditions will be inferred based on simple or weighted average indices based on the ecological optima for algal assemblages observed in-stream. For larger, nonwadeable streams we will use macroalgae composition, and water clarity measures (i.e., Secchi) in combination with various community metrics (e.g., diversity, percent EPT, total number, etc.) to develop a weight of evidence approach in the assessment.

B. Relation to State Use Classifications

Just as nutrient criteria may be different in different ecoregions, they need to address the specific concerns of the Use designations they support.

1. General Applicability to All Uses

Maryland has seven uses designated. Use I (support of aquatic life and recreation), Use II (shellfish harvesting), Use III (natural trout fishery), and Use IV (recreational ["put and take"] trout fishery). Some Use I, III, and IV waters have a subcategory (P) that also designates those waters for public water supply. At this time Maryland anticipates that nutrient criteria will apply in all uses. Relevant sections of the Code of Maryland Regulations (COMAR) for designated uses and criteria are in Appendix 1.

2. Applicability Tailored to Specific Categories

Through the regional effort with the Chesapeake Bay Program states, nutrient related criteria will be developed for the Chesapeake Bay and its tidal waters. This encompasses the tidal portions of some Use I waters and virtually all of Use II waters. In general, all shellfish waters are estuarine and thus, nutrient criteria for this use will be derived as part of the Bay criteria process. We believe that the Designated Uses developed in that process and the criteria to support them will also apply to fully supporting shellfish harvesting.

Lakes, ponds and impoundments will all fall under Use I or I-P, Use III or III-P, or Use IV or IV-P. We will evaluate the Carlson TSI for Use I in lakes. For Use I-P we will discuss with Maryland's drinking water managers at what levels turbidity or algal biomass begins to interfere with drinking water treatment and will use the more stringent of drinking water or aquatic life support values for I-P. There are areas of lakes, where rivers and streams enter that are more riverine in nature and this will be investigated in terms of the hydrologic applicability of the criteria.

Rivers and streams can be Use I, I-P, III, III-P, IV or IV-P. We will pursue an aquatic life protection approach in these waters based on the Periphyton IBI described above, and an aquatic life protection approach combined with a drinking water approach in the –P designated waters and use the more stringent of the two. The criteria will be stratified across ecoregions as well as stream order.

II. Relation to Physical Classification

1. Lake Type (size/depth/trophic status)

Trophic status will be a critical issue for lake criteria development, as well as designated uses (i.e., swimming uses demand better water clarity than non-primary contact uses such as fishing).

2. Stream Order

Stream Order within a specific ecoregion may be an issue depending on what the data tell us on detailed analysis. In evaluating biocriteria, we found that variances did not change significantly with stream order. However, the conclusions may be different for nutrients.

3. Eco-region Sub-scales

Unless some reason develops for site-specific nutrient criteria, Maryland does not plan for ecoregion sub-scales. Maryland has three ecoregions, and each

category of waterbody described above will be addressed within the specific ecoregion.

4. Other natural geographic boundaries

Watershed basins will be addressed by TMDLs when necessary and will determine loadings based on the established standards. Setting appropriate load allocations will protect downstream uses. Because of the Chesapeake Bay activities and Maryland's activities to address numerous nutrient-related impairments by developing TMDLs, watershed and water quality models, exist or soon will exist for virtually the entire state and will be used to set load allocations that meet criteria in each waterbody type. This is a more appropriate means to address downstream protection or changes in water body type (e.g., from a river to lake where due to reduced flushing impacts can develop), than simply setting conservative criteria.

D. Prioritization

The first priority for completion, because they are already in development, are the estuarine criteria for the Chesapeake Bay and its tidal tributaries. Second, criteria for lakes, ponds, and impoundments will be developed, as metrics are well established and data sets are readily available. Finally, criteria will be developed for free-flowing rivers and streams due to the development of a new approach (P-IBI). Although significant data gaps currently exist, criteria development for rivers and streams should progress rapidly across ecoregions because significant co-occurring data sets are available for correlation once the P-IBI is developed and validated.

All of these priorities will run in parallel. The longest operation will be the development of criteria for flowing waters because the P-IBI database needs to be developed. A workplan has already been developed and fieldwork will begin this spring. Approaches currently being used for impoundments in developing TMDLs will be refined as well. The development work for the estuarine and tidal nutrient standards has taken place over the last two years, and publication by EPA Region 3 of a criteria document is anticipated in April, to be followed in July by beginning the Maryland promulgation process.

E. Inventory of Existing Data

MDE will verify the data in the National Nutrient Database and supplement it with data from:

- MDE TMDL, WMA, and drinking water databases
- USGS Data
- ICPRB Data (Potomac River)
- County and City Data (limited to certain counties)

- MD non-tidal database, Lake WQ assessment.

1. Identification of Data Distribution and Gaps

The critical gap is the lack of periphyton assemblage/biomass data existing within the State. Two to three years of P-IBI and nutrient data is considered essential to delineate the minimum annual variability for these hydrologic systems. Data will be needed to establish reference conditions and examine variability across ecoregion, stream order and land use, in addition to annual monitoring.

2. Identification of Database management needs

MDE is developing the STORET system and plans to reassign staff to maintain nutrient and other data in STORET.

3. Representativeness of data

Representativeness of the data will be evaluated, but is believed to be fairly extensive. There may be some bias to more impacted areas, as that is where sampling is typically directed. For example, large numbers of samples have been analyzed for nutrients to develop TMDLs, but obviously these areas have high nutrient concentrations because they are already impaired. Normalization using means or medians to collapse data and provide representative sample numbers may be necessary.

F. Requirements for New Data Collection

1. Physical, Chemical, and Biological Measurement Variables

Rivers/Streams: PIBI metrics, as well as concurrent nutrient data. Orthophosphate may be important in streams, and will be monitored.

Lakes: Orthophosphate is more critical than TP because TP is not biologically available but is tied to sediment. Concurrent chlorophyll *a* levels and secchi depths are also critical.

Estuary: New Chesapeake Bay Program Shallow Water monitoring program to begin Spring 2003 will enable State to develop capacity to accurately monitor response variables' reaction to nutrient inputs from watershed(s)

Sampling and Analysis Plans are under development for each water body category.

2. **Data Quality Objectives**

Under development.

3. Shared Waters

Although not yet specifically addressed, River Basin Commissions and the Chesapeake Bay Program Office can assist in coordination of nutrient criteria for shared waters. Direct state-to-state interactions are also occurring.

Fresh Waters: The Interstate Commission on the Potomac River Basin can coordinate relationships on the Potomac. The Susquehanna River Basin Commission can handle that river system. Separate coordination may need to be established with Delaware.

Tidal/Bay: Will be addressed through development of Chesapeake Bay criteria and Designated Uses.

III. Schedule for Development and Adoption

A. Items to Consider

1. Administrative Procedures and Processes

The Maryland Administrative Procedures Act requires publication of proposed regulations in the Maryland Register with an economic impact statement. The proposal is sent to the Administrative, Executive, Legislative Review Committee (AELR), which must approve the proposal before it can be published. Public review and comment is required, and on an issue such as this, several public hearings are likely. Upon completion of the public review process, if substantive changes are not required, the Secretary of the Environment can publish a final notice, accepting the regulation. The whole process typically takes six to twelve months.

2. Stakeholder Input and Public Participation

Public review is required as part of our Administrative Procedures Act. In addition, we plan to expand the initial State/Federal group to include industry, municipalities, environmental groups, and others. As noted above, public participation is required. MDE will probably go beyond the minimum public participation and develop an advisory committee of stakeholders as the data evaluation proceeds. In addition, it is possible that we will hold public information meetings before Maryland Register publication and formal hearings, to get additional input.

3. RTAG Coordination

We have participated in all RTAG meetings and plan to continue to do so.

4. Scientific Review

Scientific peer review has been conducted for the estuarine criteria and will be conducted for all subsequent criteria development. Maryland is fortunate to have a scientific community actively involved in various aspects of nutrient ecology. We plan to make significant use of that expertise.

5. Other Issues

The most critical item to consider is the availability of resources for monitoring, lab analysis and data analysis.

References

Barbour et.al.1999. Chapter 6 in the EPA Rapid Bioassessment Protocol For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition, EPA 841-B-99-002.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22:361-369.

Carlson, R.E., and J. Simpson. 1996. A coordinator's guide to volunteer lake monitoring methods. North American Lake Management Society and the Educational Foundation of America.

Vollenweider, R.A., "Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in eutrophication," Technical Report to OECD, Paris, France, 1968.

Glossary

AFDM:	Ash free dry mass. A uniform measure of the amount of algae collected.
Benthic community:	Bottom living organisms. In streams, this community is dominated by insects; in the estuary by mollusks (clams) and worms.
Eutrophication:	The process by which water bodies become nutrient enriched. This process occurs naturally but is greatly accelerated by human activities causing water quality problems.
Orthophosphate:	Dissolved inorganic phosphorus (DIN); PO_4
Periphyton:	Macroalgae (not microscopic) growing on rocks and other substrates in fresh water streams.
TP:	Total phosphorus. Includes both dissolved and particulate forms.
Trophic structure:	The structure by which energy moves up the food chain. A critical characteristic of all ecological communities.

Appendix 1: Water quality standards

COMAR 26.02.08.02A: General Information

(1) "Waters of the State shall wherever attainable, be protected for the basic uses of water contact recreation, fishing, protection of aquatic life and wildlife, and agricultural and industrial water supply as identified in Use I.

(2) The determination of the designated use of a water body shall include consideration of the following factors:

(a) Existing conditions; and

(b) Potential uses which may be made possible by anticipated improvements in water quality.

COMAR 26.02.08.02B: Specific Designated Uses

(1) Use I: Water Contact Recreation, and Protection of Aquatic Life. This Use Designation includes waters which are suitable for:

(a) Water contact sports;

(b) Play and Leisure time activities where individual may come in direct contact with the surface water;

(c) Fishing;

(d) The growth and propagation of fish (other than trout), other aquatic life and wildlife;

(e) Agricultural water supply; and

(f) Industrial water supply

COMAR 26.02.08.03B: General (Narrative) Water Quality Criteria. The waters of this State may not be polluted by:

(1) Substances attributable to sewage, industrial waste, or other waste that will settle to form sludge deposits that:

(a) Are unsightly, putrescent, or odorous, and create nuisance, or

(b) Interfere directly or indirectly with designated uses.

(2) Any material, including floating debris, oil, grease, scum, sludge, and other floating materials attributable to sewage, industrial waste, or other waste in amounts sufficient to:

(a) Be unsightly

(b) Produce taste or odor

(c) Change the existing color,

(d) Change other chemical or physical conditions in surface waters,

(e) Create a nuisance, or

(f) Interfere directly or indirectly with designated uses.

COMAR 26.02.08.03-3(A): Water Quality Criteria specific to Designated Uses (Use I waters)

(2) Dissolved Oxygen. The dissolved oxygen concentration may not be less than 5 mg/L at any time.

(5) Turbidity:

(a) Turbidity may not exceed levels detrimental to aquatic life.

(b) Turbidity in the surface water resulting from any dischrge may not exceed 150 units at any time, or 50 units as a monthly average. Units shall be measured in Nephelometer Turbidity Units.

Appendix 2: Water quality standards for specific uses.

a. Specialized Aquatic Life Uses: Use II, Use III, Use IV
COMAR 26.02.08.02B(3); (4); & (6)
(3) Use II : Shellfish Harvesting Waters
(a) shellfish are propagated, stored or gathered for marketing purposes; and
(b) There are actual or potential area for the harvesting of oysters, softshell clams, hardshell clams, and brackish water clams
(4) Use III: Natural Trout Waters. This use designation includes waters which have the potential for or are:
(a) suitable for growth and propagation of trout; and
(b) Capable of supporting self-sustaining trout populations and their associated food organisms.
(6) Use IV: Recreational Trout Waters. This use designation includes cold or warm waters which have the potential for or are:
(a) Capable of holding and supporting adult trout for put-and-take fishing; and
(b) Managed as a special fishery by periodic stocking and seasonal catching.
b. Primary Contact Recreation
c. Secondary Contact Recreation
d. Drinking Water Supply: Use I-P, Use III-P, Use IV-p
COMAR 26.02.08.02B(2); (5); & (7)
(a) Must meet all uses identified for Use I, III, or IV waters; and
(b) Use as a public water supply.
e. Agricultural/Industrial Water Supply: Use I Waters only.

3. Development of Refined Use Classifications
a. **Proposed** Designated Uses and Criteria for the Chesapeake Bay Estuary and its Tidal Tributaries (COMAR 26.08.02.08.02?)
(a) Migratory Spawning and Nursery Habitat Use (1 February – 31 May)
i. Dissolved Oxygen
ii. Water Clarity
iii. Chlorophyll *a*
(b) Shallow Water (year-round)
i. Dissolved Oxygen
ii. Water Clarity
iii. Chlorophyll *a*
(c) Open Water – Dissolved Oxygen Only
(d) Deep Water - Dissolved Oxygen Only
(e) Deep Channel - (1 June – 31 September)
i. Dissolved Oxygen Only