TECHNICAL AND POLICY CONSIDERATIONS AND OPTIONS IN ASSESSING NUTRIENT STRESSES ON FRESHWATER STREAMS IN VIRGINIA

Report of the Academic Advisory Committee
for
Virginia Department of Environmental Quality

by:

Carl E. Zipper
Member, Academic Advisory Committee
Department of Crop and Soil Environmental Sciences, Virginia Tech

Kurt Stephenson
Member, Academic Advisory Committee
Department of Agricultural and Applied Economics, Virginia Tech

Len Shabman
Member, Academic Advisory Committee
Resources for the Future, Washington DC

Gene Yagow
Member, Academic Advisory Committee
Biological Systems Engineering, Virginia Tech

Jane Walker
Member, Academic Advisory Committee
Virginia Water Resources Research Center, Virginia Tech

Publication of the
Virginia Water Resources Research Center
210 Cheatham Hall
Virginia Tech
Blacksburg, VA 24061

24 December 2012

Members of the Fiscal Year 2013 Academic Advisory Committee to the Virginia Department of Environmental Quality

Stephen H. Schoenholtz, Chair
Virginia Water Resources Research Center
Virginia Tech

E. Fred Benfield
Department of Biology
Virginia Tech

Paul Bukaveckas
Department of Biology
Virginia Commonwealth University

Gregory C. Garman
Department of Biology
Virginia Commonwealth University

Carl Hershner
Department of Biology
Virginia Institute of Marine Science
The College of William and Mary

Golde I. Holtzman
Department of Statistics
Virginia Tech

Howard Kator
Department of Environmental and Aquatic Animal Health
Virginia Institute of Marine Science
The College of William and Mary

Wu-Seng Lung
Department of Civil and Environmental Engineering
The University of Virginia

Kevin J. McGuire
Virginia Water Resources Research Center
Virginia Tech

Leonard A. Shabman
Resources for the Future

Leonard A. Smock
Department of Biology
Virginia Commonwealth University

Kurt Stephenson
Department of Agricultural and Applied Economics
Virginia Tech

Jane L. Walker
Virginia Water Resources Research Center
Virginia Tech

Gene Yagow
Department of Biological Systems Engineering
Virginia Tech

Carl E. Zipper
Department of Crop and Soil Environmental Sciences
Virginia Tech

Technical and Policy Considerations and Options in Assessing Nutrient Stresses On Freshwater Streams in Virginia

Report of the Academic Advisory Committee for Virginia Department of Environmental Quality

Contents

I. Introduction

This report is prepared for the Virginia Department of Environmental Quality (DEQ) by the Academic Advisory Committee (AAC) to communicate perspectives of the Committee concerning nutrient criteria for freshwaters in the Commonwealth.

The AAC has been advising DEQ on nutrient criteria development since 2003. Activities have included providing general advice and perspectives to initiate the process in 2003-2004; advising development of criteria for lakes and reservoirs, now completed; and advising on development of criteria for freshwater rivers and streams, ongoing.

The AAC has proposed that nutrient criteria for freshwater wadeable rivers and streams be executed through what it calls the "Screening Approach." In its June 2012 report, the AAC investigated the feasibility for application of the Screening Approach by deriving potential screening parameters from Virginia DEQ water monitoring data and by conducting a preliminary investigation of the resource requirements for implementation of the approach.

Here, we provide Virginia DEQ with the Committee's perspectives concerning scientific and policy issues and options related to application of the Screening Approach. This document is intended to serve as a supplement to the AAC's 2012 report and is being provided at the request of Virginia DEQ.

The focus of this document is nutrient criteria for freshwater wadeable rivers and streams (referred to as "streams" throughout the document) in Virginia's Mountain and Piedmont regions.

II. The Screening Approach

In Virginia, all state waters are designated to support aquatic life. Virginia water quality standards define the aquatic life designated use to include "the propagation and growth of a balanced, indigenous population of aquatic life… which might reasonably be expected" (Water Quality Standards Regulation; 9 VAC 25-260-10.A.). To monitor and assess the attainment of the aquatic life designated use, Virginia has developed a procedure to assess water quality that uses benthic macroinvertebrate monitoring results to calculate a Virginia stream condition index (VSCI) (Tetra Tech 2003; Virginia DEQ 2006). Virginia stream condition index scores =60 indicate stream communities that support the aquatic life designated use, whereas VSCI scores <60 indicate aquatic life impairment.

The AAC has recommended that nutrient criteria be implemented in a manner that is consistent with the goal of assessing streams for aquatic life designated use and with current procedures that are in use within Virginia for that purpose. The procedure for the Screening Approach would employ observed-effect concentrations (OECs) and no-observed-effect concentrations (NOECs) for total nitrogen (TN) and total phosphorous (TP) in association with visual and benthic macroinvertebrate assessments (AAC 2006, 2009, 2010, 2012). The Screening Approach would be implemented in multiple stages at Virginia DEQ ambient water-monitoring locations where TN and TP concentrations are measured periodically and routinely for purposes of water-quality assessment. The Screening Approach would be applied to identify those water monitoring locations where adverse impacts on aquatic life use are occurring in association with elevated nutrient levels (Figure 1).

The first stage of the Screening Approach is based on two sets of measured TN and TP concentrations:

- No-Observed-Effect Concentrations (NOECs) for TN and TP: Streams with both TN and TP concentrations equal to or less than (=) NOECs are assessed as “not impaired” due to nutrients. NOECs are nutrient levels that are deemed unlikely to cause a biological (aquatic life use) impairment.
- Observed-Effect Concentrations (OECs) for TN and TP: Streams with either TN or TP equal to or greater than (=) OECs are assessed as “impaired.” OECs are nutrient levels deemed likely to contribute to biological (aquatic life use) impairments.

If a water body has nutrient concentrations that are higher than NOEC but lower than OEC, we cannot conclude that it is either “not impaired” or “impaired” due to nutrients without further investigation. In this case, the first stage of assessment would be inconclusive and the assessment process would proceed to a second stage.

The second stage would be a visual assessment conducted by a Virginia DEQ regional biologist. Algal biomass, a primary indicator of biotic stress in streams with elevated nutrients, is often visible to the naked eye and can be reasonably associated with conditions that would also lead to stress on the aquatic community. A visual assessment would rely on the presence of visible macrophytes and algae to assess the stream for biological impairment, in lieu of a more costly macroinvertebrate assessment at locations where benthic monitoring is not currently conducted or scheduled. If the visual assessment revealed algal biomass levels and types that the regional biologist interpreted as indicative of aquatic community impairment, the stream would be assessed as impaired. Otherwise, the second stage of assessment would be inconclusive and the assessment process would proceed to a third stage.

For monitoring locations subject to the third stage of assessment: benthic macroinvertebrates would be sampled as per the agency’s standard procedures, a VSCI value would be calculated, and the stream would be assessed for biological condition based on that VSCI score.

The Screening Approach would produce a definitive assessment of aquatic-life designated-use support at all water monitoring locations with sufficient TN and TP data to enable water-quality assessment by employing visual assessments and/or benthic macroinvertebrate monitoring as supplemental measures in some cases.

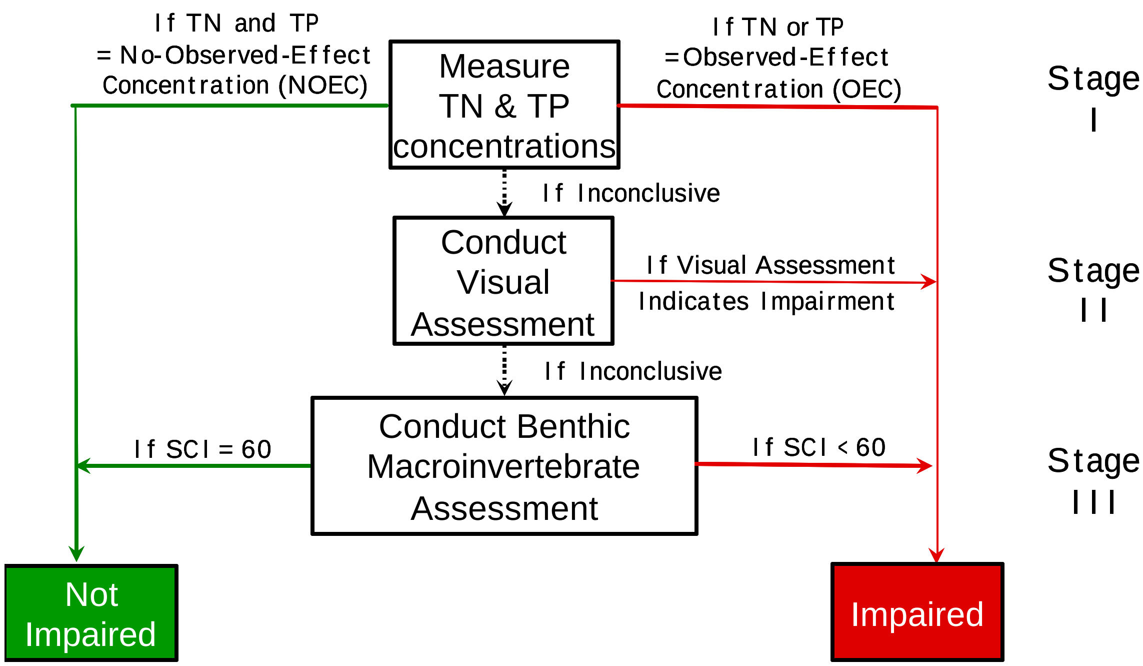

Figure 1. Screening Approach to the nutrient criteria for freshwater wadeable streams in the Mountain and Piedmont ecoregions of Virginia, as proposed by the Academic Advisory Committee. The Screening Approach can be executed as a sequence of three stages, as described in text.

III. Rationale for Recommending the Screening Approach

The AAC has recommended that nutrient criteria be applied using a screening approach considering the following logic.

U.S. EPA has required all states and tribes to establish numeric nutrient criteria (U.S. EPA, 2000):

The AAC agrees that nutrients can act as a stressor that causes biological impairment to stream communities in Virginia.

The Screening Approach is an effects-based approach:

Two basic approaches to nutrient criteria development, as outlined by U.S. EPA (2000), can be defined as a "reference approach" and an "effects-based approach." A reference approach would identify streams draining "relatively undisturbed" and/or "least impacted" landscapes, and define conditions within such streams as a "reference condition" and, as such, a desirable condition for all streams within an ecoregion represented by that reference condition. Under a reference approach: If conditions within a monitored stream are dissimilar to those defined as the reference condition, that stream would be assessed as impaired. An effects-based approach considers observed in-stream effects caused by nutrient enrichment as the basis for making a biological impairment determination. The AAC believes that an effects-based approach is a preferred approach and a feasible approach for assuring that nutrient levels do not result in failure to meet aquatic-life designated uses. Factors considered by the Committee's decision to favor an effects-based approach to nutrient criteria development include the following:

The role of nutrients in aquatic ecosystems: The nutrients N and P are essential to biological productivity in aquatic and terrestrial ecosystems. Therefore, the mere presence of nutrients at levels that are uncharacteristic of reference conditions may not necessarily constitute evidence that the biological condition within the affected stream has been degraded or otherwise rendered unable to meet designated use. Aquatic systems vary in sensitivity to nutrient inputs due to a of variety factors, including differences in water residence time and light conditions. For example, heavily shaded (forested) streams and deep (constricted) rivers are less likely than broad, exposed streams and rivers to exhibit algal blooms or other symptoms of eutrophication at any given nutrient level because low light conditions limit the ability of algae to utilize nutrient inputs.

Designated uses and criteria: The intent of water-quality criteria is to have a scientifically based means of protecting a waterbody's "designated uses," the existing and potential uses of the waterbody (e.g., recreation, support of aquatic life, drinking water supply). Therefore, instead of striving to reach a particular reference stream condition, it is more important to focus on ensuring protection of the designated uses. Nutrient criteria should be set at levels that protect all designated uses, including uses that are most sensitive to the influences of nutrients. In this instance, the protection of aquatic life is the use most sensitive to excessive nutrients. Because protection of this most sensitive use – the aquatic life use – is the goal of nutrient criteria, it seems reasonable to monitor the observed in-stream effects of nutrients on aquatic life in streams and rivers.

The pervasiveness of excess nutrients in human-inhabited landscapes: This pervasiveness occurs as a direct consequence of human habitation, as activities that sustain and enrich human populations concentrate nutrients within certain sections of the inhabited landscape. Agricultural production, for example, is essential to human food supplies, and agricultural production can be enhanced through application of nutrients as fertilizers. Similarly, livestock are managed only on certain landscape areas, and the presence of livestock and their nutritive requirements for productive growth generally cause greater concentration of nutrients on such landscape areas than on unmanaged landscapes. Similarly, human habitation tends to be concentrated in certain locations, where nutrient-rich human wastes must, of necessity, be managed and treated. Humans manage vegetation in occupied landscapes through, among other activities, management of the nutrients applied to that vegetation. Thus, the fact that human populations are distributed heterogeneously across landscapes will cause nutrient distributions across those landscapes to also be heterogeneous; which, without stringent management, will cause certain water bodies to receive nutrients in amounts and quantities that are elevated relative to uninhabited and unmanaged landscapes that commonly serve as reference conditions.

Limitations of reference-based approaches: Achieving universal in-stream nutrient conditions at levels comparable to reference conditions is not feasible in human-dominated catchments. Moreover, such an end goal is not desirable given that surface waters vary in their sensitivity to nutrient enrichment. As some systems are exposed to

> nutrient enrichment without the accompanying symptoms of eutrophication, it is preferable to direct expenditures of limited resources to achieving nutrient reduction where nutrients are shown to be causing impairment of aquatic life or other designated uses.

In our view, any criteria intended to address excessive nutrients should be aimed at detecting and preventing adverse effects of nutrients but should not be based on any small detectable changes from reference conditions that have no significant adverse effect on the aquatic community or the designated uses.

Cause-and-effect relationships between in-stream nutrient concentrations and biology are confounded by many factors.

Cause-and-effect mechanisms for relationships between in-stream nutrient concentrations and the biological condition of that stream community differ in a fundamental manner from cause-and-effect mechanisms characteristic of conventional toxicants. By "conventional toxicants," we mean the majority of stressors for which water-quality criteria have been established, such as toxic metals, pesticides, other synthetic organics, and the like (U.S. EPA, 2011). Water-quality criteria for conventional toxicants are generally developed based on species-level toxic effects, which may include reproductive failure or mortality. Species' tolerances to stressors are commonly used to establish water-quality criteria for conventional toxicants (Figure 2).

In contrast to conventional toxicants, nutrient over-enrichment causes negative effects on the biological condition through systemic mechanisms because N and P generally do not act as conventional toxicants. Nutrients stimulate rapid growth of photosynthetic algae and macrophytes, which utilize dissolved oxygen during cellular respiration. Dissolved oxygen levels in streams with excessive growth of algae and macrophytes can become particularly depleted at night because respiration continues but photosynthesis, which produces oxygen as a byproduct, ceases. Furthermore, bacteria utilize dissolved oxygen as they decompose dead algal and macrophytic material. It is the depletion of dissolved oxygen in the water column that negatively impacts the biological condition of the stream. Excessive growth of algae and macrophytes also degrades the benthic habitat for some species. In some cases, excessive algal growth can also cause both aquatic and human health concerns due to algal-produced toxins. Variations among physical and other characteristics of river and stream systems, however, can affect responses of those systems to nutrient enrichment at a given concentration. As a result, biotic responses to nutrient enrichment at specific concentration levels are highly variable among river and stream systems (Figure 3; AAC 2012).

Hence, the AAC recommends using the Screening Approach as a way of integrating a method of "biological confirmation" into the implementation of the nutrient criteria. This allows the criteria to be applied in a manner that can more accurately take into consideration the variable sensitivities of individual streams to nutrients, and their varying capacities to assimilate elevated nutrients while sustaining functional and diverse stream communities.

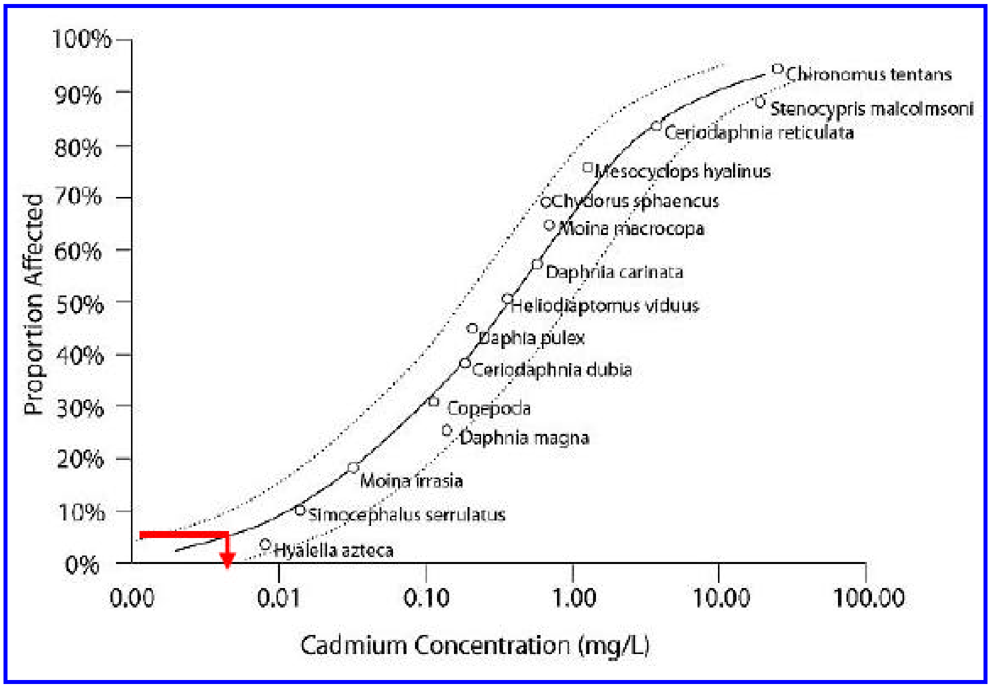

Figure 2. Illustration of typical method used to derive water-quality criteria for conventional toxicants, using the example of cadmium. The graphic shows a species sensitivity distribution for cadmium. Species represented are those for which LC50 (lethal concentration for 50% of organisms) values are available from laboratory bioassay studies for cadmium. The horizontal axis shows cadmium concentrations and the placement of species above the horizontal axis shows sensitivity (expressed as LC50) to cadmium. The vertical axis is the fraction of species experiencing LC50s for cadmium at or below a given concentration. The red angled arrow shows the application of this method to derive chronic criteria for cadmium, which is protective of 95% of tested species. The method of criteria development illustrated is based on Stephan et al. (1985). The figure is from Cormier (2010).

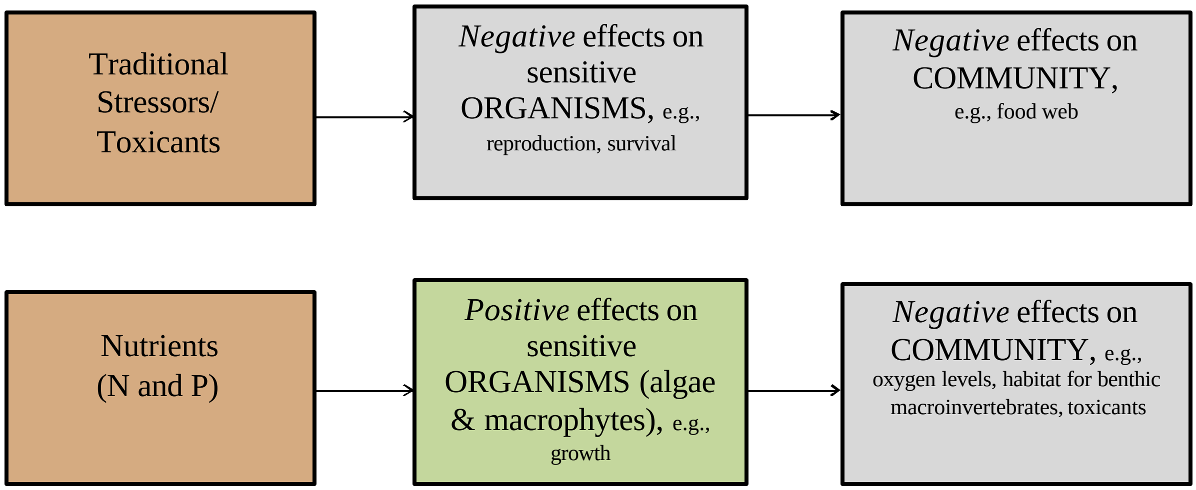

Figure 3. Diagrammatic representation of the fundamental differences between effect mechanisms by nutrients, vs. traditional stressors. Traditional stressors cause negative effects by acting as direct toxicants to sensitive organisms, whereas nutrients exert negative effects indirectly at the community level by promoting excessive growth of algae and macrophytes.

The Screening Approach is recommended with the intention of limiting errors of water-quality assessment despite the inherent variability of responses to nutrients among aquatic systems.

We define "errors of assessment" as a condition in which the water quality assessment does not characterize the biological condition of a stream correctly. Errors of assessment can occur as either of two primary types (Figure 4):

<u>False-positive error:</u> Where a stream community supports an aquatic-life designated use as per Virginia DEQ's EPA-approved method for water-quality assessment (i.e., VSCI = 60), but the assessment process concludes that the stream is "impaired."

<u>False-negative error:</u> Where a stream community fails to support an aquatic-life designated use (i.e., VSCI < 60), but the assessment process concludes that the stream is "not impaired."

Errors of assessment can cause non-productive resource expenditures. False-positive errors can cause expenditures of public and private funds for TMDL studies and implementation of controls that, in fact, may not be needed; such funds could be more productively allocated to address actual stream impairments. False-negative errors can cause loss of environmental services with consequent negative effects on public welfare.

Errors of assessment are also not desirable because, when recognized by the regulated community and the public, they may cause loss of confidence in the government's ability to maintain Clean Water Act-mandated water-quality protections effectively.

		Actual Condition	
		Impaired	Not Impaired
Assessment Outcome:	Impaired	Correct Assessment	Incorrect Assessment (false-positive error)
	Not Impaired	Incorrect Assessment, (false-negative error)	Correct Assessment (true negative)

Figure 4. The Screening Approach is being developed with the intention of limiting both false-positive and false-negative assessment errors.

The Screening Approach is recommended with the intention of reducing water-quality assessment errors in a timely and cost-effective manner.

An effective means for ensuring the greatest level of accuracy in water-quality assessments for aquatic-life designated-use support would be to conduct benthic-macroinvertebrate assessments at all water-monitoring locations. Additionally, site-specific assessments would then be necessary to identify the actual stressors causing the impairment. However, application of such a strategy within the current Virginia DEQ water-monitoring framework would be cost-prohibitive due to the resource requirements for benthic-macroinvertebrate assessments. Each benthic-macroinvertebrate assessment requires significant time expenditure by a regional biologist; DEQ's budget allows it to employ only a limited number of regional biologists and those regional biologists have numerous responsibilities.

For these reasons, lower-cost measurements of nutrient concentrations and visual assessments are offered as proxies for macroinvertebrate assessments. However, nutrient effects at any given concentration will vary among stream systems, while nutrient concentrations will vary over time within any given stream system. Therefore any water-quality assessment method for nutrient effects that relies solely on measured nutrient concentrations will be subject to potential errors of assessment.

Compared to the alternative of relying only on nutrient concentration measurements alone, the Screening Approach can result in more accurate assessments of water-quality conditions. Compared to the alternative of relying only on macroinvertebrate assessment, the Screening Approach is more cost-effective. The Screening Approach at Stage I would assess and definitively classify some streams using less expensive chemical water-quality sampling. It would allow a timely identification of waters clearly stressed by nutrients and those that are clearly not so stressed. For these waters, the screening method allows DEQ to conserve analytical resources by reducing the need for biological sampling. In addition, the Stage I screening step also reduces the incidences of both false-positive and false-negative assessments, based on NOEC and OEC values, respectively. A higher OEC would result in fewer outright designations of impairment, accompanied by more expensive TMDL-related activities in watersheds that may not be biologically impaired (achieving designated uses). A lower NOEC results in a lower probability that actual impaired conditions will fail to proceed into Stage II.

Instead, if there is uncertainty in the Stage I assessment decision, the Screening Approach immediately proceeds to Stage II. At Stage II another low-cost assessment procedure – the visual assessment of algal communities – is employed. If the visual evidence of potential nutrient impairment, supported by the best professional judgment of qualified DEQ biologists, is compelling that there is impairment at Stage II, the stream is assessed as impaired. When both chemical and algal assessments are inconclusive, the benthic-macroinvertebrate assessment process is employed (Stage III) as a means of providing a site-specific biological confirmation that the designated use is or is not being achieved.

One rationale often made favoring chemical-based nutrient criteria is that such criteria are proactive and not reactive. Specifically, because chemical assessments are of lower-cost, they can be done over a wider area and it is possible to assess streams as being under nutrient stress in advance of visible adverse effects on aquatic life. The Screening Approach recommended here is entirely consistent with the argument of the need to be proactive. In fact, the expectation is that chemical water assessments will continue to be done and perhaps expanded. The assessments can help identify priority areas for further investigation in Stages II and III of the Screening Approach if the chemistry is inconclusive.

The committee sees efficiency of resource use by Virginia DEQ as imperative given the agency's mandate to promote public welfare through environmental protection. Given the breadth of Virginia DEQ's environmental protection mandate and the state budget limitations, we see efforts to expedite mandated environmental protections, while using resources efficiently and effectively, as an essential responsibility of the agency.

The Screening Approach is applied with the intention of limiting assessment errors despite the inherent variability of responses to nutrients by aquatic systems, and doing so cost-effectively.

IV. Perspectives on Refinements to the Screening Approach

The AAC suggests that DEQ further explore application of the Screening Approach using NOEC values of 0.599 mg/L for TN and 0.05 mg/L for TP.

These values are derived as 90^{th} percentiles using a reference dataset developed from Virginia DEQ's probabilistic monitoring data, as described by AAC (2012), Section 2. The AAC has confidence that the procedure used to derive these values is a reasonable approach based on empirical analysis of the available monitoring data.

Probabilistic monitoring data were used for these analyses because the water monitoring observations within the database are accompanied by ancillary data that enable identification of those monitoring locations with characteristics suitable for reference locations. There is a precedent for use of probabilistic monitoring data to develop regulatory implementation tools (VA DEQ 2006).

However, the committee sees the relatively small number of observations included within the reference dataset as reason for caution. We suggest a review of published literature and of criteria being proposed or implemented in other mid-Atlantic states as a means of determining if these potential NOEC values are comparable to values being applied for similar purposes in similar environmental settings.

The AAC suggests that the AAC's OEC analysis (AAC, 2012, Section 3) be revisited.

We see the method that was applied to derive OEC values as a valid means of achieving its intended result but recognize that it does not assess cause-and-effect outcomes. The OEC derivation method, as applied, assesses associations between elevated nutrient concentrations and aquatic-life impairments. Those impairments occurring in association with high nutrient concentrations may be caused by nutrients, by other stressors that occur in association with elevated nutrients, or by some combination of the two. The outcome of an OEC exceedance would be for the stream segment to be designated as "impaired," and the resulting TMDL study would provide further insight concerning the biological condition and influential stressors at that monitoring location.

The potential OECs determined by the analysis are quite high relative to the bulk of Virginia DEQ monitoring data (Figure 5). As a result, those values, if implemented as OECs, would be capable of rendering conclusive assessments for only a small proportion of monitoring locations. Thus, such application would have minimal effect on reducing resource expenditures as intended by application of the Screening Approach. Hence, we recommend that the OEC analysis be revisited after reconsidering two essential factors: the implementation time frame and the probability of impairment used to define the OEC.

<u>The Implementation Time Frame</u>*:* The time frame during which nutrient-criteria assessments would be applied can be incorporated into the OEC derivation process. The AAC (2012) analyses were conducted as exploratory analyses over 6- and 12-month periods using the data sets available. A more conclusive approach would be to conduct the analysis for a period that would be compatible with DEQ's assessment process, likely two years or longer. We expect that the derived OEC values will be affected by the time period of analysis as well as by assumptions concerning the minimum number of TN and TP observations for monitoring locations to be included within the analysis. A large data set, comprised of multiple combinations of VSCI with DEQ ambient water monitoring data over a multiple-year period, would be necessary to conduct such an analysis. The analysis should be conducted in close consultation with DEQ water-quality assessment personnel to ensure that water-quality assessment procedures used by DEQ are adequately reflected by the analysis.

<u>The Probability of Impairment used to Define the OEC</u>*:* The analysis conducted by the AAC (2012, Section 3) used a 90% probability of impairment to estimate OECs. This probability was selected considering regulatory precedents. Use of a lower impairment probability for this analysis would generate potential OECs capable of rendering conclusive assessments for a higher fraction of monitoring locations. On the other hand, a lower OEC increases the possibility of a listing error (in this case a false positive). Choice of OEC thresholds has cost implications for both conducting benthic-macroinvertebrate assessments and for developing and implementing TMDLs in waters that are in fact not impaired. However, the choice of impairment-probability threshold would be a policy decision. If DEQ agrees that re-analysis for derivation of an alternative OEC is desirable, we would request that DEQ engage AAC in defining an appropriate impairment probability threshold.

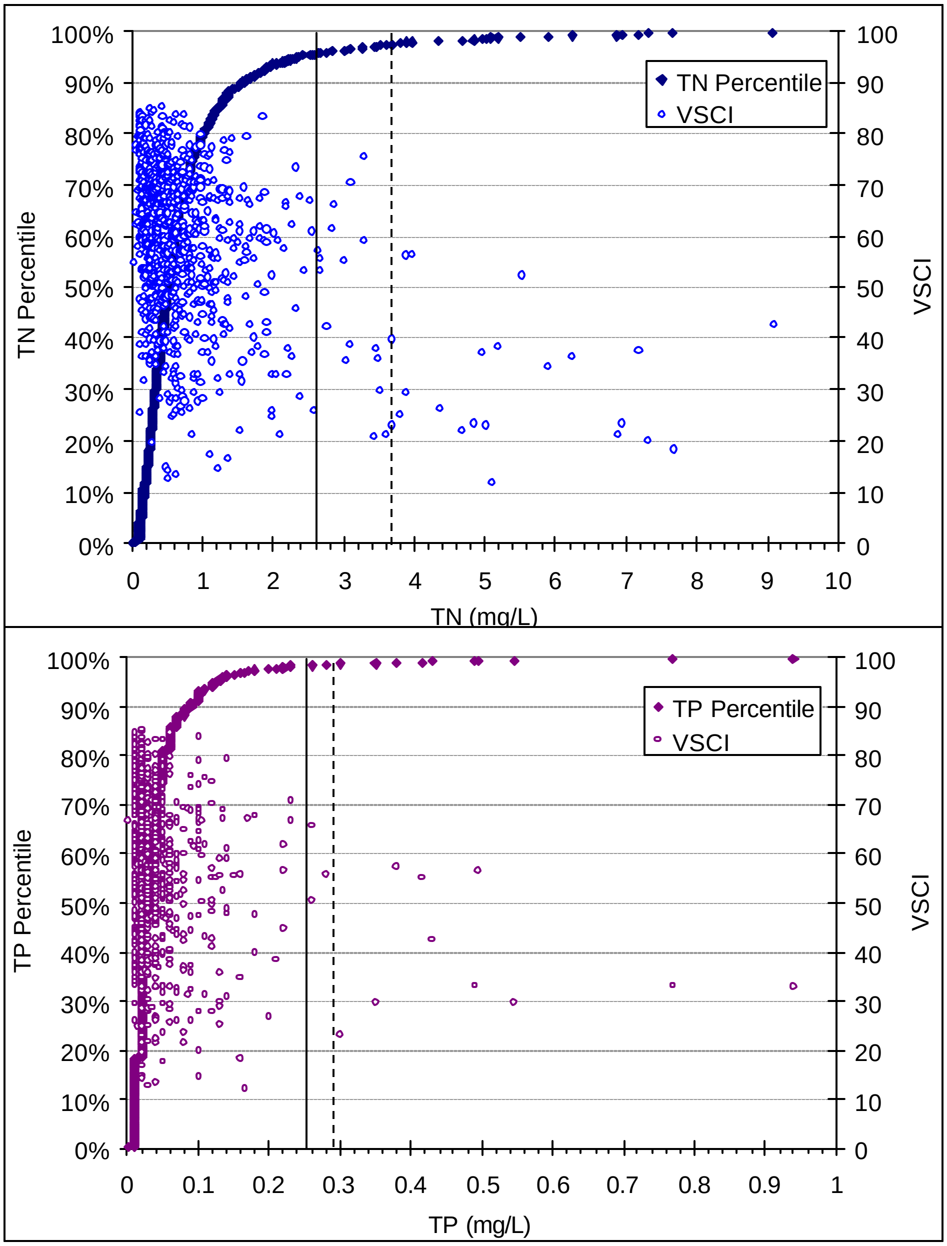

Figure 5. Potential OEC values, derived using a 90% probability of impairment (vertical lines) relative to distributions of TN (above) and TP (below) values within 6-month dataset (AAC 2012, Section 3), with associated VSCI scores. The solid vertical lines are potential OECs derived using visual interpretation (TN = 2.6 mg/L and TP = 0.25 mg/L; from AAC 2012, Table III-1), and the dashed vertical lines are potential OECs derived using the Logistic Inverse Prediction procedure (TN = 3.66 mg/L, TP = 0.284 mg/L) (AAC 2012, Table III-1). TN values > 10 mg/L, and TP values > 1 mg/L (all with VSCI<60) are off-scale, not shown.

The AAC sees visual assessments as a valid component of the Screening Approach.

During a period of three years, Virginia DEQ regional biologists applied the visual assessment procedure on a trial basis at 723 monitoring events for which measured VSCI values were available (AAC 2012, Section 4). Two types of visual assessment of biological impairment were made by regional biologists: one based solely on nutrient stressors, and one based on an assessment of all possible stressors (both nutrient and non-nutrient sources). Of these, best professional judgments by regional biologists indicated a "high probability" of biological impairment due to effects by nutrients for 56 monitoring events, and 49 of these 56 (87.5%) had VSCI values <60 indicating biological impairment, while an additional four locations were found to have VSCI values <65, only marginally greater than the biological impairment threshold. This extended trial indicates that regional biologists were able to discriminate biologically-impaired sites, affected by nutrients, with a high level of accuracy.

The trial visual assessments by regional biologists for general biological impairments (i.e., sites judged to have a high probability of biological impairment due to both nutrient and non-nutrient stressors) achieved lesser accuracy, as 79% of those 133 sites were found to have VSCI <60. Similarly, regional biologists' "low probability of impairment" best professional judgments also achieved similar accuracy levels, as 79% of 226 such sites had VSCI >60. Given our preference for nutrient criteria implementation in a manner that minimizes errors of assessment, we suggest visual assessments be applied only where the best professional judgment by the regional biologists indicate a "high probability of impairment" because of nutrient effects.

If further development of the Screening Approach is pursued, the AAC recommends that DEQ develop a priority system for conducting biological assessments in Stage III waters (i.e., those waters that cannot be definitively classified using the Screening Approach Stage I and Stage II).

Regardless of how OEC and NOEC are ultimately defined, the Screening Approach will not definitively classify all assessed waters as either impaired or not impaired using only Stages I and II. A significant number of waters will remain "inconclusive" as to whether nutrients contribute to a biological impairment after application of Stage I and Stage II. As described in the technical report (AAC 2012), the number of stream segments that would be classified in the Stage III category, thus requiring biological assessments, will be significant.

The AAC recommends the development of a system to prioritize biological assessments of these Stage III waters. A number of alternative prioritization protocols exist. For example, one prioritization approach could target biological assessments based on observed trends in ambient nutrient concentrations. Streams showing sustained increases in nutrient levels could receive higher priority for conducting a biological assessment. (We make this suggestion, noting that DEQ's current water-quality assessment procedures include temporal trend analysis). Another prioritization could rank streams based on the extent to which nutrient control activities are already occurring in the watershed (perhaps due to downstream impairments, such as the Chesapeake Bay). Watersheds where active reduction efforts are underway would provide the public with some assurance that the risk of nutrient impairments is being reduced and could receive a lower priority for assessment than watersheds with less active nutrient control programs. Both approaches are consistent with EPA's emphasis on priority setting outlined in the nutrient management framework (Stoner, March 2011). The AAC and DEQ could explore and evaluate prioritization alternatives for Stage III waters (i.e., those that have generated "inconclusive" determinations in Screening Approach Stages I and II) in the future refinements to the Screening Approach.

If further development of the Screening Approach is to be pursued, we suggest a review of strategies concerning co-location of existing biological and water monitoring to facilitate nutrient criteria development and potential implementation.

The AAC's ability to relate nutrient levels and other potential stressors with biological indicators (e.g., VSCI) might be improved if more paired biological and chemical data were available. The AAC recommends that DEQ review and explore opportunities to increase the coupling of existing biological assessments with water (chemical) monitoring data within existing monitoring budgets.

This suggestion is made considering the resource requirements of implementing the Screening Approach. Because a monitoring location's biological condition is the ultimate determinant of a stream's aquatic-life-use impairment status, we expect that measured VSCI values would be the primary factor considered in water-quality assessments at existing co-located sites. Hence, there would be no need for either visual assessment or an "extra" benthic-macroinvertebrate assessment at a co-located site regardless of measured nutrient concentrations.

We understand that DEQ is endeavoring to co-locate existing biological-monitoring and water-monitoring locations where possible, but that such co-location is not always possible. For example, the location on a given stream segment that is most appropriate for water sampling (e.g., a bridge) may not have habitat characteristics suitable for use in the agency's biological monitoring network. However, we have observed that numerous biological- and water-monitoring location "pairs" are on the same stream and in relatively close proximity, but at different locations. If the intervening stream segment does not receive any major tributaries or effluents from point sources and does not appear to receive significant input from non-point sources, it is likely that water quality at the water-monitoring location would be quite similar to that at the biological-monitoring location, and that the two locations could reasonably be considered as "co-located" despite relatively minor physical displacements.

A closer linkage between DEQ's existing biological- and water-monitoring networks would aid cost-effective development and refinement of a nutrient criteria screening approach. Strengthening the linkages between monitoring datasets would not necessarily require expenditure of additional monitoring resources, and it could provide long-term benefits in addressing regulatory and policy issues, which concern linkages of biological condition to water chemistry.

If further development of the Screening Approach is pursued, we suggest a further assessment of the resources that would be required for its implementation.

Several factors influencing potential resource requirements can be revisited in conducting such analysis:

<u>The assessment time period</u>: The longer the assessment time frame during which the Screening Approach would be applied, the fewer resources will be required for application. This effect occurs because short-term assessment periods result in more frequent >NOEC determinations at Stage I. We are not suggesting that the assessment period be lengthened for the purpose of reducing resource allocations. We are suggesting that an analysis that is more closely linked to the agency's assessment

process would yield a different result from that derived by the AAC (2012, Section 5) exploratory analysis.

Other regulatory actions: As discussed elsewhere in this report, it is possible that other regulatory actions that were not considered in the exploratory analysis by the AAC (2012, Section 5) would influence the resource requirements of implementing the Screening Approach. For example, the Chesapeake Bay TMDL implementation may take precedent in the Bay tributaries over statewide criteria implemented as the Screening Approach. If that were to be the case, results would include a significant reduction in resource expenditures required to implement nutrient criteria as a screening approach. It is possible that other ongoing regulatory actions would also have similar influences.

If further development of the Screening Approach is pursued, methods to assure that the Screening Approach is protective of designated uses in downstream waters should be developed.

The Screening Approach is designed to protect biological uses in wadeable flowing waters by identifying nutrient levels that will be a biological stressor in local streams. However, identifying nutrient levels in local streams that would be protective of uses in downstream waters has not been part of the AAC work plan. The AAC recognizes that Virginia has assigned nutrient-load reduction targets to all localities in the Chesapeake Bay Watershed that are expected to be protective of Bay uses. Furthermore, Virginia has approved nutrient criteria for Virginia lakes and reservoirs. The AAC should identify and recommend analytical methods to assure that Bay load reduction targets and Virginia lake criteria can be used in combination with the Screening Approach to identify thresholds that are protective of both wadeable flowing waters and downstream waters. The AAC also should make recommendations for protection downstream waters outside of the Bay Watershed.

V. Policy Considerations for Potential Screening Approach Implementation

Distinguishing Nutrient Thresholds versus Numeric Nutrient Criteria in Rule Development

The Screening Approach identifies nutrient levels that will result in decisions regarding biological impairments. We suggest that the Screening Approach should be advanced within a policy context that allows waters with elevated nutrient levels to be listed for biological impairment, not nutrient impairment. Our reasoning for this suggestion is explained below. This distinction between a nutrient impairment and nutrient levels as an indicator of biological impairment should be established in the rulemaking process if the Screening Approach is translated into an administrative rule.

To clarify this distinction in rule, the AAC recommends that DEQ clearly define OEC and NOEC as nutrient “thresholds” (or some similar term) rather than numeric nutrient “criteria.” The term “criteria” has specific regulatory interpretations under the Clean Water Act. Defining nutrient concentrations as criteria will mean that those concentrations themselves are an ambient end-state to be achieved, when, in fact, the biological conditions (aquatic-life designated uses) are the desired end state. Clearly defining nutrient concentrations as thresholds that trigger either a listing for biological impairment (OEC) or set in motion the biological assessment sequence

(NOEC) has important implications for the 303(d) listing process as well as for permitting discharges of regulated sources in impaired waters.

Under the 303(d) listing process, the use of the term nutrient "threshold" would avoid the premature conclusion that exceedance of a threshold automatically implies a violation of the biological criteria and an impaired-waters listing. Between the NOEC and OEC thresholds waters are classified as inconclusive, indicating the possibility that nutrients are contributing to a biological impairment. Biological assessments would follow before waters are placed on the 303(d) list as being biologically impaired. If described as criteria, exceedance of the NOEC could result in such waters being placed on the 303(d) list without information from biological assessments. In such instances, unnecessary TMDL development costs would be incurred for some waters that are, in fact, not biologically impaired.

In instances where nutrient concentrations fall above the OEC "threshold" the stream would be listed as biologically impaired with nutrients as the most likely stressor. Note that while waters are automatically listed when the OEC threshold is exceeded, the waters would be listed as biologically, not nutrient, impaired. Once in the TMDL process, DEQ would then be able to confirm if nutrients are the primary stressor and if so, determine the degree to which nutrients would need to be managed for that specific waterbody to achieve the biological designated use and thus avoid prematurely locking in on a predetermined ambient nutrient target (such as the OEC level). In instances where nutrient concentrations levels fall below the NOEC "threshold" the stream would be deemed unimpaired as a consequence of nutrients as a stressor (note that it is possible that the stream biota might still be impaired due to other stressors).[1]

With respect to permitting, defining the NOEC as a threshold also provides DEQ more discretion in setting nutrient permit levels and provides regulated point sources some assurance that the NOEC and OEC do not become end-of-pipe discharge permit limits. If nutrient levels (OEC or NOEC) are defined as criteria, the identified nutrient concentrations become the *de facto* ambient levels used to calculate load targets within the TMDL. The risk is that these ambient nutrient numeric requirements could become end-of-pipe concentration limits because any point-source discharge above the OEC would result in an elevated nutrient load in the receiving waters.

Florida proposes similar language when identifying nutrient-induced biological impairments for flowing streams and rivers and uses the term "nutrient impairment thresholds," rather than numeric criteria. The "threshold" language also allows Florida Department of Environmental Protection (DEP) flexibility to refine 303(d) listings and NPDES permitting so nutrient management is better targeted toward improving biological conditions. The proposed Florida rule (62-303.150) stipulates that waters that exceed the nutrient thresholds (equivalent to NOEC) be placed on a "planning list." The planning list is not a 303(d) listing. The Florida rule explicitly stipulates that the "planning list shall not be used in the administration or implementation of any regulatory program" and that the planning list be submitted to "EPA for informational purposes

[1] The use of the term "thresholds" directly addresses independent applicability guidelines issued by EPA several years ago. If nutrient concentrations are called criteria, and if the VSCI also remains in place, then there are two criteria that would determine whether a water body is listed, what the TMDL would have to achieve, and what would be required to define the water as being unimpaired. By defining nutrient concentrations as thresholds, then the VSCI as a proxy for the aquatic-life use becomes the focus for water-quality management activities in Virginia streams.

only." Once placed on the planning list, waters must be confirmed to be biologically impaired before being verified and listed as impaired (under federal law). Once listed as impaired, Florida can conduct TMDL studies and devise implementation plans based on achieving desired biological conditions.

The Committee suggests that Virginia should carefully consider similar approaches for classifying inconclusive waters so that nutrient levels do not trigger a 303(d) listing until the waters can be confirmed as biologically impaired.

Recommendations for Proceeding with the Screening Approach in Virginia

The AAC suggests that DEQ continue to refine the technical analysis and policy evaluation of the Screening Approach. However, we also suggest that DEQ may wish to consider deferring Screening Approach implementation in the near term. There are two primary reasons to defer implementation of the Screening Approach.

1) As this report summarizes, the AAC believes there are additional refinements and improvements that can be made to the Screening Approach. Additional time to make improvements will produce a better rule, if and when the state moves forward with implementation of this approach.

2) Uncertainty exists as to whether EPA will approve the Screening Approach as a means to meet development of nutrient water-quality criteria. This uncertainty will likely be reduced as EPA resolves pending issues in other states that have proposed rules with components that are similar to the Screening Approach.

The case of Florida's proposed approach to nutrient criteria, for example, is especially relevant (see discussion above). In Florida, the legislature has written its rule into statutory law and rules have been adopted by the Florida DEP (62-303.150), but EPA has yet to formally approve the entire rule. If EPA does approve Florida's rule, the rule will likely be challenged by some environmental groups in court (Water Policy Report, June 29, 2012) so the acceptability of the Florida approach will remain uncertain in the near-term. If EPA accepts the new Florida rule, the Florida approach can be referenced as a justification for the Virginia-specific screening approach. The Florida rule is in the advanced stages of implementation, and Virginia stands to benefit from an EPA determination in Florida.

Based on Virginia's record of nutrient management and stated EPA policies (Stoner, 2011), we expect Virginia DEQ would be able to advance a strong case for the delay that will be required for further refinement of the Screening Approach. The EPA Framework for Nutrient Management (Stoner, 2011) allows time for states to refine approaches to identify and control excessive nutrients in their waters if they can show progress on nutrient controls. Several states (including Colorado, Kansas, Montana) have been allowed to postpone implementation of broad-based numeric nutrient requirements for streams and rivers in exchange for development and implementation of state-wide nutrient reduction strategies. These strategies typically involve plans to implement nutrient-based effluent limitations on regulated point sources. Virginia, perhaps more than these other states, has demonstrated sustained and successful progress on nutrient reduction including:

- <u>Specific Nutrient Reduction Watershed Goals:</u> Virginia established numeric nutrient and sediment load targets within the Chesapeake Bay Watershed (covering 55% of the state).

- <u>Effective Point-Source Permits in Targeted Watersheds:</u> Within the majority of the state, regulated point sources operate with nutrient limits far more stringent than most states (including those that have been granted long-term extensions for development of nutrient criteria). Within the Chesapeake Bay Watershed, all new point sources must install state-of-the-art nutrient-control technology (3 mg/L annual average for TN, plus a requirement to offset any new nutrient loads) and the majority of point sources designated as "Significant Dischargers" (accounting for more than 95% of the point-source wastewater flow discharged in Virginia's Chesapeake Bay Watershed) operate at near technology concentration limits.

- <u>Stormwater:</u> Virginia recently implemented a statewide rule to limit post-development phosphorus runoff from all construction-related land disturbance activities (for both new and redevelopment sites).

- <u>Agriculture:</u> Virginia is also implementing broad-based efforts to limit nonpoint-source runoff under the Chesapeake Bay TMDL. Virginia also recently passed legislation providing farmers incentives to adopt resource management plans to reduce nutrient losses from farms.

- <u>Lake Criteria:</u> Virginia has adopted and EPA has approved numeric criteria, which employ chlorophyll *a* and TP concentrations, for both of Virginia's natural lakes and approximately 98% of the total acreage of man-made reservoirs that have some public access and fishing and recreational opportunities.

The actions listed above demonstrate sustained and committed progress toward achieving nutrient reductions and are strongly consistent with EPA's Framework for Nutrient Management (Stoner, 2011). These actions may be referenced as justification for EPA acceptance of a Virginia proposal for additional time to refine the Screening Approach. Should Virginia DEQ choose to postpone implementation as suggested above, it would be possible for Virginia DEQ to continue refinements to the Screening Approach during the intervening period, thus providing additional support for the case it must make within Virginia to demonstrate the Screening Approach's validity and relevance while bolstering an eventual request for EPA approval.

References

Academic Advisory Committee (AAC). 2006. December 2006 Report of the Academic Advisory Committee to Virginia Department of Environmental Quality: Freshwater Nutrient Criteria for Streams and Rivers.

AAC. 2009. A Screening-Value Approach to Nutrient Criteria Development for Freshwater Wadeable Streams in the Mountain and Piedmont Regions of Virginia: July 2008 – June 2009 Activities.

AAC. 2010. Report of the Academic Advisory Committee: Developing Freshwater Nutrient Criteria for Virginia's Streams and Rivers Fiscal Year 2010 Activity Report.

AAC. 2012. A "Screening Approach" for Nutrient Criteria in Virginia. July 2012 report to Virginia DEQ.

Cormier, S. 2010. Benchmark for Conductivity and Applicability in the Central Appalachian Region. Presentation, 11 May 2010. U.S. EPA, Office of Research and Development.

Stephan, C.E., D.I. Mount, D.J. Hanson, et al. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. U.S. Environmental Protection Agency, Washington, D.C. PB85-227049.

Stoner, Nancy. 2011. "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions." March 16 Memorandum from the Acting Assistant Administrator, Office of Water, Environmental Protection Agency, Washington DC.

Tetra Tech, Inc. 2003. A Stream Condition Index for Virginia Non-Coastal Streams.

U.S. Environmental Protection Agency (EPA). 2011. National Recommended Water Quality Criteria.

U.S. EPA. 2000. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002.

Virginia Department of Environmental Quality (DEQ). 2006. Using Probabilistic Monitoring Data to Validate the Non-Coastal Virginia Stream Condition Index. VDEQ Technical Bulletin WQA/2006-001.

Virginia Department of Environmental Quality (DEQ). 2011. Water Quality Standards. Virginia Administrative Code,

Water Policy Report. 2012. Poison Pill' In Florida Nutrient Rule May Shape EPA Review, Legal Fight. June 29, 2012