BCWSA

PHONE: 215.343.2538 • 800.222.2068 FAX: 267.200.0324

VIA EMAIL AND CERTIFIED MAIL

Ms. Lenka Berlin
USEPA Region III, 3WP30
1650 Arch Street
Philadelphia, PA 19103
berlin.lenak@epa.gov

July 30, 2015

Subject: Wissahickon Creek TMDL

Dear Ms. Berlin,

Enclosed are Bucks County Water and Sewer Authority (BCWSA) comments regarding the draft Wissahickon Creek TMDL.

BCWSA owns and operates the Upper Dublin WWTP, located in the Upper Dublin Township. The Upper Dublin WWTP discharges directly into Sandy Run, which is a tributary of the Wissahickon Creek. The Upper Dublin WWTP received an allocation of annual Total Phosphorus (TP) load from the draft Wissahickon Creek TMDL.

The draft Wissahickon Creek TMDL was based on a proposed TP endpoint concentration of 0.04 mg/L. We believe the methods used by the EPA to derive the TP endpoint are not appropriate for the Wissahickon Creek, and the proposed TP endpoint is not supported by the studies conducted by the EPA. We do not believe the draft Wissahickon Creek TMDL is an appropriate management plan for the restoration of the Wissahickon Creek Watershed.

Very truly yours,

Benjamin W. Jones, CEO

Attachments

CC: John Butler, COO
John A. Swenson, P.E., V.P. Carroll Engineering Corporation
X. Sean Zhang, Ph.D., P.E. Carroll Engineering Corporation

"Your Utility Partner for a Safer Environment"

Draft Wissahickon Creek TMDL Comments
July 30, 2015

A. General Comments:

1. It is our understanding that the chronology of the development of the TMDL for the Wissahickon Creek Watershed (Wissahickon Creek TMDL) is as follows:

   a. In 2003, EPA established the first nutrient TMDL for the Wissahickon Creek Watershed based on dissolved oxygen (DO).

   b. In 2005, PADEP requested EPA to amend the nutrient TMDL based on a proposed total phosphorus (TP) endpoint of 0.24 mg/L. Subsequent to DEP's request, EPA began stream monitoring in the Wissahickon Creek to collect data needed to establish a TP based nutrient TMDL.

   c. During the same timeframe, EPA contracted with Tetra Tech to conduct a study to set a single TP endpoint for six watersheds in southeastern PA, including the Wissahickon Creek Watershed.

   d. In a 2007 study titled "Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application" (2007 Study), Tetra Tech proposed a TP endpoint of 0.04 mg/L for all six watersheds. The 2007 Study relied upon methods described in EPA guidance documents (2000a, 2000b, 2001, 2007) on "frequency distribution based analysis". The 2007 Study also used "stressor response analysis" and "literature based values" to derive nutrient endpoints in a weight-of-evidence approach.

   e. In 2009, EPA developed a draft guidance document titled "Empirical Approaches for Nutrient Criteria Derivation" (2009 Draft Guidance), which provides a limited set of statistical methods in deriving nutrient criteria based on stressor-response relationships. EPA subsequently requested a review of the 2009 Draft Guidance by its own Science Advisory Board Committee (SAB). The SAB is a public advisory group providing extramural scientific information and advice to the EPA and is structured to provide balanced, expert assessment of scientific matters related to the problems facing the EPA in the development of technical guidances.

   f. In 2010, the SAB published its review (2010 Review) of the 2009 Draft Guidance, which exceeded 50 pages and included opinions of experts from the SAB and additional experts with specific knowledge and expertise in assessing the effects of nutrient enrichment in aquatic systems. In its review, the SAB strongly criticized the 2009 Draft Guidance as not representing "a complete or balanced view of using the statistical methods to develop criteria", and, being "problematic", because "statistical associations do not prove cause and effect" and the proposed method needs to address "linkages among designated uses and stressors".

   g. Nevertheless, EPA published the 2009 Draft Guidance as final in 2010, titled "Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria" (2010 Guidance), largely ignoring the SAB's criticisms and recommendations.

h. In 2012, Tetra Tech conducted a follow up analysis to its 2007 Study based on EPA's 2010 Guidance on stressor response analysis, titled "Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application: Follow-up Analysis" (2012 Study). In the 2012 Study, it reconfirmed the recommendation of setting the TP endpoint as 0.04 mg/L for the 6 watersheds in southeastern PA.

i. Also in 2012, EPA published another study by Tetra Tech, titled "Evaluation of Nutrients as a Stressor of Aquatic Life in Wissahickon Creek, PA" (2012 Evaluation). The objective of the 2012 Evaluation was to evaluate support for the basis that nutrients are a stressor on the condition of aquatic life in the Wissahickon Creek.

j. In 2015, EPA published the draft Wissahickon Creek TMDL, based on a TP endpoint of 0.04 mg/L as recommended by the Tetra Tech Studies (2007, 2012).

2. The EPA's own SAB provided the following criticisms and recommendations in the review of the 2009 Draft Guidance on stressor-response based approach in developing numerical nutrient criteria. Please explain why these criticisms and recommendations were not followed or considered in deriving the TP endpoint for the Wissahickon Creek TMDL.

a. "Considerable unexplained variation can be encountered when attempting to use the empirical stressor-response approach to develop nutrient criteria", and, "such unexplained variation presents significant problems in the use of this approach," because "statistical associations may not be biologically relevant and do not prove cause and effect." Additionally, large uncertainties in the stressor-response relationship and the fact that causation is not directly addressed indicate that the stressor-response approach using empirical data cannot be used in isolation to develop technically defensible water quality criteria that will "protect against environmental degradation by nutrients."

Comments: Given the SAB's comments above, why was the stressor-response approach used to develop nutrient criteria?

b. "Multiple statistical methods on one data set do not equate to a reasonable weight-of evidence that significantly reduces uncertainty. Rather, the weight-of-evidence should involve different assessment methods (e.g., different data sets, different biological endpoints, measures of habitat, etc.). This premise has been embraced by other EPA programs and the scientific community."

Comments: Why were different assessment methods not used to reduce the uncertainty of the weight-of-evidence approach?

c. More supporting analyses are needed to "improve the basis for conclusions that specific stressor-response associations can predict nutrient responses with an acceptable degree of uncertainty. Such predictive relationships can then be used with mechanistic or other approaches in a tiered weight-of-evidence assessment including cause and effect relationships to develop nutrient criteria."

Comments: Why were more supporting analyses not performed to reduce the degree of uncertainty in predicting nutrient responses?

d. More data "needed to characterize other stressor and constraint variables (e.g., shaded versus unshaded streams) which are critical … for stratification/classification of univariate nutrient-response relationships."

Comments: Why were other stressor and constraint variables not studied to better understand the nutrient-response relationships?

e. "The Guidance focuses on total nitrogen and total phosphorus as the primary nutrient stressor variables … additional consideration should be given to inorganic nitrogen and phosphorus"

Comments: Why was inorganic phosphorus not considered in the nutrient-response relationships?

f. The Guidance "does not address or partition the inherent critical uncertainties associated with the stressor-response approach … these uncertainties can be extremely large (e.g., several orders of magnitude). To address these uncertainties, the Guidance should better document the physical, chemical and biological variables comprising the morphological relationships (e.g., habitat, spatial, and temporal) that define the aquatic system of interest, and which may be important in modifying the relationship between nutrient concentrations (both nitrogen and phosphorus) and observed endpoints. These factors may dominate the cause-effect pathway and should be documented so that uncertainty in the relationship between nutrient concentrations and measured endpoints can be reduced."

Comments: Explain how these above-mentioned relationships were studied to address the inherent critical uncertainties in the stressor-response approach.

g. "There is considerable uncertainty in linkage of the response variables discussed in the Guidance to the Clean Water Act goals of drinkable, swimmable, and fishable waters. The recommended response variables in the Guidance should be directly linked to these Clean Water Act goals."

Comments: Explain how the response variables used in the Tetra Tech Studies (2007, 2012) are linked to Clean Water Act goals.

h. "Substantial revision of the document is needed to facilitate identification of the most scientifically defensible approaches to deriving numeric nutrient criteria. The Committee emphasizes that understanding the causative link between nutrient levels and impairment is necessary in order to assure that managing for particular nutrient

levels will lead to desired outcomes … the stressor-response framework in the Guidance may often not be the most appropriate approach for deriving numeric nutrient criteria."

Comments: Given the SAB's comments above regarding the inappropriate use of the stressor-response approach in deriving numeric nutrient criteria, explain why this approach is still used in the development of the Wissahickon Creek TMDL.

i. "The absence of a direct causative relationship between stressor and response is one of the most serious issues raised by the Committee. Without a mechanistic understanding and a clear causative link between nutrient levels and impairment, there is no assurance that managing for particular nutrient levels will lead to the desired outcome."

Comments: Given the lack of demonstration of the causative relationship between stressor and response in the development of the Wissahickon Creek TMDL, provide support that such proposed nutrient levels will lead to the desired outcome.

j. Numeric nutrient concentration criteria may not be the most appropriate approach for accomplishing the goal of controlling excessive nutrient loadings. The way in which EPA is currently using mechanistic models for nutrient and sediment TMDLs for Chesapeake Bay does not involve development or use of numeric nutrient criteria. Instead, these load-response models, not empirical stressor-response models, obviate the need for numeric nutrient criteria because they directly link nutrient loads to response variables that represent water quality impairments.

Comments: Explain why load-response models were not used in the development of the Wissahickon Creek TMDL.

k. In the 2010 Review, the SAB agreed with the statement by the Florida Department of Environmental Protection regarding Florida's TMDL that the "most scientifically defensible strategy for managing nutrients within the range of uncertainty is to verify a biological response prior to taking a management action. Those risk-based linkages are not addressed in the EPA Guidance documents".

Comments: Provide support showing that a desirable biological response will be achieved by the Wissahickon Creek TMDL. Explain why the Draft Wissahickon Creek TMDL was published before a desired biological response is verified.

l. "The problem of eutrophication is complex, involving multiple causal variables, multiple response variables, and feedbacks among the variables. Moreover, response variables can be at multiple levels - primary response variables (plants), secondary response variables (DO, pH), and tertiary response variables (macroinvertebrates). A change in a response variable is unlikely to be satisfactorily described by changes in a single 'causal' variable (TP)."

Comments: Give the SAB's comments above, explain why EPA believes that a change in a single nutrient concentration (TP) will result in satisfactory changes in all response variables in the Wissahickon Creek.

m. "The stressor-response relationship is relatively strong and well-established in lakes and reservoirs as opposed to streams and rivers where the relationship is more complex and influenced by many factors (e.g., shading)… the most appropriate criteria may depend upon contexts of the waterbody (e.g., shaded versus open canopy streams), as was done in Florida's guidance document. Searching for a single statewide criterion might obscure important relationships".

Comments: Explain why factors that are more relevant and more influential for streams and rivers were not considered in deriving the nutrient criteria for the development of the Wissahickon Creek TMDL.

n. "The most appropriate numeric criterion may not be a particular concentration level of a nutrient. Moreover, the stressor-response framework is but one approach for developing numeric nutrient criteria, and often it may not be the most appropriate."

Comments: Given the SAB's comments above, explain why EPA believes that a single nutrient (TP) concentration derived from such an inappropriate method is the most appropriate numeric criterion for the Wissahickon Creek.

o. "The approaches presented in the Guidance are correlative and do not demonstrate causation. Many water quality problems are site-specific and confounding variables likely exist."

Comments: Explain why more site specific studies were not conducted to demonstrate causation for water quality problems in the Wissahickon Creek.

p. "The proposed selection of nutrient concentrations as stressor variables has a basic conceptual problem because nutrient concentrations directly control only point-in-time, point-in-space kinetics, not peak or standing stock plant biomass. Since plant biomass is driven by nutrient supply rates (i.e., nutrient mass loads), ambient nutrient concentrations are not necessarily good surrogates for nutrient mass loads. For many systems nutrient concentrations will not be appropriate stressor variables, rather, site-specific mechanistic models incorporating loading to determine the nutrient controls required to attain designated uses are more appropriate and scientifically defensible to use".

Comments: Explain why site-specific mechanistic models incorporating loading were not studied and used in the development of the Wissahickon Creek TMDL.

q. "Relationships between nutrient mass loads and ambient nutrient concentrations are highly system-specific and depend on many factors. Consequently, statistical methods alone will not adequately account for the influence of confounding variables and reduce uncertainties, and stressor-response statistical analysis may not lead to a scientifically justified endpoint".

Comments: Given the SAB's comments above on stressor-response statistical analysis, explain why this method is used in the development of Wissahickon Creek TMDL.

r. "Laboratory experiments are of limited use in validating causal relationships between nutrient and response variables… because other factors such as bottom substrate, turbidity, canopy cover, hydrology, or depth will affect the relationship."

Comments: Explain why these other factors highlighted by the SAB were not considered in validating the causal relationship between nutrient and response variables in the development of the Wissahickon Creek TMDL.

s. "A large degree of unexplained variation can be encountered when attempting to use empirical stressor-response approaches to establish criteria … statistical associations may not be biologically relevant and do not prove cause and effect … the use of these statistical methods alone cannot provide sufficient evidence of a cause-effect relationship".

Comments: Explain why EPA believes that the empirical stressor-response approaches should be used to establish nutrient criteria without sufficient evidence of a cause-effect relationship, as it did in the development of the Wissahickon Creek TMDL.

t. "Breakpoints identified in non-parametric change point analysis (nCPA) may not necessarily have any biological significance, nor will they necessarily be related to designated uses that are to be protected by numeric nutrient criteria".

Comments: Explain why nCPA is used in the development of Wissahickon Creek TMDL to derive numeric nutrient criteria without proving biological significance or relation to designated uses.

u. "Relationships for streams … are more complex than for lakes and must account for multiple stressors/conditions and/or stream 'types' or conditions, and then be applied appropriately. It is important to deal with both N and P simultaneously and to consider inorganic N and dissolved P. For example, the relationship between 'Chlorophyll a' and TP … is less certain in streams because they are more heterogeneous than lakes. It is also inappropriate to assume that only nutrients affect taxa. The functionality of aquatic food chains is not solely dependent on one type of biota, sediment type, or single nutrient concentration. There are multiple stressors affecting receptors in a number of ways, over the landscape and watershed in question".

Comments: Explain why the relationship between "Chlorophyll a" and TP was used in the development of the Wissahickon Creek TMDL, even though it is not appropriate to use for streams. Explain why other factors were not considered, as suggested by the SAB, that may affect other receptors in streams.

v. "The validation process of the empirically derived stressor-response relationship is limited and inconsistent with other EPA guidance documents (e.g., 2009a)".

Comments: Explain why a more comprehensive validation process that is consistent with other EPA guidance documents was not used in the development of the Wissahickon Creek TMDL.

3. Numeric nutrient criteria developed and implemented without consideration of system specific conditions can lead to management actions that may have negative social, economic, and unintended environmental consequences without additional environmental protection. Nutrient endpoints shall be developed using site-specific parameters that represent ecological processes unique to each individual watershed. Yet, majority of the site specific data used in the development of the Wissahickon Creek TMDL was from 2005 and 2006. Explain why more recent site specific data was not collected, and why it is considered appropriate to use outdated data to assess the current conditions of the Wissahickon Creek, and, to develop management plans for the restoration of the Wissahickon Creek Watershed.

4. The Wissahickon Creek TMDL acknowledged that "in addition to point sources, nonpoint sources contribute to water quality impairments in the Wissahickon Creek Watershed ... Nonpoint sources can be precipitation driven and occur as runoff from common, widespread land uses, such as golf courses, agricultural lands, wooded areas, and other landuses ... or direct deposition of pollutants from wildlife and livestock" (page 33). Further, the Wissahickon Creek TMDL indicated that since "the entire watershed is within the MS4 political boundaries ... without the sewershed maps, EPA had no way to separate the nonpoint and point source discharges. Thus, for this modeling effort, all lands within the political boundaries were assumed to be within the MS4 jurisdiction" (page 33). As such, only septic systems and background nutrient loadings from groundwater were included as nonpoint source contributions in the Wissahickon Creek TMDL (page 34).

   Explain why the Wissahickon Creek TMDL did not include nonpoint source contributions that are not part of the stormwater sewer systems and not regulated by the MS4 discharge permits, such as overland storm runoff that is not captured by the stormwater sewer systems and agricultural nonpoint source contributions that are not part of MS4.

5. The Wissahickon Creek TMDL proposed annual allocations of TP loads for WWTP and MS4 sources, as summarized in Table 5-13 (page 79).

   North Wales WWTP was decommissioned in 2013; the allocation analysis of the Wissahickon Creek TMDL should be revised to exclude North Wales WWTP.

   TP load percent reductions of 98.2% to 99.4%, or TP concentrations of 0.0327 mg/L to 0.0719 mg/L (Table 5-6, page 70), were required for all WWTP point sources. Provide support showing that these levels of TP concentrations can be consistently achieved with currently available technologies.

   TP load percent reductions of 91.7% to 98.9% were required for all MS4 point sources. Explain how these levels of TP reductions from MS4 sources can be consistently achieved.

6. On July 1, 2015, EPA made computer models and the associated input files used in the development of the Wissahickon Creek TMDL available on its website for downloading. These downloadable files include EFDC Executable Model and Input Files, LSPC Executable Model and Input Files, and Weather Files. Given the amount of work needed to review these documents and the modeling methods, the amount of time provided by EPA for such reviews is insufficient before the deadline of the commenting period. As such, these models and input files were not reviewed at this time, and, we reserve the right to provide further comments at a later time.

B. Specific Comments Regarding "*Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application (2007 Study)*":

The 2007 Study by Tetra Tech was the study relied upon by EPA to set the TP endpoint of 0.04 mg/L for the Wissahickon Creek TMDL. The purpose of the 2007 Study was to establish TMDL nutrient endpoints for six (6) watersheds in Northern Piedmont ecoregion of southeastern PA, including Chester, Indian, Neshaminy, Skippack, Southampton, and Wissahickon Creeks. The 2007 Study relied on the following three approaches in a multiple-line, weight-of-evidence method to derive the nutrient endpoints: (i) frequency distribution based or reference based approach, (ii) stressor-response analyses, and (iii) literature based values.

7. The 2007 Study proposed an "ecoregional nutrient endpoint" (page 3) and lumped all six watersheds together with the same numerical nutrient criteria. The 2007 Study "made the assumption that nutrient dynamics in the six watersheds should be similar to nutrient dynamics in this portion of the Northern Piedmont ecoregion" (page 4). Furthermore, the 2007 Study relied on data from all across the Northern Piedmont ecoregion, including from Maryland and New Jersey, plus literature values obtained from Virginia, Delaware, New England, or nationwide studies, to develop the nutrient endpoints for these six eastern PA watersheds, citing "limitation of watersheds sizes and the difficulty in obtaining stressor response gradients in the target watersheds" (page 3).

Comments: Provide support why it is appropriate to use a general, ecoregional nutrient endpoint for the Wissahickon Creek, instead of using a watershed specific endpoint that is derived using site specific data. Specifically, data obtained from the Wissahickon Creek indicated that it exhibits distinguishably different nutrient dynamics than the rest of the ecoregion does (See Comment #28 below). Therefore, nutrient criteria derived based on data from other areas across the ecoregion are not appropriate for the Wissahickon Creek.

8. Regarding (i) *frequency distribution based or reference based approach* (three lines of evidence were from this approach):

   a. Water quality samples collected by a variety of agencies from streams in the Northern Piedmont ecoregion were used in the reference based approach, including data from Maryland and New Jersey. In using these data, the 2007 Study "made the assumption that nutrient dynamics in the six watersheds should be similar to nutrient dynamics in this portion of the Northern Piedmont ecoregion" (page 4).

      Comments: As acknowledged in the 2012 Evaluation, that "N:P ratios in the Wissahickon ... calculated based on paired N and P data from 2005 ... suggesting that most sites in this watershed were relatively N limited, in contrast to reference sites" in the Piedmont region. Therefore, this "reference based approach" that was based on other sites in the Northern Piedmont region that exhibit totally different nutrient dynamics than the Wissahickon Creek does is inappropriate and invalid in the development of the Wissahickon Creek TMDL.

   b. Using the "frequency distribution based" approach, and based on the 25th percentile value of data from All Sites and 75th percentile value of data from sites "for which

watershed land cover was available," a TP endpoint of 0.017 mg/L was concluded as a line of evidence (pages 4-6).

Comments: Provide support why using these 25th and 75th percentile values from a broad dataset is appropriate to set the TP endpoint for the Wissahickon Creek. Furthermore, explain why the final TP endpoint for the Wissahickon Creek was set to be 0.04 mg/L, more than twice the value suggested by this reference based approach, if EPA believes this approach is appropriate in the development of the Wissahickon Creek TMDL.

Additionally, as acknowledged later in the 2007 Study, these percentile value estimates either "based on few sites" or included "a variety of data spanning many different periods", and, "the reference approach is less easy to link directly to use protection, given that it is based on percentiles of a frequency distribution" (pages 26-27). Therefore, relying on these percentile values is not appropriate to set the TP endpoint for the Wissahickon Creek or to develop the Wissahickon Creek TMDL.

c. The 2007 Study also included a Modeled Reference Expectation approach where "multiple regression models of total nutrients versus human land cover (agriculture and urbanization) are built and then solved for the condition of no human land cover … This approach has been used to estimate nutrient concentrations in the absence of human disturbance". Subsequently, the 2007 Study developed a model for nitrogen (N), based on data obtained from the Northern Piedmont region. However, the 2007 Study acknowledged that "no significant model for total phosphorus (TP) could be created with the land cover data, so we estimated the TP value for this approach based on N:P ratios". Yet, instead of using the actual N:P ratio obtained from the Wissahickon Creek, the 2007 Study used the "average N:P ratio" from All Sites in the Northern Piedmont region dataset, and, concluded that the TP endpoint should be 0.003 mg/L for the Wissahickon Creek. The 2007 Study also referenced a "natural ratio" of N:P based on EPA recommended nutrient criteria for this ecoregion (source unknown) and concluded that the TP endpoint should also be 0.014 mg/L for the Wissahickon Creek (pages 7-8).

Comments: Provide support showing that extrapolation of multiple regression models using nutrient ratios is appropriate to derive numeric nutrient criteria in the Wissahickon Creek. Explain why site specific nutrient ratio was not used in such an extrapolation to set the TP endpoint for the Wissahickon Creek. Further, explain why EPA believes it is appropriate to set the TP endpoint as 0.04 mg/L for the Wissahickon Creek while the above approach indicated that the TP endpoint should be in a range of 0.003 – 0.014 mg/L.

In summary, none of the three "lines of evidence" under the "Reference Approach" (page 27) is appropriate to set the TP endpoint for the Wissahickon Creek or supports the proposed TP endpoint of 0.04 mg/L.

9. Regarding (ii) *stressor-response analyses* (four lines of evidence were from this approach):

a. "Stressor-response approaches refer to a suite of analytical techniques that derive candidate endpoints by exploring the relationships between response variables and nutrient concentrations" (page 8).

Comments: In 2010, EPA requested its own SAB to review the 2009 Draft Guidance, which focused specifically on stressor-response relationships. Among its strong criticisms of the 2009 Draft Guidance, the SAB specifically pointed out that "considerable unexplained variation can be encountered when attempting to use the empirical stressor-response approach to develop nutrient criteria", and, "such unexplained variation presents significant problems in the use of this approach" to develop nutrient criteria, because "statistical associations may not be biologically relevant and do not prove cause and effect". The 2010 Review further indicated that "there are inherent critical uncertainties in the stressor-response approach, as demonstrated in the analysis results in the studies which exhibited extremely large uncertainties (several orders of magnitude). As such, the prediction from such analyses cannot be interpreted as an accurate prediction of future conditions". Please explain why the SAB's advice and recommendations were not followed in revising the stressor-response approach to develop nutrient criteria. Specifically, why were these advice and recommendations not considered in the development of Wissahickon Creek TMDL?

b. The Stressor-response approach included data from studies of "Chlorophyll a", citing "the primary response variable of interest for stream trophic state characterization is algal biomass, which is most commonly reported as … Chl a" (page 9).

Comments: As highlighted in the SAB's review, "Chlorophyll a" level is not an appropriate indicator of nutrient impairment in streams, as opposed to in lakes. Therefore, relying upon data from studies of "Chlorophyll a" is inappropriate in the development of the Wissahickon Creek TMDL.

c. The Stressor-response approach relied upon "data from seven different national and state programs, similar to those used in the distribution based analyses". Five of the programs were nationwide studies, one was from Maryland, and one was from PADEP-Penn State study which was the only study that "focused on the targeted watersheds" (pages 10 and 16). However, the four lines of evidence derived from this approach that the 2007 Study mainly relied upon to recommend the TP endpoint for the Wissahickon Creek were mostly from the Maryland studies, and, the PADEP-Penn State study was not used. Additionally, as indicated by the 2007 Study, the PADEP-Penn State Study showed that "surprisingly, the highest algal biomass occurred at sites where TP concentrations were relatively low (0.014–0.035 mg/L). It is possible that algal growth has been saturated even at this low level".

Comments: Relying upon data from nationwide studies of different ecoregions with different nutrient dynamics and different environmental factors is inappropriate in the development of the Wissahickon Creek TMDL. Explain why site specific studies were not used to set TP endpoint for the Wissahickon Creek. Specifically, since the only site specific study referenced by this approach indicated that algal growth will not be affected at TP concentrations even below the proposed TP endpoint of 0.04 mg/L, explain why such a TP endpoint was proposed in the development of the Wissahickon Creek TMDL.

d. In analyzing the algal biomass – nutrient relationship, the 2007 Study examined "all the metrics with TN and other nitrogen parameters" for the Northern Piedmont ecoregion, but, "did not find strong correlations with biological variables". As a result, the 2007 Study "considered Northern Piedmont streams as principally P-limited systems and focused on relationships with TP concentrations". However, the 2007 Study acknowledged that "not surprisingly, a strong algal biomass–nutrient relationship was not present in our examination of the datasets" and "it is possible that at some of the high nutrient concentration sites there was a light and flow limited accumulation of algal biomass" and that "elevated levels of algal biomass can exist at relatively low nutrient concentrations" (page 15).

Comments: As acknowledged in the 2012 Evaluation, that "N:P ratios in the Wissahickon ... calculated based on paired N and P data from 2005 ... suggesting that most sites in this watershed were relatively N limited". Explain why the 2007 Study relied on studies on relationships of TP and algal biomass in a P-limited ecoregion to set the TP endpoint for the Wissahickon Creek which is N-limited. Furthermore, explain why the 2007 Study did not consider other factors, such as light and flow, in the development of the Wissahickon Creek TMDL when the Study itself acknowledged that these factors possibly affected the algal biomass-nutrient relationship.

e. In deriving the first line of evidence under the Stressor-response approach, the 2007 Study relied on data from nationwide studies of Algal Metrics – Nutrient relationship. However, of the 11 algal metrics studies, the 2007 Study found that only "four nutrient based metrics were significantly related to TP concentrations," and, only one algal metric was used as a line of evidence to derive the TP endpoint (pages 16-19).

Comments: Provide support why algal metrics-nutrient relationships were used to derive the TP endpoint for the Wissahickon Creek when seven of the 11 algal metrics studied do not show any correlations with nutrient concentrations.

f. One of the 11 algal metrics studied, Diatom TSI, was used as a line of evidence to derive the TP endpoint. The correlation between Diatom TSI and TP was shown in Figure 5 using a linear regression model, with a correlation coefficient (R^2) of 0.22 and 0.35, for data from two types of samples, respectively (page 19).

Comments: The very low R^2 values showed high degrees of data scatteredness which indicated very poor nutrient-response relationships and incomplete description of large uncertainty. It essentially means that TP can only explain one third to one fourth of the variations in the data. These results indicate that variables other than TP have a greater impact on response variables, which further indicates that reducing TP may not have the desired effect of reducing Diatom TSI values. Therefore, this line of evidence is inappropriate to use in developing numerical nutrient criteria, and specifically, in the development of the Wissahickon Creek TMDL.

g. The remaining three lines of evidence under the Stressor-response approach were derived from data on Benthic Macroinvertebrate metrics in a Maryland study with samples obtained in the Northern Piedmont ecoregion. The Maryland study included six metrics; however, the 2007 Study only relied on three of them to derive the TP endpoint, acknowledging that "the other three metrics were either not sensitive to

nutrient enrichment or more sensitive to other stressors". The data was used in scatterplot relationships with a conditional probability analysis to derive the TP endpoints. These analyses recommended the TP endpoint should be in a range of 0.038 – 0.064 mg/L, with a probability of impairment at such TP levels estimated at approximately 50% (pages 18-22).

Comments: The SAB strongly criticized these types of statistical analyses in its 2010 Review, indicating that these types of analysis show very weak correlations that have high levels of uncertainty with widely varying data, and, demonstrate weak relationships. Explain why the SAB's advice and recommendations were not considered, and, provide support why such scatterplot regressions were used to derive numeric nutrient criteria for the Wissahickon Creek.

In summary, none of the four "lines of evidence" under the "Stressor-Response" (page 27) is appropriate to set the TP endpoint for the Wissahickon Creek or supports the proposed TP endpoint of 0.04 mg/L.

10. Regarding (iii) *literature based values* (ten lines of evidence were from this approach):

a. The 2007 Study included literature studies as additional lines of evidence to set the TP endpoint for the Wissahickon Creek. These literature studies included experimental and theoretical interests in the impact of nutrients in natural stream systems throughout the country, including studies "using artificial stream channels that are fully exposed to nutrient and light gradients to evaluate algal growth potential", studies based on "Chlorophyll a" levels, studies focused on inorganic phosphorus instead of total phosphorus, and studies based on reference approaches in different ecoregions. The data in these studies came from a broad area of the US, including mostly nationwide researches and regional studies in New England area, Virginia, New Jersey, and Delaware. Based on these literature studies, the recommended TP endpoint was 0.013-0.100 mg/L (pages 22-26).

Comments: These nationwide and regional studies relied on data from different ecoregions with different nutrient dynamics and other environmental factors. Indeed, the 2012 Study itself acknowledged that some of these literature data is "less applicable to Pennsylvania" (page 28). Therefore, these results are inappropriate to use in the determination of the TP endpoint for the Wissahickon Creek, and specifically, in the development of the Wissahickon Creek TMDL. Furthermore, as highlighted in the SAB's review, "Chlorophyll a" level is not an appropriate indicator of nutrient impairment in streams, as opposed to in lakes. Additionally, also as discussed in the SAB's review, "laboratory experiments are of limited use in validating causal relationships between nutrient and response variables ... the relationship is often not observed in data sets because other factors such as bottom substrate, turbidity, canopy cover, hydrology, or depth limit algal production". Therefore, relying on studies on "Chlorophyll a" or "using artificial stream channels" is not appropriate to determine the TP endpoint in the Wissahickon Creek and in the development of the Wissahickon Creek TMDL.

In summary, the vast majority of the 10 "lines of evidence" under the "Other Literature" (page 27) is not appropriate to set the TP endpoint for the Wissahickon Creek or supports the proposed TP endpoint of 0.04 mg/L.

11. Regarding TP Endpoint Recommendation:

a. The 2007 Study relied on a multiple-line, weight-of-evidence analysis from the above-mentioned three approaches to recommend the TP endpoint for all six watersheds in the southeastern PA ecoregion. A total of 17 lines of evidence were used from these approaches. The three lines from "Reference Approach" were weighted less as it "is less easy to link directly to use protection". The ten lines from "Scientific Literature" were variably weighted, since they included "data from regions proximate to Pennsylvania, as well as data less applicable to Pennsylvania." The four lines from "Stressor-Response Analyses" carried more weight as most of the data came from "comparable Piedmont streams in Maryland" (pages 26-30).

Comments: As discussed above, most, if not all, of the lines of evidence presented in Table 7 (page 27) are not appropriate to set the TP endpoint for the Wissahickon Creek. Further, the TP endpoints based on these lines of evidence span a range of multiple orders of magnitude (0.002-0.100 mg/L), which represents a significant degree of uncertainty and, therefore, does not support the theory of setting a single nutrient level to address the impairment of the Wissahickon Creek.

In summary, the recommendation of setting the TP endpoint at 0.04 mg/L is not supported by the 2007 Study and not appropriate for the Wissahickon Creek.

C. Specific Comments Regarding "*Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application, Follow-up Analysis (2012 Study)*"

The 2012 Study added to the 2007 Study in the determination of the TP endpoint for the Wissahickon Creek. Specifically, it used the same multiple-line, weight-of-evidence approach, and included three more lines of evidence under "Stressor-Response" approach, one more line under "Literature based values", and an additional line under a new "Mechanistic Model" approach.

12. The 2012 Study revisited the TP endpoint proposed in the 2007 Study with additional stressor-response analyses, following the EPA 2010 Guidance for conducting stressor-response analyses in nutrient criteria derivation.

Comments: As discussed above, the SAB strongly criticized the EPA 2009 Draft Guidance which the 2010 Guidance was based upon, largely without addressing the critical issues raised in the 2010 Review. Explain why the SAB's advice and recommendations were not followed in revising the stressor-response approach to develop nutrient criteria.

13. The 2012 Study indicated that "primary elements relevant to the current analysis" included "urban point and non-point pollutant sources generating nutrient stressors" (Figure 3, page 4). Further, the 2012 Study acknowledged that "there was substantial evidence that, in this ecoregion, urbanization was associated with several stressors including nutrients and TP,

consistent with the conceptual model. This is likely due to both point and non-point TP sources that have been demonstrated to deliver this particular pollutant" (page 9).

Comments: The 2012 Study suggested that "an essential insight from the causal model in Figure 3 is the identification of alternate potential stressors that co-vary with nutrients such as flow, sediment, and toxics data" (page 3). The 2012 Study further suggested that these alternate potential stressors "should be evaluated for their potential to confound results ... their co-occurrence with nutrient stressors could interfere with the nutrient response and this needs to be evaluated to the extent possible" (page 3). Yet, "Agricultural Nonpoint Sources", one of the three alternate stressors shown on the top of the Figure 3, was not mentioned in the discussion. Explain why "Agricultural Nonpoint Sources" is not included in the evaluation of the conceptual model of the causal relationship between nutrients and responses, specifically, why its potential interference with the nutrient response was not evaluated in the development of the Wissahickon Creek TMDL.

14. The 2012 Study largely relied on data from Maryland Biological Stream Survey to revise the TP endpoint proposed in the 2007 Study "since this was the most substantial dataset available for the Piedmont ecoregion" (page 4). The 2012 Study further indicated that "the ultimate goal of this analysis was to strengthen the defensibility of TP threshold concentrations developed to protect aquatic life in Piedmont streams for the purposes of TMDL modeling" (page 9).

Comments: As discussed above, it is not appropriate to use data from studies in other parts of the Piedmont ecoregion to derive nutrient criteria in the Wissahickon Creek; rather, site specific studies should be used in the development of the Wissahickon Creek TMDL.

15. The 2012 Study acknowledged that "there are several variables that contribute to predicting invertebrate declines in the Piedmont, but TP is defensibly one of them" (page 7).

Comments: Explain what these other variables are and why they are not considered in the determination of nutrient endpoints for the Wissahickon Creek.

16. The 2012 Study included three additional lines of evidence under "Stressor-Response" approach, by analyzing the relationship between TP concentrations and several biological metrics using data from the Maryland Study. The data was presented in a scatterplot graphs and the relationship between TP and biological metrics was analyzed using simple linear regression method. The target TP endpoint ranges were then interpolated as between the lower 25^{th} and 50^{th} percentile intervals, using a threshold value for each metrics to represent the adverse response condition (Figures 7-12, Table 7, pages 12-19).

Comments: The SAB strongly criticized these types of statistical analyses in its 2010 Review, indicating that these analyses show very weak correlations that have high levels of uncertainty with widely varying data, and, demonstrate weak relationships. Indeed, the three additional lines of evidences summarized on page 24 under "Stressor-Response" were derived using a simple linear regression method with extremely low correlation coefficients (R^2 values of 0.084, 0.105, and 0.137, respectively) and large degrees of uncertainties (TP endpoint ranges of 0.010-0.085, 0.008-0.082, and 0.008-0.052 mg/L, respectively). This essentially means that TP can only explain approximately 8% to 14% of the variations in the biological metrics data. These results indicate that factors other than TP have a greater impact on these response

metrics. Therefore, relying on these methods to derive numeric nutrient criteria is not appropriate, and, the proposed target TP endpoint for the Wissahickon Creek is not supported.

17. The 2012 Study also included data from USGS studies conducted between 1981 to 1997 on selected streams in Chester County, PA, to validate the model linking invertebrate response to nutrients and to support the proposed TP endpoint of 0.04 mg/L. The data was presented in a wedge shaped plot, in which the 2012 Study indicated that "invertebrate richness decreases with increasing nutrient concentrations and that this general decline begins at approximately 0.03-0.04 mg/L" (Figure 13, pages 19-20).

Comments: Using outdated data from studies in different areas of the ecoregion is not appropriate in the development of the Wissahickon Creek TMDL as the data does not represent the current conditions and nutrient dynamics in the Wissahickon Creek. Additionally, the wedge shaped plot shows very weak correlations with a high level of uncertainty, and, is not appropriate to derive numeric nutrient criteria. As shown in Figure 13, the "outer decline" in values for the USGS dataset did not begin until at a TP concentration greater than 0.3 mg/L, an order of magnitude greater than the proposed TP endpoint for the Wissahickon Creek. Therefore, the proposed TP endpoint of 0.04 mg/L is not supported by this "validation" and is not appropriate for the Wissahickon Creek.

18. The 2012 Study included data from a study in Indian Creek, PA, as an additional line of evidence to support the proposed TP endpoint. The Indian Creek study used computer models to evaluate the relationship between TP concentrations and benthic "Chlorophyll a". The Indian Creek study considered the loadings of nitrogen and phosphorus from both point sources and non-point sources; however, the non-point source loading was simulated by computer models instead. The models were not calibrated using benthic "Chlorophyll a" data as it was not available. The Indian Creek study indicated that at an average TP concentration between 0.020-0.033 mg/L the "Chlorophyll a" levels are predicted to be below a desired threshold (pages 20-22).

Comments: It is not appropriate to use data from studies in other parts of the Piedmont ecoregion to derive nutrient criteria in the Wissahickon Creek; rather, site specific studies should be used in the development of the Wissahickon Creek TMDL. Additionally, as discussed above, "Chlorophyll a" level is not an appropriate indicator of nutrient impairment in streams, as opposed to in lakes. Furthermore, the proposed TP endpoint of 0.04 mg/L for the Wissahickon Creek is not supported by the Indian Creek study which suggested TP concentrations as low as one half of the proposed TP endpoint.

19. The 2012 Study included another literature value as an additional line of evidence to support the proposed TP endpoint. The additional literature value was from "an analysis of national nutrient data" (page 23). The 2012 Study used "the 75th percentile TP concentration" of 0.060 mg/L "in reference streams from the comparable nutrient ecoregion to the PA Piedmont" as a support to the proposed TP endpoint (page 23).

Comments: Nationwide studies relied on data from different ecoregions with different nutrient dynamics and other environmental factors. Therefore, these results are inappropriate to use in the determination of the TP endpoint for the Wissahickon Creek, and specifically, in the development of the Wissahickon Creek TMDL.

20. The 2012 Study concluded that since the "range of endpoints" derived with the new stressor-response analyses "included the recommended endpoint" in the original report and the other two new lines of evidence recommended "comparable values" to the original TP endpoint, the proposed TP endpoint of 0.04 mg/L in the 2007 Study remained unaltered.

Comments: As discussed above, none of the additional lines of evidence presented in the 2012 Study (page 24) is appropriate to set nutrient criteria or support the proposed TP endpoint for the Wissahickon Creek. Additionally, the "range of endpoints" derived with the "new stressor-response analyses" in the 2012 Study indicated a much wider range and more uncertainty in the "Stressor-Response" approach than it did in the 2007 Study, further echoing the SAB's criticism in the 2010 Review that such method is not appropriate to develop nutrient criteria.

In summary, the recommendation of setting the TP endpoint at 0.04 mg/L is not supported by the additional lines of evidence in the 2012 Study and not appropriate for the Wissahickon Creek.

D. Specific Comments Regarding "*Evaluation of Nutrients as a Stressor of Aquatic Life in Wissahickon Creek, PA (2012 Evaluation)*":

21. The objective of the 2012 Evaluation is to evaluate support for the basis that nutrients are a stressor on the condition of aquatic life in the Wissahickon Creek. The 2012 Evaluation was based on EPA Stressor Identification Guidance (2000a), and evaluated the strength of evidence of nutrients as "a single stressor" (page 6).

Comments: As discussed above, the SAB strongly criticized the 2009 Draft Guidance in its 2010 Review, and provided useful recommendations for the revision of the 2009 Draft Guidance. Explain why the SAB's advice and recommendations were not followed in revising the stressor-response approach to develop nutrient criteria. Specifically, why were these advice and recommendations not considered in the development of the Wissahickon Creek TMDL?

Furthermore, provide support why it is appropriate in using nutrient as "a single stressor" to evaluate the environmental impact on aquatic life conditions in the Wissahickon Creek, especially given the SAB's criticisms on its use.

22. The 2012 Evaluation proposed a conceptual model to examine the effect of nutrients on the invertebrate assemblage in the Wissahickon Creek, which it presumed to be an indicator for the impairment impact on aquatic life use in Wissahickon Creek (page 6).

Comments: Provide support showing how invertebrate assemblage is directly related to Clean Water Act goals in the Wissahickon Creek, and, how the effect of nutrients on the invertebrate assemblage is appropriate and useful in proving the biological causal linkage of the impairment in the Wissahickon Creek.

23. The 2012 Evaluation acknowledged that "primary producer response can be limited by light, flow, and substrate. Where the stream is shaded from riparian canopy, primary production may be light limited and therefore show limited response to nutrient enrichment," and, "these modifying factors are important in interpreting causal-response data" (page 9).

Comments: Given the above statement, explain why these modifying factors, such as shading from stream canopy, are not considered or evaluated in deriving numeric nutrient criteria. Specifically, why were these factors not considered in the development of the Wissahickon Creek TMDL?

24. The 2012 Evaluation acknowledged that "N:P ratios in the Wissahickon … calculated based on paired N and P data from 2005 … suggesting that most sites in this watershed were relatively N limited, in contrast to reference sites" in the Piedmont region, or "the Wissahickon exhibits greater relative P enrichment". Also, these "ratios ... have reduced applicability in interring true limitation since it is unlikely … either N or P are limiting primary producer growth" (pages 14-15).

Comments: Since site specific data has indicated that the Wissahickon Creek is actually nitrogen (N) limited, unlike other areas in the Piedmont region or the reference sites which are phosphorus (P) limited, it is therefore inappropriate to use data obtained from these sites to derive numeric nutrient criteria for the Wissahickon Creek. Additionally, the "reference approach" used in the 2007 Study to derive numeric nutrient criteria in the six watersheds in southeastern PA is also inappropriate because the assumption that "nutrient dynamic in the six watersheds should be similar to nutrient dynamic in this portion of the Northern Piedmont ecoregion" is invalid.

25. The 2012 Evaluation suggested that data obtained in 2005 from the Wissahickon Creek indicated elevated "Chlorophyll a" levels in the Wissahickon Creek, which was used as a surrogate for increased algal/plant biomass, at locations pursuant or coincident with elevated nutrients (pages 17-19).

Comments: The information referenced by the 2012 Evaluation included data that was obtained from only four sites along the Wissahickon Creek in 2005 and some data obtained from 1998. Therefore, the data does not represent the current conditions in the Wissahickon Creek as it is outdated.

Furthermore, as pointed out in the SAB's review, "Chlorophyll a" level is not an appropriate indicator of nutrient impairment in streams, as opposed to in lakes. Additionally, no biological causal linkage is provided between nutrient levels and Chlorophyll a levels, and, no analysis of the complex stressor-response relationship in streams that is influenced by many factors such is shading is performed in the 2012 Evaluation. Therefore, this "verification of the evidence" is invalid.

26. The 2012 Evaluation presented evidence that "altered plant /algal assemblage structure" is pursuant or coincident with elevated nutrients (pages 19-20).

Comments: The data referenced by the 2012 Evaluation was mostly obtained in 1998. Some limited data obtained in 2005 was also used. However, the data obtained from 2005 also indicated that the plant/algal assemblage structure has changed over the period of time from 1998 to 2005, and the dominant taxa in 2005 were not the same as in 1998. Therefore, the data does not represent the current conditions in the Wissahickon Creek because it is limited and outdated, and, cannot verify the "evidence" as stated.

27. The 2012 Evaluation presented evidence that "altered DO dynamics" is pursuant or coincident with elevated nutrients (pages 20-23).

Comments: The 2012 Evaluation referenced DO data measured at two sites in 2005, one with relatively low nutrients and one with much higher nutrients (both N and P). However, no analysis was performed in the 2012 Evaluation to ascertain the relationship between DO dynamics and any single nutrient level.

Moreover, as shown in Figure 7, the site with lower nutrients exhibited the highest DO diel maxima (around and after 10/25/2005), much higher than those exhibited by the site with much higher nutrients. This indicates that nutrients alone do not contribute to the altered DO dynamics.

This is further demonstrated by Figure 8: "TP seasonal averages vs. Daily Minimum DO seasonal 10^{th} percentile". The relationship showed a poor correlation coefficient ($R^2 = 0.33$), which essentially means that only one third of the variation in the data can be explained by TP. Therefore, this data does not support the theory that a single nutrient endpoint for TP will alleviate DO problems in the Wissahickon Creek, and, cannot verify the "evidence" as stated.

28. In searching for evidence that "altered pH" is pursuant or coincident with elevated algal/plant biomass, the 2012 Evaluation acknowledged that "the Wissahickon appears to be a well buffered system as pH ranges were not large (essentially all under 1.5 pH units) … there was insufficient paired periphyton algal biomass and water chemistry data to relate to pH measurements directly" (page 24).

Comments: No data was presented to support the linkage or correlation between altered pH and elevated algal/plant biomass. Without meaningful statistical analysis of data to confirm the correlation, this evidence is invalid and does not support the proposed causal model.

29. The 2012 Evaluation presented evidence that "altered invertebrate assemblage composition" is pursuant or coincident with several other factors (pages 24-27).

Comments: The 2012 Evaluation acknowledged that "there was little expectation that a clear signal with these specific endpoints would manifest itself in the invertebrate assemblage ... the data set was sparse and a variety of confounding factors limited an unequivocal demonstration".

Furthermore, as shown in Figure 9, both correlations between "Total Richness" and "Hilsenhoff Biotic Index" with "Chlorophyll a" exhibited very poor regression and correlation coefficients ($p=0.0763$ and 0.138, $R^2=0.156$ and 0.112, respectively), which essentially means that these correlations showed very weak statistical significance and "Chlorophyll a" could only explain about 10-15% of the variation in data presented. Also, as discussed earlier, "Chlorophyll a" levels are not an appropriate indicator of nutrient impairment in streams, as opposed to in lakes. Additionally, no biological causal linkage is provided between nutrient levels and "Chlorophyll a" levels, and, no analysis of the complex stressor-response relationship in streams that is influenced by many factors, such is shading, is performed in the 2012 Evaluation. Therefore, this "verification of the evidence" is invalid.

Similarly, in Figure 10: "Hilsenhoff Biotic Index vs. Daily Average pH", the relationship again showed a poor correlation coefficient ($R^2 = 0.33$), which essentially means that only one third of the variation in the data can be explained by pH. Therefore, this data does not support the "evidence" as stated.

30. In summary, the 2012 Evaluation indicated that 6 of the 8 predictions from the causal model were substantially supported, and that there should be high confidence that nutrients are contributing to biological impacts in the stream (pages 28-31).

Comments: As discussed above, these predictions from the causal model were either invalid or cannot be verified by the data presented. They either lack sufficient and relevant data to demonstrate the proposed correlation, or show very poor correlation between the factors in question to explain the variation in data sufficiently. Therefore, the conclusion in the 2012 Evaluation that "there should be high confidence that nutrients are contributing to biological impacts in the stream" is not supported.

List of Additional Literature References

In addition to the Draft Wissahickon Creek TMDL, including the appendices and attachments, and the literature references contained therein, the following additional literature articles were reviewed and referenced in the preparation of the comments.

1. Dodds, W.K. and E.B. Welch. Establishing nutrient criteria in streams. J. North Am. Benthol. Soc. 19:186-196. 2000.

2. Dodds, W.K., V.H. Smith, and K. Lohman. Erratum: Nitrogen and phosphorus relationships to benthic algal biomass in temperate streams. Canadian Journal of Fisheries and Aquatic Sciences 63:1190-1191. 2006.

3. Dodds, W.K., V.H. Smith, and K. Lohman. Nitrogen and phosphorus relationships to benthic algal biomass in temperate streams. Canadian Journal of Fisheries and Aquatic Sciences 59:865-871. 2002.

4. Florida DEP. Overview of EPA's Proposed Numeric Nutrient Criteria for Lakes and Flowing Water. February 2, 2010.

5. Fumero, John. Numeric Nutrient Criteria in Florida - An Overview. March 23, 2012

6. Linkov, I., D. Loney, S. Cormier, F.K. Satterstrom, and T. Bridges. Weight-of-evidence evaluation in environmental assessment: Review of qualitative and quantitative approaches. Science of the Total Environment 401:5199-5205. 2009

7. Maryland Department of Natural Resources. New Biological Indicators to Better Assess the Condition of Maryland Streams. CBWP-MANTA-EQ-05-13. 2005

8. Pennsylvania Department of Environmental Protection. A Benthic Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in PA. 2009.

9. USEPA Science Advisory Board Nutrient Criteria Review Panel. Meeting Minutes. Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters. December 13-14, 2010.

10. USEPA Science Advisory Board Nutrient Criteria Review Panel. Summary Points for the Executive Summary. Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters. February 1, 2011.

11. USEPA Science Advisory Board. SAB Review of Empirical Approaches for Nutrient Criteria Derivation. SAB-10-006. April 27, 2010. Meeting Minutes, March 24, 2010, Attachments A-G.

12. USEPA. EPA's Approval of Florida's Numeric Nutrient Criteria Rules. 820-F-12-054. November 2012.

13. USEPA. Guidance on the Development, Evaluation, and Application of Environmental Models. 100-K-09-003. 2009a.

14. USEPA. Numeric Nutrient Criteria for the State of Florida: Withdrawing the Federal Actions. 820-F-14-006. September 2014.

15. USEPA. Nutrient criteria technical guidance manual. Estuarine and Coastal Marine Waters. 822-R-07-004. 2007.

16. USEPA. Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters. 822-B-01-003. 2001.

17. USEPA. Nutrient Criteria Technical Guidance Manual: Wetlands. 822-B-08-003. 2008.

18. USEPA. Stressor Identification Guidance Document. 822-B-00-025. 2000c.

19. USEPA. The Wadeable Streams Assessment: A collaborative survey of the nation's streams. 841-B-06-002. 2006.

20. USEPA. Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria. 820-S-10-001. November 2010.

21. USEPA. Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions. March 16, 2011.

22. Weed, D.L., Weight-of-evidence: A review of concept and methods. Risk Analysis 25:1545-57. 2005

23. Wickwire, T. and C.A. Menzie. The causal analysis framework: Refining approaches and expanding multidisciplinary applications. Human and Ecological Risk Assessment. 2010.