UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

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July 19, 2011

EPA-SAB-11-010

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Review of EPA's draft Approaches for Deriving Numeric Nutrient Criteria for Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters

Dear Administrator Jackson:

Nitrogen and phosphorus inputs from urban and agricultural sources are known to impact water quality, and nutrient pollution has been identified as a source of impairment for estuarine, marine and fresh waters in Florida. In 2009, the EPA determined that numeric nutrient criteria were needed to protect aquatic life in Florida, and initiated a process to develop such criteria for categories of state waters. As part of that process, the Agency developed a draft document, *Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters.* The EPA document proposes a conceptual model for relating nutrient levels to biological endpoints, and describes data sources and possible approaches to define criteria for each of the categories of waters: estuaries, coastal waters, inland flowing waters (including canals) in South Florida, and South Florida marine waters. The Science Advisory Board (SAB) was asked to review and provide advice on the draft EPA document and an *ad ho*c SAB panel, the Nutrient Criteria Review Panel, was formed for this task.

The SAB acknowledges the substantial effort that already has been made by EPA to get the work to this stage, much of it solid and thoughtful. However, much work remains to be done to develop nutrient criteria for Florida waters (for example, to develop and validate models for over 20 Florida estuaries). Given the extent of the task at hand, the SAB has attempted to prioritize its recommendations and to emphasize a role for future refinements of criteria in the spirit of adaptive management.

To guide its development of nutrient criteria, the EPA proposes a conceptual model that links nitrogen and phosphorus levels in Florida waters to biological endpoints to be protected using one or more analytical approaches. Nitrogen and phosphorus may be limiting in different portions of the fresh-to-marine continuum, and in some cases may be co-limiting. Thus, a dual nutrient (N and P) strategy is warranted, and we agree with the Agency's decision to take this approach. Although the general conceptual model provides a starting point for choosing numeric criteria, the SAB has numerous concerns about how the driver variables—total nitrogen (TN) and total phosphorus (TP)—would be linked to measurable biological endpoints. The SAB recommends that the EPA provide a more detailed conceptual model that includes additional endpoints and flows, and suggests that system-specific diagrams be included for each of the four waterbody types.

The EPA is proposing three general approaches to relate nutrient levels to balanced natural populations: (1) reference conditions; (2) predictive stressor-response relationships; and/or (3) numerical water quality models. The SAB noted the uneven treatment of the three approaches (i.e., the emphasis on water quality modeling), and encourages the EPA to continue to develop all three. The SAB agrees that these approaches all have utility and recommends that a combination be used where data and models are available. However, the Agency should provide more detail on the adequacy of the data for applying each approach; how decisions would be made on which approaches to use; and how discrepencies in targets derived from different approaches would be resolved. Although a complete uncertainty analysis may not be feasible, the document should clearly indicate what is included in any uncertainty analysis undertaken or contemplated. In particular, the EPA may need to specify some probabilistic goals for meeting the specified nutrient criteria and then set thresholds for nitrogen and phosphorus loading accordingly, to ensure that the criteria are met with a desired level of confidence.

The proposed biological endpoints (healthy seagrasses, balanced phytoplankton biomass, and balanced faunal communities) are appropriate, but it is critical that the EPA define "balanced" for each of these endpoints, preferably in quantitative terms. The SAB agrees with the Agency's broad delineation of Florida coastal waters into four categories (estuaries, coastal waters, South Florida inland waters, and South Florida estuarine and coastal waters) for purposes of criteria development, but suggests some refinements to segmentation within the categories. The EPA also proposes to use downstream protection value (DPV) criteria to ensure that upstream nutrient criteria will be set at levels that will protect downstream estuaries. While agreeing with the goal of downstream protection from nutrient impacts, the SAB has concern with the overlap between DPV and the Total Maximum Daily Load (TMDL) process.

In the enclosed report, the SAB provides numerous recommendations to strengthen the application of the three approaches to develop numeric nutrient criteria for Florida waters. However, given the Agency's time frame, the SAB offers the following priority recommendations:

- To provide greater confidence in the criteria, a combination of approaches should be used to develop numeric nutrient criteria for each category of waters where data and models are available.
- For estuaries, the SAB recommends that the EPA adopt additional measures of seagrass health beyond the proposed use of chlorophyll-*a*, and encourages the use of direct measures of the faunal communities to be protected, rather than relying on a dissolved oxygen criterion.
- For coastal waters, the SAB agrees that a criterion based on satellite-derived estimates of chlorophyll may be the only feasible approach for this large, poorly sampled region. However, the SAB recommends that the Agency expand the dataset to include waters farther than three miles offshore and verify the strength of the relationship between pollutant loads from land and observed chlorophyll-*a* concentrations using direct measurements of nutrients, where possible.
- For South Florida inland waters, the SAB was not convinced by the available data that nutrient criteria based on instream protection values were meaningful for man-made and managed canals. The canals do provide ecosystem services, but habitat quality and flows—rather than nutrients—have the greatest influence on biological condition in these managed waterways. The SAB does agree that nutrients in canal waters should be managed to ensure downstream, estuarine designated uses.
- For South Florida coastal and estuarine waters, the SAB recommends that seagrass endpoints be considered in addition to chlorophyll-*a*.

- If the DPV approach is pursued, the SAB recommends that apportionment strategies not preclude flexible nutrient allocation across tributaries to achieve the necessary estuarine load reductions.

In closing, the SAB encourages the EPA to continue efforts to develop numeric nutrient criteria for Florida estuarine and coastal waters, using the best available scientific data and methods. Ongoing changes in regional hydrology and climate, which will alter freshwater flows (and thereby, nutrient concentrations) and ecological responses, make it important that these nutrient criteria be revisited periodically in an adaptive management approach. We appreciate the opportunity to provide advice on this important endeavor, and look forward to your response.

Sincerely,

/signed/ ***/signed/***

Dr. Deborah L. Swackhamer, Chair
Science Advisory Board

Dr. Judith L. Meyer, Chair
SAB Nutrient Criteria Review Panel

Enclosure

NOTICE

U.S. Environmental Protection Agency
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Nutrient Criteria Review Panel

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Table of Contents

1. EXECUTIVE SUMMARY

Nitrogen (N) and phosphorus (P) inputs from urban and agricultural sources are known to influence water quality, and nutrient pollution has been identified as a source of impairment for estuarine, marine and fresh waters in Florida. The state of Florida has a narrative criterion for nutrients, which states that "in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of flora or fauna." The criterion specifically refers to degradation from anthropogenic loads of total nitrogen (TN) or total phosphorus (TP). In 2009, EPA determined that numeric nutrient criteria were needed to protect aquatic life in Florida, and initiated a process to develop such criteria for categories of state waters.

The SAB was asked to review and provide advice on the proposed approaches for estuarine, coastal and South Florida waters, as described in the draft EPA document, *Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters.* An *ad hoc* SAB panel, the Nutrient Criteria Review Panel, was formed for this task. The Charge to the SAB included questions about the conceptual model used to select assessment endpoints, data sources, and possible approaches to define criteria for each of the categories of waters: estuaries, coastal waters, inland flowing waters (including canals) in South Florida, and South Florida marine waters.

The SAB acknowledges the substantial effort that already has been made by EPA to get the work to this stage, much of it solid and thoughtful. However, much work remains to be done. It is not clear what approaches will be selected, if multiple approaches will be used, and which approaches will provide useful information towards the goal of developing nutrient criteria. Under a court-ordered consent decree, the Agency has committed to proposing nutrient criteria for estuaries, coastal waters, and South Florida inland flowing and marine waters by November 14, 2011 and final criteria by August 14, 2012. Given this time frame, and the extent of the task at hand, the SAB has attempted to prioritize its recommendations and to emphasize a role for future refinements of criteria in the spirit of adaptive management.

Different approaches are being considered for each of four major categories of Florida waters. Consistent with the Charge to the SAB, the SAB provides review and advice on the proposed approaches for developing nutrient criteria for each category of waters.

Conceptual Model (Charge Question 1a)

EPA proposes a conceptual model that links nitrogen and phosphorus levels in Florida waters to biological endpoints to be protected, using one or more analytical approaches. Although the general conceptual model provides a starting point for choosing numeric criteria, the SAB has numerous concerns about how TN and TP would be linked to measurable biological endpoints. The SAB recommends that the EPA provide a more detailed conceptual model that includes additional endpoints and flows, and suggests that system-specific diagrams be included for each of the four waterbody types. TN and TP should be considered driver (rather than causal) variables because nitrogen and phosphorus are two factors that regulate primary production but they do not "cause" it. The conceptual model should acknowledge that there are many factors other than nutrients that control water column chlorophyll (Chl-*a*). TN and TP loadings are likely to be better predictors of Chl-*a*, hypoxia and seagrass loss than TN or TP concentrations. TN and TP concentrations also can be considered response variables in that they reflect long-term loading rates; the temporal and spatial scales over which they would be measured should be clarified.

The conceptual diagram is a representation of important linkages, but Biological Endpoints and Objectives are not discussed in sufficient detail. The three biological endpoints (healthy seagrasses, balanced phytoplankton biomass, and balanced faunal communities) are appropriate. However, these endpoints need to be much better defined and, in some cases, more clearly connected to the explanatory variables that would be the basis for setting numeric criteria. It is critical that EPA define "balanced" for each of the three biological endpoints, preferably in quantitative terms. Simply relying on the state's assessment of whether or not waters are "healthy" is not an adequate definition.

EPA proposes to identify levels of water quality variables that would protect the biological endpoints using reference condition, stressor-response, and/or modeling approaches for a particular water body. The SAB strongly recommends that multiple approaches be applied to each of the systems where data and models are available. The EPA document should discuss how the results from multiple approaches would be integrated to develop the final numeric criteria. The three analytical approaches are being applied somewhat differently within the different categories of Florida waters, and each approach has different data requirements and—more importantly—different assumptions, limitations and uncertainties. EPA should describe the uncertainty associated with the various approaches to criteria development and discuss how this uncertainty might influence the use and appropriateness of specific numeric criteria.

The SAB agrees that Chl-*a* concentration in the water column is both sensitive to nutrient inputs and an important measure of ecosystem health and therefore a reasonable endpoint in itself. However, the EPA document should be explicit that Chl-*a* measures phytoplankton biomass and cannot be used to infer anything about primary productivity or whether or not phytoplankton populations are "balanced" in terms of species composition or relative abundance/dominance. Water column Chl-*a* also is linked to seagrass health because it is an indirect measure of water clarity, which influences seagrass photosynthesis. However, the SAB is concerned about relying upon Chl-*a* as the sole criterion to protect seagrasses because, in some systems, macroalgae or epiphyte growth can significantly impact seagrass communities even as water column Chl-*a* levels remain low. Thus, the SAB recommends that EPA use a stressor-response approach to link nutrient loading with seagrass areal extent for protecting seagrass communities.

The SAB is concerned that no direct measures of the faunal community are proposed to define whether a balanced community is being protected and maintained. Instead, EPA proposes to rely on attainment of the State of Florida dissolved oxygen (DO) standard as an indicator for the presence of balanced faunal communities. EPA proposes to look for relationships between TN and/or TP and DO, and use those relationships to determine numeric criteria for TN and TP that are protective. The SAB recommends that faunal metrics be considered to evaluate the estuarine endpoint of balanced faunal communities.

General Delineation of Florida Waters (Charge Question 1b)

In the document, EPA proposes an initial grouping of Florida waters into four categories: estuaries, coastal waters, South Florida inland flowing waters, and South Florida marine waters. Separation of estuarine and coastal waters is appropriate, and the separate consideration of South Florida also is warranted. The SAB recommends that the term "marine waters" be replaced with "estuarine and coastal waters." Further, South Florida inland flowing waters appears to be a default category without strong scientific rationale for this classification; for purposes of criteria development, these waters should be subdivided into managed canals and natural streams. Additional comments are provided on sub-delineation and classification within the four broad categories of waters, below.

Florida Estuaries

Delineation and Data (Charge Question 2a). The geographic delineations of estuaries seem appropriate although it was not clear why a salinity of 2.7 psu rather than 0.5 psu was used to delineate the upper reaches of these systems. A finer classification based on degree of impact may be useful (e.g., to separate Caloosahatchee and St. Lucie estuaries from the others given their unique hydrologic relationship to Lake Okeechobee). EPA should consider adding tidal creeks as a separate ecosystem type because they have different characteristics than the open estuaries and therefore may require different nutrient criteria. The SAB has few issues with the data sets presented and has provided suggestions for additional sources of data.

Assessment Endpoints (Charge Question 2b). Healthy seagrass communities are an appropriate biological endpoint for Florida estuaries, given their widespread occurrence and ecological (and economic) significance. To protect seagrass communities, EPA should consider a measure of epiphyte abundance in addition to the proposed determination of Chl-a in the water column. Whether Chl-a is an appropriate endpoint for assessing "balanced" phytoplankton communities, depends on how EPA defines "balanced", which has not been done. Direct indicators of faunal community balance should be considered in addition to DO. When hypoxic conditions are observed, impacts on the biota usually have already occurred. Therefore, it is preferable to identify indicators that show stress on the faunal community before such degraded conditions develop. Diel variability in DO needs to be considered when establishing DO water quality targets. DO criteria may be better characterized by percent saturation than by concentration.

Approaches (Charge Question 2c). N and P may be limiting in different portions of the fresh-to-marine continuum, and in some cases may be co-limiting. Thus, a dual nutrient (N and P) strategy is warranted and the SAB agrees with the EPA's decision to take this approach. The SAB acknowledges the substantial effort made to date to collect data and evaluate possible approaches to criteria development for these waters, but is concerned about the timetable for completion of this work. Previous experience suggests that if the reference condition approach can be implemented, it might be the most "time-efficient" pathway to developing nutrient criteria, although the stressor-response approach is worthy of more attention than it has been given. The SAB is aware of a separate EPA report on stressor-response approaches, but would have preferred additional discussion in the present document on how such approaches might be applied in Florida's estuaries. The SAB urges caution in EPA's apparent emphasis on water quality modeling approaches because development and validation of simulation models for numerous estuaries to establish nutrient criteria would be a major undertaking, requiring considerable time and money, and useful results are not guaranteed; for waters where this approach is selected, a reasonable representation of internal nutrient cycling needs to be included.

In light of climate-related effects on hydrology and temperature regimes, as well as increases in freshwater withdrawals for human use, the SAB recommends that the EPA consider the possibility that thresholds could be crossed, fundamentally changing these systems. In a spirit of adaptive management, the SAB recommends that future refinements to proposed nutrient criteria for Florida estuarine, coastal and marine waters explicitly consider the impact of changing hydrology and climate on the numeric criteria needed to ensure the protection of designated uses.

Florida Coastal Waters

Delineation and data sources (Charge Question 3a). EPA proposes to use remotely sensed chlorophyll (Chl_{RS}-*a*) to develop a reference criterion associated with a balanced phytoplankton population in coastal waters. The approach is appropriate and sensible for this large, poorly sampled region, although the SAB recommends that direct measurements of nutrients, where available, be used to verify the strength of the relationship between pollutant loads from land and observed Chl-*a* concentrations in coastal waters. EPA proposes to use chlorophyll data from coastal waters out to three miles. However, under the Clean Water Act, water quality criteria apply to state coastal waters, defined for Florida as waters out to three nautical miles on the Atlantic coast and nine nautical miles on the Gulf coast. In developing coastal criteria, the SAB recommends that EPA consider remote-sensed chlorophyll in waters beyond the three-mile zone because some blooms observed in coastal waters may form further offshore. In addition, data from the entire shelf should be used to improve the calibration of remotely sensed and field-measured (*in situ*) chlorophyll. The SAB further notes that the proposed coastal segments are a result of historical precedence, and EPA may wish to consider segments defined in terms of bathymetry.

Assessment Endpoints (Charge Question 3b). While acknowledging that Chl_{RS}-*a* is the most feasible indicator of nutrient status for coastal waters, given available data and the lack of a better alternative, the SAB has several concerns: (1) there is a causal relationship between Chl_{RS}-*a* and nutrient loads but a number of other factors also influence Chl_{RS}-*a* levels; (2) few *in situ* Chl-*a* data are available for calibration; (3) the ten-year remote-sensing dataset may not constitute an adequate baseline, given decadal-scale variability; and (4) the future availability of Chl_{RS}-*a* data is in doubt, particularly given the loss of the SeaWiFS sensor.

Approaches (Charge Question 3c). The SAB agrees that the reference condition approach for coastal waters using remotely sensed Chl-*a* is an appropriate application of remote sensing data, with certain caveats. In order to relate remotely sensed chlorophyll to water column chlorophyll levels, it is necessary to calibrate satellite sensor readings using field-measured chlorophyll data. The approach to calibration has been thorough, and the SAB agrees with use of *in situ* calibration data taken within 3 hours of the satellite overpass. The ratio between the chlorophyll concentrations in the upper two meters and the full euphotic zone needs to be established, and obvious antecedent bloom data points should be removed from analyses. Because available satellite-based sensors will change over time, as some platforms are retired and others are launched, the SAB recommends that EPA cross-calibrate data from existing sensors with future sensors as they become available.

South Florida Inland Flowing Waters

Rationale for Criteria (Charge Question 4). For purposes of nutrient criteria development, the SAB recommends that EPA subdivide South Florida inland flowing waters into human-managed canals vs. natural flowing streams. Canals would be viewed as a source of nutrients to downstream, more oligotrophic, systems and canal nutrient criteria would be in the form of DPV. Depending on data availability, criteria could be developed for natural flowing streams as instream protection values (IPV).

Delineation and Data Sources (Charge Question 4a). EPA proposes to derive numeric criteria for South Florida inland flowing waters, including canals, as instream protection values (IPV) for TN and TP using the reference condition approach. Canals apparently account for approximately 90 percent of waters in this category. This extensive network of canals provides ecosystem services but these services are controlled primarily by hydrology and habitat quality rather than nutrient levels. The SAB is not convinced from the material provided that IPV nutrient criteria are appropriate for these uniquely artificial and highly managed ecosystems. The underlying problem is that the canals are classified as Class III waters (with a designated use of recreation and balanced population of fish and wildlife), although their primary purpose is flood control and management of water supply. The proposed inventory of inland flowing waters that catalogues and distinguishes natural streams and canals should provide very useful information, and could provide the basis for subdividing this category of waters as recommended above.

EPA is considering use of the Landscape Development Index (LDI) as an approach to identify areas with reference conditions. The LDI is a surrogate for stressors, including TN and TP loads, associated with various land uses. The 100-m stream/canal buffers proposed for use with the LDI may be too limited, and may not capture impacts from land uses in the full watershed. The proposed classification appears reasonable as it incorporates surface and subsurface flow regimes, soil types and land use; however legacy N and P loads from previous land management practices also must be considered. The SAB recommends that the LDI not be used for canals.

Assessment Endpoints (Charge Question 4b). If canal IPVs are to be developed, more information needs to be presented on how balanced natural populations would be assessed for these unique aquatic ecosystems. The SAB recommends further consideration and assessment of the response variables to be used and the form of the nutrients (i.e., those with short-term versus long-term bioavailability) that are most relevant. It was not clear that sufficient data are available to support either invertebrate or phytoplankton endpoints for canals.

Approaches (Charge Question 4c). EPA proposes two approaches for determining numeric criteria for South Florida inland flowing waters. The first is based on reference conditions and the second is based on stressor-response relationships. As noted above, based on the available data, the SAB recommends that nutrient criteria for canals focus on downstream protection, rather than IPV. If canal IPVs are developed, either of these approaches could work, although it was not clear if the available data would show interpretable patterns. Finding patterns in natural streams may be more likely than in the highly managed canals. For the reference condition approach, data on historical annual values of TN and TP from a set of least-disturbed sites (identified using LDI < 2) would be used to develop lognormal distributions of TN and TP under least disturbance. Variability of nutrient levels at the least-disturbed sites will reflect heterogeneity in hydrology, geology, etc. Failure to account for such heterogeneity, which is also present in disturbed sites, may result in numeric criteria that are under- or over-protective. The SAB also notes that selecting "least disturbed sites" using an LDI < 2 may not be feasible in this region that has been subject to active management for many years.

The stressor-response approach also should work if a suitable relationship between Chl-*a* and nutrient load can be demonstrated, but several of the same caveats apply here as for setting limits in coastal waters. As with the approach based on reference conditions, the relationship between Chl-*a* and TN or TP is likely to be modulated by the effects of hydrological, geological, and other covariates. Failure to account for such factors may lead to criteria that are over- or under-protective. The document needs to address how regression models will be used to determine numeric criteria, specifically, how they will determine the level of Chl-*a* considered to be protective of balanced phytoplankton and faunal communities.

South Florida Estuarine and Coastal Waters

Delineation and Data (Charge Question 5a). South Florida estuarine and coastal waters have a different nutrient regime than other parts of the state, given their oligotrophic nature and susceptibility to upstream water management (versus nutrient regulatory) decisions. The SAB agrees that these waters should be considered separately for purposes of nutrient criteria development. The data identified for South Florida estuarine and coastal waters seem appropriate. However, the proposed subdivision/subclassification of these waters does not clearly relate to the oceanographic circulation and degree of connectivity in the region. EPA might consider an alternative segmentation scheme that incorporates alongshore and cross-shelf circulation patterns.

Approaches (Charge Question 5b). EPA proposes to use a reference condition approach using least-disturbed sites or a binomial test applied to a distribution of raw data. Both approaches have merit and the SAB encourages application of both to provide a more robust evaluation of criteria. However, if least-disturbed sites are those most distant from land-based sources, nutrient levels at these sites may reflect dilution by oligotrophic ocean water rather than a significant difference in nutrient loading. In addition, the coastal and estuarine waters of South Florida have experienced enormous changes over the last century in freshwater inflows, salinity and residence times, with associated changes in nutrient cycling and seagrass extent. These past alterations should be considered when defining reference conditions. The SAB recommends that seagrass coverage and extent of epiphytic colonization be considered as endpoints in addition to water column chlorophyll. The document should clarify which coastal and estuarine areas will be under the jurisdiction of the forthcoming nutrient criteria, versus other regulations (e.g., for federal and state protected waters).

Downstream Protection Values (Charge Question 6)

EPA proposes to use DPV criteria to ensure that upstream N and P water quality criteria will be set at levels that will protect downstream estuarine designated uses. While agreeing with the goal of downstream protection from nutrient impacts, the SAB has concern with the overlap between DPV and the Total Maximum Daily Load (TMDL) process. For development of an estuarine TMDL, standard practice is to model the estuary and watershed to determine the additional pollutant load reduction needed, and then to allocate the load reduction based on input from state and local officials. This process thus allows consideration of socio-economic factors, natural background levels of nutrients in different tributaries, etc. in determining the load allocation. However, a significant drawback of relying on TMDLs rather than DPVs is the fact that the TMDL process is not triggered until impairment has occurred in a waterbody.

The EPA document includes an example of a DPV developed using an equal load reduction for each tributary to an estuary. The SAB notes that this equal allocation approach ignores the possibility of different background nutrient concentrations in upstream segments, and other characteristics of segments that would make nutrient load reductions impractical. In response to a SAB request for further information, the Agency described four options for distributing loads for calculation of DPV, each of which presents some difficulties. If the DPV approach is pursued, the SAB urges that selected apportionment strategies not preclude flexible nutrient allocation across tributaries to achieve the necessary load reductions.

Whether developing a DPV or a TMDL, the modeling of load reduction apportionment for upstream segments is a valid approach, but watershed characteristics such as predominant land-use (especially urbanized area) should be considered. EPA should justify the choice of the LSPC watershed model to estimate average flow for streams that discharge to an estuary, and explain why it is the most applicable model for this case. The timeframe of the modeling should be linked to the response of biological endpoints in the receiving waters; annual average values may grossly under-predict the impact of large storm events. In addition, the document needs to discuss the impact on criteria of P cycling and transformation.

2. INTRODUCTION

2.1. Background

Nitrogen (N) and phosphorus (P) inputs from urban and agricultural sources are known to influence water quality, and nutrient pollution has been identified as a source of impairment for estuarine, marine and fresh waters in Florida. The state of Florida has a narrative criterion for nutrients, and is in the process of developing numeric nutrient criteria for its estuaries and coastal waters. In 2009, EPA determined that numeric nutrient criteria were needed to protect aquatic life in Florida, and initiated a process to develop such criteria for categories of state waters. Criteria for total nitrogen (TN), total phosphorus (TP) and chlorophyll *a* (Chl-*a*)—a measure of water column algal biomass—were finalized for Florida lakes and inland flowing waters in 2010. Numeric nutrient criteria for estuarine and coastal waters, and South Florida inland flowing waters, are being developed separately, using a variety of approaches and ecological endpoints. The SAB was asked to provide review and advice on the proposed approaches for estuarine, coastal and South Florida waters, as described in the draft EPA document, *Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters* (November 17, 2010 draft; U.S. EPA 2010).

An *ad hoc* panel of the SAB, the Nutrient Criteria Review Panel, was formed for this task. The Panel met on December 13-14, 2010, to hear EPA technical presentations and public comments, and to discuss responses to the questions in the Charge to the SAB (Appendix A). A follow-up public teleconference of the Panel was held on February 7, 2011, to discuss an initial Panel draft report. The chartered SAB conducted a quality review of the Panel's report on May 17, 2011. Public comments were received and considered throughout the advisory process.

2.2. Charge to the SAB

The Charge to the SAB included questions about the conceptual model used to select assessment endpoints, data sources for the various categories of waters, and possible approaches to define criteria for each of the categories of waters: estuaries, coastal waters, inland flowing waters (including canals) in South Florida, and South Florida marine waters. Relevant charge questions are included at the beginning of each section of the Panel's report, and the full Charge to the SAB is included as Appendix A.

3. Response to Charge Questions

3.1. Conceptual Approach

3.1.1. Conceptual Model

> *<u>Charge Question 1(a).</u> EPA has introduced a general conceptual model in Chapter 2, including the selection of assessment endpoint and indicator variables. What is your perspective of the general conceptual model?*

The State of Florida currently has a narrative criterion for nutrients that says, "in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of flora or fauna," with specific reference to degradation from "man-induced nutrient enrichment (total nitrogen or total phosphorus)" (Florida Administrative Code 62-302.530). EPA has put forward a conceptual model, describing the relationships between nutrient levels (total nitrogen [TN] and total phosphorus [TP]) and biological responses, to guide its efforts to translate Florida's current narrative nutrient criterion into numeric nutrient criteria. Although the general conceptual model (Figure 1, below) provides a starting point for choosing numeric criteria, the SAB has numerous concerns about how the causal variables will be linked to biological endpoints.

The conceptual model would translate Florida's objective of "balanced natural populations of aquatic flora and fauna" into numeric criteria for three biological endpoints: seagrasses, phytoplankton, and faunal communities. While agreeing that these endpoints are appropriate, the SAB strongly felt that these endpoints need to be much better defined and, in some cases, connected to the explanatory variables that would be the basis for setting numeric criteria. As detailed below, the SAB did not always see a direct link between causal variables and the endpoints.

The term "balanced" is not defined in the document and is subject to a great range of interpretation. EPA needs to provide a definition of "balanced" early in the document. Simply relying on the state's assessment of whether or not waters are "healthy" is not an adequate definition. EPA also must define how it will measure and interpret these three endpoints, preferably in quantitative terms. The Florida DEP has defined a balanced community as one that may have experienced "modest" change, but which still has: (1) reproducing populations of sensitive taxa; (2) a balanced distribution of all expected major groups; and (3) an ecosystem with functions that are largely intact due to redundant system attributes (FDEP 2010). If EPA chooses to use this definition, then the link between the water quality targets and these goals should be documented.

More information is needed on the methodologies that will be used in order to determine if the general conceptual approach is workable within the time constraints[1]. The SAB recognizes that details on methods are to some extent specific to type of water body and appropriate for later chapters, but further information on the methods is needed in this chapter as well. EPA is proposing three general approaches to relate nutrient levels to balanced natural populations:

[1] Under a consent decree, EPA is required to issue proposed criteria by November 14, 2011, and final criteria by August 14, 2012 (U.S. District Court, Northern District of Florida, Tallahassee Division, Case No. 4:08-cv-00324-RH-WCS).

1. Identify reference conditions for a water body type based on available data or best professional judgment;
2. Use predictive stressor-response relationships and nutrient/algal thresholds; and/or
3. Use numerical water quality models to predict nutrient loadings that would be protective of system biology.

The SAB agrees that these approaches all have utility and recommends that a combination of approaches be used where data and models are available. However, more detail is needed on: (1) the adequacy of the data for applying each approach; (2) how decisions would be made on which approaches to use; and (3) how discrepencies in targets derived from different approaches would be resolved. As noted below, each of the three approaches has strengths and weaknesses.

The use of **nutrient reference conditions** implies that nutrient concentrations and loadings to a system are known with enough certainty that target values protective of biological endpoints can be determined. In cases where data specific to a system are not sufficient, best professional judgment could be used to determine suitable target values. There has been extensive hydrologic modification of Florida's waters and extreme weather events, a number of which have occurred in the last 15 years, which complicates defining reference conditions in the context of spatial and temporal variability. Current reference conditions may not represent historical conditions. EPA may need to state explicitly the general hydrologic ranges over which these targets will be useful and have clearly stated goals in cases where remediation is suggested. When using the reference condition approach, EPA also needs to evaluate whether data sets used to set values are representative of long-term averages or (in the case of relatively short-term data sets) are heavily influenced by recent hurricanes. Comments by Briceño et al. (2010) may be useful in this regard.

The use of predictive **stressor-response relationships** and thresholds assumes that data on nutrient-organism interactions from Florida waters and other regions, or countries, could be appropriately applied to setting protective target values. The use of numerical **water quality models** assumes that models would be a useful and realistic representation of nutrients and other water quality parameters. For practical application of numerical models, there still remain questions as to the appropriateness of selected models, availability of data, and level of detail required to adequately populate each model approach. For example, the EPA document states that a watershed model will be run with all anthropogenic sources removed to determine background TN and TP levels. More information and justification is needed to provide assurances that the models being used can adequately accomplish this with the stated degree of certainty. Most water quality models have been developed to assess and predict fate and transport processes as a result of anthropogenic activities and not for determining pristine conditions. Detailed validation of such uses is needed, which means calibration with non-impacted watershed loads. However, there are few non-impacted watersheds with conditions that reflect baseline concentrations in relation to determining water impairment. A key factor involved in using numerical models would be their validation and some analysis of uncertainty for each of the systems where they are applied. It may not be feasible to apply these models to a large number of estuaries in a short period of time.

The three methodological approaches listed above are being applied somewhat differently within the different categories of Florida waters. Since each approach has different data requirements (and more importantly, different assumptions, limitations and uncertainties), it is critical that the reasoning behind applying or not applying a given method be provided. The EPA document notes that EPA may use one, two or all three of these approaches for a particular water body. There would be a greater confidence in the criteria if multiple approaches were applied to each of the systems for which data and models are available. This would provide an ensemble approach and a range of values for setting numeric criteria. However, this could result in more than one answer as to what numeric values would be protective. This is understandable given the different conceptual bases for each approach, but the EPA document should discuss how the results from multiple approaches would be integrated to develop the final numeric criteria.

Specific suggestions on the conceptual model for different ecosystem types follow. Further discussion of EPA's proposed approaches can be found in the responses to the charge questions for specific categories of waters.

Conceptual Diagram

The conceptual diagram (Figure 1) gives a general overview of how the conceptual model will be linked to three biological endpoints and how the approaches would be applied in each of the categories of Florida waters. The upper three levels of the diagram (Causal Variable, Response Variable, and Water Quality Targets) are dealt with at great length, but the bottom two levels (Biological Endpoints, Objective) are not discussed in sufficient detail. The SAB recommends that the EPA provide a more detailed conceptual model that includes additional endpoints and flows. In addition, it would be helpful to include system-specific diagrams for each of the four waterbody types, perhaps at the beginning of each chapter.

Terminology that implies TN and TP are causal variables should be dropped in favor of terms such as driver variables because N and P are two factors that regulate primary production but they do not "cause" it. While there is a cause/effect relationship between nutrients and Chl-*a*, the conceptual model should acknowledge that there are many other factors that control Chl-*a*.

In Figure 1, Chl-*a* also is shown to be a water quality target that relates to balanced faunal communities. There are mechanisms by which these two are linked, in addition to changes in DO (e.g., through increased sediment loading), but the SAB did not find any discussion of mechanistic links in the EPA document. Also, while low DO is closely linked with eutrophication, it is not the only mechanism of nutrient impacts, which is what is implied in the diagram. The SAB recommends that the EPA alter the diagram or include an explanation in the text on how numeric criteria for Chl-*a* will be linked to balanced faunal communities. EPA also should provide more background and theory on the relationships between biological endpoints and water quality targets. There are many factors that regulate "balanced" ecosystem functions in addition to the few listed in Figure 1, including predation and other food web interactions, harvest, salinity, substrate, species turnover, and N:P ratios.

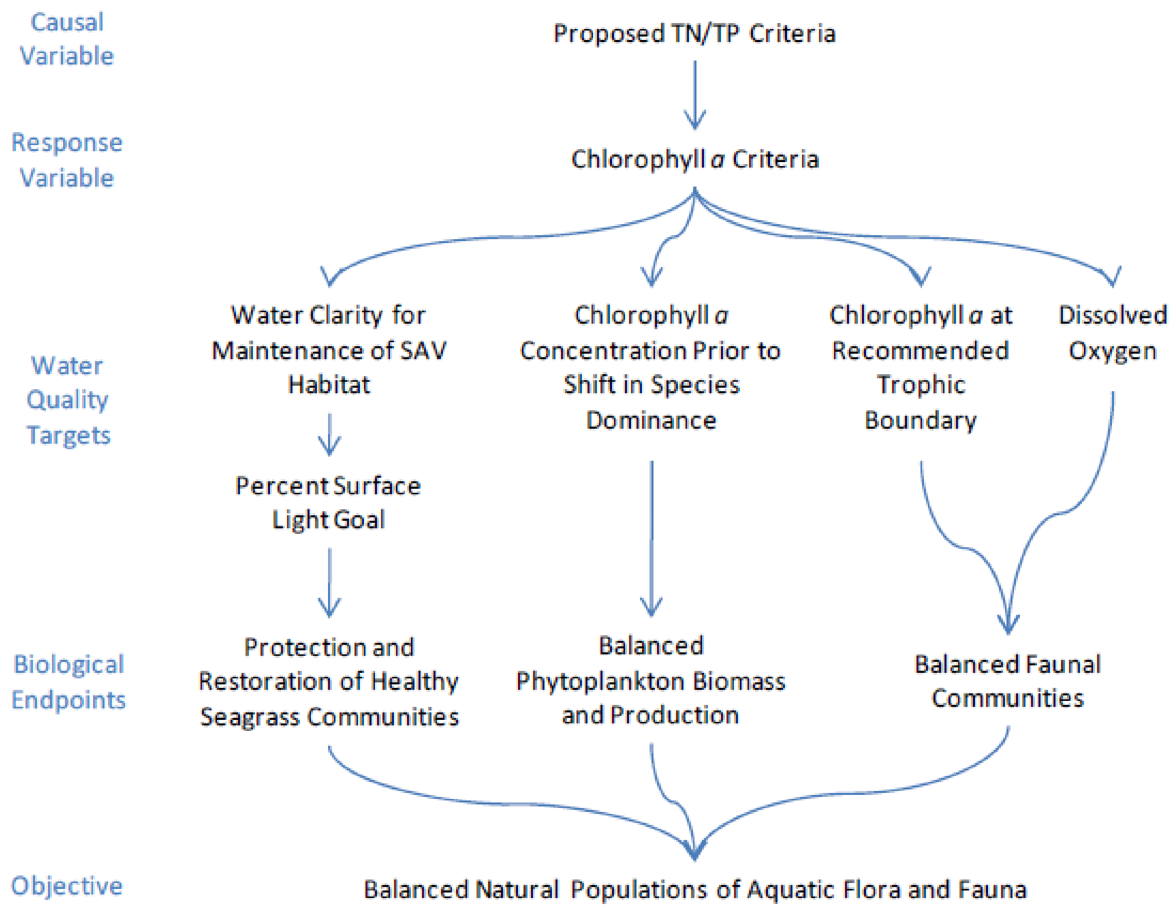

Figure 1. EPA's Proposed Conceptual Diagram Relating TN/TP Criteria to Florida's Narrative Nutrient Criterion (Source: U.S. EPA 2010, Fig. 2-1)

An additional concern is that the conceptual model does not include any discussion about how seasonal and inter-annual variability will be addressed. Average annual values for parameters may not be protective if there are wide seasonal changes. Seasonal variability (e.g., warm vs. cold, wet vs. dry) should be evaluated to determine whether multiple criteria are required.

The goal of the criteria development effort is protection of biological populations, and so the SAB begins its comments with the biological endpoints to be protected and works through the conceptual diagram from the bottom up.

Protection and Restoration of Healthy Seagrass Communities

Chapter 3 of the EPA document describes in more detail how a healthy seagrass population might be determined using historical data and colonization depth. This is a specific and quantifiable parameter (see section 3.2.2). A brief explanation of this is needed in Chapter 2 to outline the approach. The SAB did not find specific decision criteria in the document for determining when management objectives have been met for impaired water bodies or what magnitude of changes would be considered a significant change (i.e., what percent of historical seagrass coverage would be set as a target for restoration?). Data tables provided in Appendix B of the EPA document (Estuarine and Marine Assessment Endpoints and Water Quality Indicator Variables Literature Review) may be used as a starting point. A thorough presentation of key parameters and breakpoints needs to be included if numeric criteria are to be applied.

The SAB is concerned about relying upon water column Chl-*a* as the sole criterion to protect seagrasses. No numeric criteria directly related to macroalgae or epiphytes are being proposed. In systems where the nutrients are largely taken up by the phytoplankton, Chl-*a* will reflect the major impact of nutrient loading. However, there are systems where macroalgae proliferate in response to increased nutrient loadings, but water column Chl-*a* remains low due to short water residence times. In these systems, water column Chl-*a* is a poor measure of nutrient effects. Hauxwell et al. (2001, 2003) found that light levels in benthic macroalgal mats prevented young eelgrass shoots from being established. Epiphytes also can increase in response to nutrient loading in systems even though water column Chl-*a* levels remain fairly low.

EPA could consider an approach linking nutrient loading with changes in seagrass areal extent for protecting seagrass communities. This approach has been successful in Tampa Bay (Greening 2010). It was also applied to a range of systems in New England (Latimer and Rego 2010), with data on eelgrass loss for a number of estuaries being compared to calculated nutrient loadings. The Latimer and Rego study found eelgrass loss began to occur at N loads above 50 Kg ha^{-1} y^{-1} and eelgrass disappeared at 100 Kg ha^{-1} y^{-1}. It may be possible to develop a similar relationship for Florida seagrass systems. The SAB recommends that EPA consider this approach and also ways to back-calculate concentrations from specific loadings that impair seagrasses.

Phytoplankton Production and Biomass

The SAB agrees that Chl-*a* concentration is both sensitive to nutrient inputs and an important measure of ecosystem health and therefore a reasonable endpoint in itself. However, the EPA document should be clear that Chl-*a* measures biomass and cannot be used to infer whether or not populations are “balanced” in terms of species composition or relative abundance/dominance. In testimony, EPA provided examples where toxic blooms are known to occur at high Chl-*a* values. Although undesirable species may be more prevalent in areas with higher nutrient loading (and higher algal biomass), low biomass does not ensure that a toxic species will not occur or that species composition has not changed. Similarly, while Chl-*a* is a measure of biomass (standing stock), it is not a measure of production (a rate) and cannot be used to assess the biological endpoint of production.

Balanced Faunal Communities

The conceptual model does not include a direct metric for balanced faunal communities, but instead proposes that healthy faunal communities rely upon sufficient concentrations of DO. While this is true and the document cites studies where low DO (hypoxia and anoxia) causes mortality and impairment of marine life, low DO usually is a secondary response to excess nutrients in a system. The primary response of excess nutrients is eutrophication, the excess production and accumulation of organic matter in a system. For Florida, in particular, there are also many swamp and backwater systems that feed into tidal waters that are naturally low in DO and not related to TN or TP concentrations or loadings.

EPA proposes to use the State of Florida’s DO standard to maintain the biological endpoint of balanced faunal communities. Specifically, EPA proposes to look for relationships between TN and/or TP and DO, and use those relationships to determine numeric criteria for TN and TP that are protective (i.e., that are associated with attainment of the existing DO standard). How linkages between these variables and faunal metrics will be assessed needs to be clarified. Chapter 3 (p. 49) of the EPA document implies that the absence of hypoxia will be the indicator for the presence of balanced communities, so that numeric criteria would be based on ambient nutrient levels where hypoxia is absent. The SAB recommends that faunal metrics be considered to evaluate the endpoint of balanced faunal communities (see also response to charge question 2).

Chapter 3 also notes that DO can be computed in water quality models from TN and TP loading. However, in determining if hypoxia is present in any particular system, seasonality needs to be considered as hypoxia is a seasonal phenomenon and not present all year round

Dissolved Oxygen Targets

Additional concerns arose during the discussions and submitted testimony about using a single DO standard. Some seagrass meadows routinely exhibit low oxygen conditions at night even in the absence of any nutrient impairment. This diel cycling of oxygen—from supersaturated during daylight hours to undersaturated, and at times hypoxic, at nighttime—has recently been found to be common in shallow vegetated and unvegetated habitats (Moore et al. 2004; Verity et al. 2006; Tyler et al. 2009). Similar conditions appear to occur in some Florida waters (see Boyer and Briceño 2010). Another issue is that oxygen is less soluble under higher temperatures and higher salinity, conditions seen in many of Florida's warm temperate and subtropical waters. Hence, low DO criteria may be better characterized by percent saturation. Although the Florida DO numeric standard is not a subject of the current review, the SAB raises these issues to emphasize the challenges in relying on a DO standard to protect healthy biological communities. There are factors other than nutrients involved in development of hypoxia and anoxia such as water column stratification and water residence time.

TN and TP Criteria

In the EPA document, TN and TP are listed as "causal variables" and defined (p. 39) as concentrations (mg/L) of total (organic and inorganic) N and P. This may lead to confusion. As the table on page 36 of the document points out, TP and TN <u>loadings</u> are normally considered to be the ultimate driver of ecosystem changes while TP and TN water column <u>concentrations</u> are "associated with influent loading over the long term". Hence this would make water column concentrations of both TP and TN explanatory or response variables. The narrative (p. 53) also refers to loading as the causal variable and water column concentrations as a response variable. This distinction is important when considering using TP or TN to predict other parameters.

Many assessments have been based upon loading. Loading data, when available, would be expected to be a better predictor of Chl-*a*, hypoxia and seagrass loss than concentration. Furthermore, TN and TP concentrations may co-vary with Chl-*a*, since both are contained in phytoplankton, so they also are not completely independent from Chl-*a*. This presumes TN and TP are measured on unfiltered samples; yet the document does not clearly state whether that is what is proposed. Given the availability of data, there may be excellent reasons to use TN and TP concentrations as numeric criteria but they should be considered response variables. It also would be useful to characterize these variables in more detail, including the temporal and spatial scales over which they would need to be measured (i.e., weekly or monthly averages, surface values, depth-integrated samples, discrete depths).

The issue remains of whether TN and TP or "reactive N and P" (i.e., dissolved inorganic N [DIN] and P [DIP]) are the most relevant variables to link nutrient enrichment to specific effects on biological endpoints (i.e., primary production, biomass as Chl-*a*, and cascading effects such as food web alterations and hypoxia). This issue has been the subject of considerable research, discussion and controversy for decades. Much of the uncertainty regarding whether to use TN and TP or more "reactive" dissolved forms of these nutrients revolves around the bioreactivity and roles of organic forms of these nutrients.

Bioreactivity may be system-specific (or even system-component-specific), adding to the complexity and uncertainty of measuring responses and impacts on water quality and habitat condition. It is important for EPA to discuss this issue in the context of developing numeric nutrient criteria for nutrient-sensitive waters, both in Florida and nationally.

Regardless of form, some consideration is needed for what portion of TN and TP loading in a system is from natural sources versus anthropogenic sources. This is particularly important for open coastal waters where conditions may be influenced by non-anthropogenic nutrient sources from outside the geographic boundaries of the coastal zone. While we know that reducing nutrients is key to restoring ecosystems in general, careful consideration needs to be given to all sources of N and P that in combination affect the biological endpoints for a system.

Uncertainty

Throughout the document, uncertainty is mentioned only briefly, and that in the context of uncertainty introduced because some environmental variables can covary with the explanatory variable of interest. It would be easier to convey the concept of statistical uncertainty by presenting confidence intervals. However, the level of uncertainty or size of confidence intervals associated with particular numeric criteria should be described further. Predictions developed using stressor-response models should explicitly state the level of confidence and be validated with site-specific data. The possibility that multiple covarying factors are involved in the cause-effect relationship for a particular system should be assessed. For example, the morphology of a system, habitat, and biological interactions within the water body may modify the relationship between nutrient concentrations (both N and P) and observed biological endpoints. These covarying factors need to be better documented, so that the uncertainty of the relationship can be reduced. In other words, a relationship between nutrient levels and a biological metric could be derived that is statistically significant, yet which accounts for only a small portion of the total variability in the data. Inclusion of covarying factors would strengthen statistical relationships, reduce uncertainty, and provide greater confidence in the final criterion.

3.1.2. Categories of Florida Waters

> *Charge Question 1(b). EPA has delineated the State of Florida into 4 general categories of waters—Florida estuaries, Florida coastal waters, South Florida inland flowing waters, and South Florida marine waters—for purposes of considering approaches to numeric nutrient criteria development. Are these categories appropriate and scientifically defensible?*

Separation of estuarine and coastal waters is appropriate given the differences in natural populations of aquatic flora and fauna between higher salinity coastal systems and lower salinity estuarine and inland systems. Freshwater management in the region is complex and the separate consideration of South Florida also is warranted, although the SAB recommends that the term "marine waters" be replaced with "estuarine and coastal waters" for clarity and consistency. A finer classification based on degree of impact may be useful; for example, to separate the Caloosahatchee and St. Lucie estuaries from the other Florida estuaries, given their unique (i.e., strong human influence) hydrological relationship to Lake Okeechobee. While nutrients clearly influence the biota in these systems, salinity levels play a stronger role than is typically the case in other Florida estuarine systems (Kraemer et al. 1999; Doering et al. 1999; Steinman et al. 2002a).

The category of South Florida inland flowing waters seems to be a catch-all for waters that are primarily man-made canals, but which also include a small percent of natural streams. These canals present a unique challenge for setting numeric nutrient standards because of their morphology and management regime. It would be preferable to have a strong scientific rationale for this classification, and further information on canal management could be helpful in this regard.

3.2. Florida Estuaries

3.2.1. Delineation and Data Sources

> *Charge Question 2(a). Are the data sources identified appropriate for use in deriving numeric criteria in Florida's estuaries (as discussed in Sections 2.4 and 3.2)? Is the SAB aware of additional available, reliable data that EPA should consider in delineating estuaries or deriving criteria for estuarine waters? Please identify the additional data sources.*

In general the geographic delineations of estuaries seem appropriate. The SAB was unclear why a salinity of 2.7 psu was used to delineate the upper reaches of systems. Traditionally, such salinity would denote an oligohaline region of an estuary. Why not use "head of tide" or salinity of less than 0.5 psu? In any case, sediment nutrient dynamics change in this salinity transition zone (from approximately 0.0 to 5.0 psu). For example, at the toe of the salinity front, P-releases from sediments can increase sharply. Wherever the upper boundary is fixed, such issues need to be considered.

EPA should consider adding another unit to the estuary delineation that would focus on tidal creeks. A case was made that these systems are common but have different characteristics than the open estuaries and therefore should have different nutrient criteria.

The SAB has few, if any, issues with the data sets presented. The summary tables in the EPA document indicate a careful review of data sources, including attention to time-series data. We encourage continued searching for appropriate data. In public comments to the Panel, one researcher (Dr. Tom Frazer, University of Florida) indicated that additional data are available for some estuarine areas and have yet to be utilized. It may be that County agencies have data sets not yet considered. This effort could be especially useful in the Big Bend area, where offshore seagrass beds are extensive, satellite data on Chl-*a* are not useful, and existing data sets from prior studies are rare. All data sets would need to meet EPA requirements for QA/QC, but the SAB encourages EPA to continue consultations with state and local agencies and researchers to access additional data and local knowledge where possible.

3.2.2. Assessment Endpoints

> *Charge Question 2(b). Are the assessment endpoints identified in Sections 2.3 and 3.2 (healthy seagrass communities; balanced phytoplankton biomass and production; and balanced faunal communities) appropriate to translate Florida's narrative nutrient criterion into numeric criteria for Florida's estuaries, given currently available data? Does the SAB suggest modification or addition to these assessment endpoints?*

Healthy Seagrass Communities

Florida seagrass beds are an extremely valuable natural resource, and the two largest contiguous seagrass beds in the continental United States are found in the Florida Keys and Florida's Big Bend region. Approximately 2.2 million acres of seagrass have been mapped in estuarine and near-shore Florida waters by researchers at the Florida Fish and Wildlife Research Institute in St. Petersburg (Carlson and Madley 2007). However, when seagrass beds growing in water too deep to easily map are included, the total area of seagrasses within Florida waters and adjacent federal waters is likely over 3 million acres. Florida's seagrass beds improve water quality and reduce shoreline erosion, but their most important ecological role is to provide food and shelter for many economically important finfish and shellfish species (Carlson and Madley 2007). Estimates of the ecological services provided by Florida seagrass beds are approximately $20,500 per acre per year (Handley et al. 2007), and it is entirely appropriate that EPA use healthy seagrass communities as one of its assessment endpoints**.**

There are, however, several issues relating to seagrasses that deserve further consideration. First, as acknowledged in the draft EPA document, Chl-*a* usually explains a significant amount of variation in water clarity, but frequently does not explain the majority of this variation. Water clarity is often greatly influenced by colored dissolved organic matter (CDOM) and inorganic suspended material in the water column. Of greater importance, seagrasses in the shallow waters of Florida are typically shaded more by epiphytes growing on their leaves and by associated macroalgae (see Dixon 1999, and review by Burkholder et al. 2007) than by Chl-*a* in the water column. Thus, EPA should consider a measure of epiphyte abundance in addition to the proposed determination of Chl-*a* in the water column. Epiphyte abundance is also often controlled to a significant extent by the animals that feed on these epiphytes (Hughes et al. 2004; Burkepile and Hay 2006; Heck and Valentine 2007; Baden et al. 2010). This control by consumers, often referred to as top-down control, is beyond the scope of the draft document, but it is notable that both nutrients and herbivorous consumers affect the condition of seagrass meadows. As pointed out in Section 3.4.3, similar consumer effects can also be important in controlling Chl-*a* in the water column (Cloern 1982; Cohen et al. 1984; Thompson et al. 2008).

It might also be possible to develop direct seagrass targets. In comments to the Panel, Dr. Paul Carlson suggested submerged aquatic vegetation (SAV), which includes seagrasses, as a management endpoint in support of the EPA plan but went further, arguing that SAV occurrence (abundance, density, etc) might be thought of as an integrative numeric criterion. In support of this suggestion, he states the following: (a) measures of SAV occurrence over time and space can integrate water quality issues of hypoxia, water clarity and nutrient conditions; (b) Florida has many areas dominated by SAV and thus these plant communities are representative of many estuaries; and (c) some beds are surveyed every two years, so there is a very good temporal record of their condition. The SAB suggests that serious consideration be given to Dr. Carlson's suggestion.

Balanced Phytoplankton Biomass and Production

As noted earlier (3.1.1), EPA needs to provide a clear definition of "balanced". If EPA is not referring to species composition and relative abundance, but rather the entire phytoplankton or benthic microalgal communities, then Chl-*a* or other indicators of biomass (i.e., dry weight, particulate C, total cell counts) will suffice. If EPA is referring to species diversity or some other index of biological diversity, then more specific techniques will have to be employed, including microscopic species identification, photopigment analyses, molecular analyses, etc. The SAB recommends community-level biomass metrics, using Chl-*a* or other indicators of biomass, as this is best related to nutrient and C-flux, hypoxia, and other drivers/indicators of impacts of and responses to nutrient inputs. Endpoints that require taxonomic-level resolution (e.g., to characterize harmful algal blooms, HAB) will need more specific suites of indicators to identify, quantify and characterize factors such as toxicity and food web effects. Taxonomic identification of HABs can provide diagnostic value, but the SAB acknowledges that such taxonomic analysis may not be possible with current monitoring programs in the systems and regions of interest.

Balanced Faunal Communities

There is little discussion in Chapter 3 of how "balanced faunal communities" are defined, and this is a concern for several reasons. First, given the generally shallow nature of Florida estuaries and our general impression that water clarity is (or was) high, it is likely that these systems are (or were) benthic-dominated. If this is the case, a variety of benthic heterotrophs could provide strong metrics for estuarine health, as a complement to seagrass community measures. Second, a strong shift from one common benthic species to another (e.g., a pollution tolerant species) can provide a good indicator of benthic habitat condition or deterioration, although the "species pair" might differ among estuaries. Has this approach, using indicator species, been considered as a measure of the health of faunal communities for Florida estuaries?

Chapter 3 indicates that hypoxia will be used as an indicator of compromised benthic habitat condition. As a first pass, this will certainly tell us something about these habitats but not all that is needed. Unfortunately, when hypoxic conditions are observed, impacts on the biota usually have already occurred. It would be useful to have indicators of stress on the faunal community before such degraded conditions develop. In addition, DO in Florida seagrass meadows during the early morning hours is often below the levels considered to be hypoxic in unimpaired Florida waters, owing to the low amounts of oxygen that can be dissolved in the high temperature and high salinity waters characteristic of Florida and the high rates of nighttime respiration in the biomass-rich seagrass meadows. Thus, as suggested in comments provided by Boyer and Briceño (2010), a percent saturation criterion may be more useful than an absolute measure of oxygen concentration.

3.2.3. Approaches

> <u>*Charge Question 2(c).*</u> *EPA describes potential approaches in Section 3.3 (reference conditions, stressor response relationships, and water quality simulation models) for deriving numeric criteria in Florida's estuaries. Compare and contrast the ability of each approach to ensure the attainment and maintenance of natural populations of aquatic flora and fauna for different types of estuaries, given currently available data?*

The EPA proposes to use three approaches to develop nutrient criteria for Florida estuaries: reference conditions, stressor-response models, and water quality simulation models. The SAB comments on the application of each of these approaches to estuaries in Florida, and then discusses the need to consider the impacts on the criteria of future changes to hydrology and climate.

As noted previously, the SAB recommends that EPA provide a more quantitative description of the concept of balanced phytoplankton and faunal communities, and remove the word "production" in the description of phytoplankton unless measures of production are added. Nutrient criteria development should take into account the natural diversity of Florida estuarine systems. For example, in some systems having low N/P nutrient ratios, blue-green algae may be the normal dominant species. Recognition of special system features will prevent systems from failing to meet criteria on the basis of natural background conditions. In addition, the estuarine continuum, from freshwater to the sea, often involves a transition from P- to N-limitation and possibly zones where co-limitation occurs. Thus, a dual nutrient strategy is warranted and we agree with EPA's decision to take this approach. Similar strategies have been adopted in the Chesapeake Bay, Neuse River Estuary and Baltic Sea (e.g., see Elmgren and Larsson 2001; Conley et al. 2009; Paerl 2009).

The SAB has a general concern about the timetable for completion of this work. A substantial effort already has been made to get the work to this stage, much of it solid and thoughtful. However, much work remains to be done. In the case of Florida estuaries, it is not clear what approaches will be selected, if multiple approaches will be used, and which approaches will provide useful information towards the goal of developing nutrient criteria.

The SAB emphasizes that there is no single approach that is ideal for developing nutrient criteria. This being the case, we support using multiple approaches where possible. If results for two or more approaches converge, then there is increased confidence in the results, and EPA needs to provide guidance on how to use this information to develop a criterion. If different approaches yield conflicting results, then EPA needs to have a defensible methodology to resolve the differences and move forward.

Reference Condition

Philosophically, the reference condition approach is the most satisfying, although making it operational is often difficult because sufficient data are lacking to define "reference conditions", and because of the problem of "shifting baselines" (Pauly 1995)—in other words, many ecosystems have been impacted by human activities for some time and we run the risk of using degraded coastal environments as reference conditions when the true (unimpacted) reference conditions have long since ceased to exist. The SAB is aware of at least one other State (New Hampshire) using the reference approach for developing nutrient criteria and that effort yielded some useful results. Experience suggests that this approach, if it can be implemented, might be the most "time-efficient" pathway to developing nutrient criteria.

Stressor-Response Models

The SAB was disappointed that more attention was not given to the stressor-response approach. Although a previous SAB SAB was critical of this approach as a stand-alone method for developing nutrient criteria (U.S. EPA SAB 2010), the available data for Florida suggest a stronger relationship between stressor (nutrients) and response (chlorophyll) than for the stressor-response relationships used in the EPA document reviewed by that panel. One of the Nation's best estuarine restoration examples is Tampa Bay, where a stressor-response approach was used to develop local criteria. The Tampa Bay success suggests that this approach should be utilized more in the State-wide effort. The SAB is aware of a separate EPA report on the stressor-response approach (U.S. EPA 2010), but would have preferred to see more discussion in the current document of how this approach might be applied to development of nutrient criteria in Florida. Limnologists have had great success with this approach. Recently, EPA staff in New England published results of an analysis relating nutrient loads to seagrass health in a variety of small coastal systems (Latimer and Rego 2010). These sorts of studies suggest that the stressor-response approach needs to be more seriously considered. The EPA document simply refers to "regression models," leaving many readers with the impression that EPA is considering only the simplest forms of regression analysis. (In contrast, the discussion of simulation modeling packages is presented in considerable detail.) Statistical models are correlative and the amount of variance explained by the correlations can be less than that needed for criteria development. However, the SAB encourages EPA to apply the stressor-response approach, in combination with other approaches, when developing criteria for Florida waters.

Water Quality Simulation Models

The level of detail on simulation modeling in the EPA document suggests that EPA has decided to use modeling as the primary tool for development of nutrient criteria. This may not be the case but the SAB urges some caution here. The description of the model(s) sounds great, which can be quite seductive, and some issues can only be addressed with simulation models (e.g., forecasting, understanding highly interactive processes). At the December 2010 meeting of the Panel, the EPA staff noted that significant staff resources are being devoted to develop simulation models for specific Florida waters. Nonetheless, using simulation models to establish nutrient criteria is a major undertaking, requiring considerable time and money, and useful results are not guaranteed. The SAB notes as a caution that the Chesapeake Bay model has been under development for about 25 years, and although it has achieved a great deal, it still does not predict inter-annual hypoxic volumes well. There also are very considerable issues related to data needed for calibration and verification of model results.

For waters where the simulation modeling approach is used, a reasonable representation of internal nutrient cycling needs to be included. In the generally shallow Florida systems, benthic processes will be especially important. In addition, these processes will interact with temperature and flow changes. Ultimately, nutrient concentrations reflect the net effect of these biogeochemical processes, as well as loadings.

Implications of Changing Hydrology and Climate

The SAB recognizes that the Agency is required to establish water quality criteria using the best science currently available. However, Florida is experiencing increased demand for freshwater and changes in climate that may directly impact the response of ecosystems to nutrient loadings. In a spirit of adaptive management, the SAB recommends that future refinements to proposed nutrient criteria for Florida estuarine, coastal and marine waters explicitly consider the impact of changing hydrology and climate on the numeric criteria needed to ensure the protection of designated uses.

- ***Hydrologic Forcing.*** From a spatial perspective, the location of phytoplankton production and biomass responses to nutrient inputs is strongly influenced by freshwater inflow and its impacts on estuarine residence time. Under drought conditions, the biomass peak, or Chl-*a* maximum (C_{max}) will tend to be in the most upstream portion of estuaries (Valdes-Weaver et al. 2006). Under moderate freshwater discharge and flow conditions, C_{max} will form in mid-estuarine locations, while under high flow conditions, C_{max} will tend to predominate downstream (Valdes-Weaver et al. 2006; Paerl et al. 2007). Under extreme hydrologic conditions resulting from tropical cyclones, C_{max} may not form at all, but rather the maximum phytoplankton biomass response will be in the sounds and coastal waters (Paerl et al. 2006a, b). These conditions represent a special challenge, because it may be difficult to evaluate and assign numeric criteria for nutrient loads to estuaries, as the response may not occur in estuarine waters.

  The earth is experiencing a sustained period of elevated tropical cyclone activity and intensity (Webster et al. 2005). Florida is particularly impacted, because it experiences more tropical cyclone strikes than any other state in the U.S. Therefore, this aspect of climate change needs to be factored into the anticipated/predicted responses to nutrient inputs and the development of nutrient criteria. Conversely, periods of extreme (and record) droughts require additional attention and consideration in the context of the development of nutrient criteria, as the location and amounts of phytoplankton biomass responses to nutrient inputs will be dramatically affected.

- ***Groundwater and Surface Water Withdrawals.*** Florida is undergoing significant increases in freshwater withdrawal (for drinking water and agricultural irrigation purposes) from its lakes and rivers (Steinman et al. 2004). In addition, continued (and increasing) groundwater withdrawal will reduce freshwater recharge from springs and other natural seepage sources. These withdrawals will impact freshwater discharge to estuarine and coastal waters, which in turn will affect the location and magnitude of phytoplankton (including HABs such as cyanobacteria and dinoflagellates) responses to nutrient inputs, as well as the responses of benthic microalgae and macrophytes. Growing human demand for freshwater will need to be factored into the formulation of nutrient criteria as it will influence freshwater discharge, nutrient loads, nutrient concentrations and microalgal responses in impacted estuaries. Changes in freshwater flows add further uncertainty to derivation of nutrient criteria based on historical relationships and will need to be considered in triennial reviews of nutrient standards.

- ***Climate and Temperature Changes***. In addition to climate-related hydrologic effects, changes in temperature need to be considered. Changes in the range of 1.5 °C have been noted in some systems during the past 60-70 years. Temperature changes on this order can influence phytoplankton community composition (i.e., "cyanobacteria like it hot"; Paerl and Huisman 2008), as well as key biogeochemical nutrient and organic matter transformation processes (e.g., nitrification, denitrification, and sediment oxygen demand). These changes may alter relationships between nutrients and chlorophyll based on previous climatic conditions and will need to be considered in triennial reviews of nutrient standards.

- ***Threshold Changes***. When setting nutrient criteria, the SAB recommends that EPA recognize that threshold changes could occur in these systems. We include here non-linear responses, lags relative to input changes and general "state changes". These changes will in part be a result of changing nutrient loading and freshwater discharge dynamics due to changing anthropogenic activities in watersheds and airsheds. They will also be modulated by climatic changes, including changes in rainfall (and conversely drought) intensities, frequencies and geographic patterns, as well as temperature changes (i.e., warming, which will favor the growth and proliferation of nuisance taxa such as cyanobacteria). These changes need to be considered during future triennial water quality standards reviews.

3.3. Florida Coastal Waters

3.3.1. Delineation and Data Sources

Charge Question 3(a). Are the data sources identified in Sections 2.4, 4.1.1 and 4.2 appropriate for use in deriving numeric criteria in Florida's coastal waters? Is the SAB aware of additional available, reliable data that EPA should consider in delineating coastal waters or deriving criteria for coastal waters? Please identify the additional data sources.

The EPA document defines the outer boundary of the coastal zone as extending 3 nautical miles from shore. However, Florida's territorial waters extend out to three nautical miles on the Atlantic coast and nine nautical miles on the Gulf coast. Thus, additional data points could be included in the analysis and the SAB recommends that EPA also consider monitoring remotely sensed chlorophyll in waters further from shore. Given the dynamic nature of algal blooms in the Gulf of Mexico in particular, it is possible, and perhaps even likely, that blooms that form more than three miles offshore will migrate toward the coastline, thus eventually "appearing" in the state's coastal waters. It will be important to understand the source of such patches of elevated chlorophyll, and to determine whether they are found in close proximity to the shoreline because of land- and estuary-derived nutrients or formed offshore.

Restricting the offshore boundary to three nautical miles greatly reduced the number of calibration samples compared to the available data. As there is no clear boundary in water types at three nautical miles, it is appropriate to use data from the entire shelf. Extending the outer boundary to the shelf break in this way will improve the quality of the dataset. According to EPA personnel, adding these additional data increased both the correlation and the slope of the calibration graph (Fig. 4.5 in the EPA document) considerably (i.e., r^2 increased from 0.52 to ~ 0.8). EPA might consider using anomalies relative to either seasonal or annual means, rather than absolute Chl-*a* concentrations, in their estimates (see Stumpf et al. 2003, 2009; Tomlinson et al. 2004). This approach will mitigate problems inherent in working close to the coast, as bottom backscatter reflectance, for example, will be constant and therefore disappear from the equation.

The coastal segmentation scheme suggested in the EPA document apparently is a result of historical precedence, rather than any underlying scientific rationale. Given the general alongshore flow that creates anisotropy with strong gradients perpendicular to the coast and weaker gradients parallel to it, EPA may wish to consider segments defined in terms of bathymetry.

Another recurrent topic in SAB discussions was the "missing kilometer" at the coast where Chl_{RS}-*a* data are not being used because the satellite chlorophyll estimate is corrupted by the presence of land within the pixels and because of backscatter from shallow water. A potential solution may be to use turbidity data to connect conditions in the estuary proper with the coastal system just offshore, thus bridging the km gap. Another potential solution would be to collect airborne spectrographic imagery, but this would require a new data collection scheme.

The SAB agrees that the use of remotely sensed data to develop a reference criterion for Chl-*a* is appropriate and sensible for this large, poorly sampled region. The use of these data, however, requires calibration with *in situ* chlorophyll samples, of which there are few. The SAB accepts that these sources are limited, but felt that additional sampling, including opportunistic sampling (using ferries, fishing and charter boats, etc.), where feasible, would improve the dataset. While the use of a reference criterion (Chl-*a*) is reasonable, the SAB is concerned with the sole reliance on a surrogate (see below) with no direct measurements of nutrients being made.

The question also arises as to what reference level is applicable in this region. Historic nutrient concentrations were likely very different from today (although few data are available to provide quantitative information), yet the document assumes that these areas are currently supporting a balanced phytoplankton community. Although the SAB recognizes that a longer data record is not available, it is not clear that the ten-year dataset available from satellite observations constitutes an adequate baseline, given decadal-scale variability.

The SAB notes that reliance on satellite observations may not be as feasible in the future, as existing sensors near the end of their lifetime. The Panel's concerns about the continued availability of SeaWiFS data were born out by the announcement in February 2011 that after several months of attempts to communicate with the spacecraft, GeoEye has determined that the SeaWiFS mission is no longer recoverable (per a notice posted on NASA's Ocean Color website, at http://www.nasa.gov/vision/earth/lookingatearth/seawifs_10th_feature.html).While VIIRS may be launched in time to avoid disruption in the collection of ocean color data, there is also question about that sensor's capability to produce high quality data for chlorophyll. Therefore, the SAB recommends that the EPA ensure that data from the existing U.S. and European satellites, as well as future sensors, be cross-calibrated to ensure as complete a data record as possible.

3.3.2. Assessment Endpoints

> <u>Charge Question 3(b).</u> *Is the assessment endpoint identified in Section 4.2 (chlorophyll-a to measure balanced phytoplankton biomass and production) appropriate to translate Florida's narrative nutrient criteria (described above) into numeric criteria for Florida's coastal waters, given currently available data? Does the SAB suggest modification or addition to this assessment endpoint?*

EPA's suggested reference-based approach with satellite remote sensing of Chl-*a* (Chl_{RS}-*a*) to derive numeric values is likely to be effective in Florida coastal waters, because they are optically amenable to remote sensing of chlorophyll, color (CDOM) and turbidity (Hu et al. 2005; Muller-Karger et al. 2005; Palandro et al. 2004). Remote sensing technology has evolved sufficiently to begin using calibrated imagery for estimating chlorophyll.

The SAB acknowledges that Chl_{RS}-*a* is the most feasible indicator of nutrient status for coastal waters, given available data and the lack of a better alternative (i.e., direct monitoring of nitrogen and phosphorus offshore). However, we caution that Chl-*a* levels in these waters also are influenced by seasonal water temperatures, circulation and mixing, and influx of nutrient-rich waters from advection or upwelling. Thus, there may be only a weak relationship between nutrient concentrations and chlorophyll concentrations. There is certainly a potential relationship between nutrients and organic carbon production, but the strength of this relationship can vary depending on factors such as season or relative availability of N and P, as shown clearly in Fig. 4.4 of the EPA document. Walker and Rabalais (2006), cited in the EPA document, found only about 40 percent of the variance in phytoplankton production could be ascribed to nutrient concentration, and this was in an area of the northern Gulf of Mexico known to be affected strongly by nutrient inputs from the Mississippi River. Also, the carbon-to-chlorophyll ratio within phytoplankton can vary by an order of magnitude (Banse 1977), while *Trichodesmium* blooms can arise in low N regimes because these organisms are nitrogen fixers. The SAB notes that Chl-*a* will not be useful as an indicator of species composition, as has been discussed earlier.

3.3.3. Approaches

> <u>Charge Question 3(c).</u> *Does the approach EPA describes in Section 4.2 appropriately apply remote sensing data to ensure attainment and maintenance of balanced natural populations of aquatic flora and fauna in Florida's coastal waters? If not, please provide an alternate methodology utilizing available reliable data and tools, and describe the corresponding advantages and disadvantages.*

EPA is considering a reference condition approach for coastal waters using remotely sensed Chl-*a* and the SAB agrees this is an appropriate application of remote sensing data, with certain caveats. First, the SAB recognizes the problems with other approaches, but notes that the reference condition approach is being undertaken with no linkage to nutrient input into the coastal zone. The SAB recommends that a preliminary assessment of nutrient inputs be undertaken to better understand chlorophyll levels in the coastal zone (i.e., to relate observed chlorophyll levels in coastal waters to TN/TP concentrations or loadings from land). A first pass calculation might consist of an estimate of the total nitrogen and total phosphorus released into the coastal zones from all sources.

Second, the SAB notes the thorough approach to calibration, but recommends several refinements:

- According to the document, EPA used a 3 x 3 km pixel matrix and used only *in situ* calibration data taken within 3 hours of the satellite overpass. This should be sufficient, as tidal current velocities, particularly off the Florida panhandle and over the wide West Florida shelf, are generally small (< 10 cm/s; He and Weisberg 2002). Largest values are about 20 cm/s in the vicinity of the Big Bend and Florida Bay. Tidal ellipses here tend to be perpendicular to the bathymetry except very close to the coast, where they tend to parallel it (Koblinsky 1981; He and Weisberg 2002).
- The SAB recommends that satellite data within a larger, “coastal” context be used for the calibration, i.e., including data from outside the 3-mile zone. Because the calibration presented was not strong ($r^2 = 0.52$), this inclusion of additional data should improve the predictive power of the model. The SAB also recommends that EPA cross-calibrate its imagery from multiple existing (and future) sensors so that Chl_{RS}-*a* values can be compared over time.
- Another issue on calibration concerns the relation between remotely sensed chlorophyll and water column measurements. EPA calibrated the satellite data to chlorophyll measured in the uppermost two meters of the water column. The ratio between the chlorophyll concentrations in the upper two meters and the full euphotic zone needs to be established for the subtropical waters around Florida. In many cases, there is not a strong relationship between total water column chlorophyll and near-surface values, particularly in areas with upwelling and other circulation complexity.
- The SAB recommends that obvious antecedent bloom data points be removed from analyses as these are likely not representative of desired “reference conditions” (p. 83, paragraph 1, regarding *Karenia* blooms).

3.4. <u>South Florida Inland Flowing Waters</u>

3.4.1. Rationale for Criteria

The SAB recognizes the considerable time and effort that has been put into identifying data sources, assessing endpoints, and developing two approaches for deriving nutrient criteria for inland flowing waters of South Florida. However, waters included in this category are dominated by man-made canals and the SAB is not convinced from the material provided that nutrient criteria are appropriate for these uniquely artificial and highly managed ecosystems. We identify five specific concerns in this introductory section before addressing the specific charge questions. We acknowledge that these comments and questions may not have explicit answers; however, they deserve thought and consideration.

- The category of South Florida inland flowing waters includes a variety of different water types, including both human-created/human-controlled canals and natural streams (the latter of which are largely confined to the southwest region of South Florida; Tom DeBusk, personal communication; Hecker and Young 2011). A rough estimate from the SFWMD (Garth Redfield, personal communication) indicated that approximately 90 percent of the waters in this region are classified as canals, and the remaining 10 percent are natural streams. Although canals dominate in number, the range of water types included in this category make it unlikely that there will be a consistent response to nutrients.

- South Florida's inland flowing waters have a long history of being highly manipulated and managed, and in this regard they represent a special challenge to developing numeric nutrient criteria. The underlying problem is that the canals are classified as Class III waters, although their primary purpose is management of water quantity to alleviate flooding potential. The SAB notes the difficulty in determining what constitutes an appropriate reference condition for these systems, and the related issue of whether or not appropriate data are available to help define reference conditions.

- Internal nutrient loading from sediment accumulated in canals may confound the relationship between nutrient criteria and system response if sediments are a major source of nutrients (and based on SFWMD [2010], sediment accumulation and P mass are quite variable).

- It is unclear how nutrient sources from past activities (i.e., legacy nutrients), including legacy losses or inputs of N and P to water bodies, will be accounted for in the proposed approach. If no water quality improvement or indicator biological response is seen after numeric nutrient criteria are put in place, is this because (1) the nutrient criteria are not stringent enough, (2) legacy nutrient inputs are an increasingly significant contributor, or (3) the monitoring interval is not long enough to capture the response of dynamic ecosystems and watersheds? How will continued legacy inputs of N and P be distinguished from decreased loadings related to management changes? Internal recycling of nutrients can mask water quality improvements brought about by nutrient reductions resulting from land management changes. Given the role of legacy nutrients in influencing water quality in these systems, the EPA should employ an adaptive management approach (e.g., as part of the triennial review of water quality standards) to incorporate new monitoring data and revise criteria or loading targets as appropriate.

- South Florida inland flowing waters involve a spatially and temporally dynamic interaction between surface and groundwater flows and as such, biological condition of these waters may be more responsive to hydrology than to nutrients. For instance, N and P loadings at different times of the year can influence biotic responses in different ways. In other words, it is not just how much or in what concentration, but at what time these loadings occur. In dry years, ground water will greatly influence surface water chemistry/quality compared with wet years. There also is concern that cross watershed / ecoregion / system transfers of water and nutrients in ground waters could confound the ability to relate ecological response to water column nutrient concentrations or loadings.

3.4.2. Delineation and Data Sources

> *Charge Question 4(a). Are the data sources identified in Section 2.4 and 5.4 appropriate for use in deriving numeric criteria in South Florida's inland flowing waters (as discussed in Chapters 2 and 5)? Is the SAB aware of additional available, reliable data that EPA should consider in delineating or deriving criteria for South Florida's inland flowing waters? Please identify the additional data sources.*

The SAB recommends that the category of South Florida inland flowing waters be subdivided into two subclasses, each with separate approaches for nutrient criteria development: (1) human-managed canal systems (or some equivalent term) and (2) natural flowing lotic systems. EPA should identify characteristics to separate these two classes of water bodies, with one suggested characteristic being whether their flow regime is natural or managed.

The network of human-managed canals provides ecosystem services, but these services are controlled primarily by hydrology and habitat quality rather than nutrient levels. Thus, for purposes of nutrient criteria, these canals should be viewed as connecting channels from inland water sources to downstream estuaries. This would be consistent with the canal science summary document (SFWMD 2010), which describes the aquatic life in the canals (macroinvertebrates, fish, alligators), but acknowledges that the ecological value of the canals is secondary to their use for water conveyance. These canals serve as a water conduit, but also transport considerable nutrient loads to downstream receiving areas. Hence, the nutrient content in the canals can serve as a proxy for "potential impact" to the more natural wetlands and water bodies adjacent to and downstream from canals and may be best addressed through downstream protection values (DPVs) for estuaries, rather than by establishing canal nutrient IPVs. (However, see section 3.6.2 on DPV).

The SAB recommends that EPA evaluate the appropriateness of developing nutrient criteria for South Florida natural flowing lotic systems, given their greater potential for valued ecological attributes relative to canal systems. Suggestions on approaches for nutrient criteria development are provided in the next section.

There is considerable debate as to whether or not the data in Sections 2.4 and 5.4 of the EPA document are sufficient to derive numeric criteria for South Florida's inland flowing waters. These data sources are certainly the most logical beginning point. However, EPA should look into datasets potentially available from the local water/drainage districts (not water management districts), such as Lake Worth; these local regulatory authorities can control water regulation and were created for the purpose of reclaiming the lands within their boundaries and to provide water control and water supply for settlement and agriculture (see www.lwdd.net). In addition, agricultural interests that border the canals (e.g., U.S. Sugar Corp.) may have useful data, although these data may be proprietary.

The proposed inventory of inland flowing waters that catalogues and distinguishes natural streams and canals should provide very useful information. This inventory could provide the basis for dividing inland flowing waters into two subcategories for purposes of criteria development, as recommended above.

The EPA document explores the use of the Landscape Development Index (LDI) as a potential approach (and data source) for determining reference conditions in inland flowing waters (reference conditions where LDI < 2, p. 105). It is well established that surrounding land use can have substantial impacts on receiving water bodies, so this approach has conceptual and intuitive appeal. However, insufficient information is available in the EPA document to determine the appropriateness of the LDI approach for

South Florida's inland flowing waters. The SAB does not recommend that the LDI be applied to South Florida canals. Further concerns include the use of a 100-m buffer along canals; would not the canal's water quality to be determined by the entire area that drains into it? The document cites a study by Fore (2004) to justify this approach. However, Fore (2004) was based on streams throughout the state and not just canals; there are considerable differences in hydrology and land-water interactions between canals and natural stream channels. The 100-m buffers proposed for use with the LDI (p. 105-106) may be too limited, particularly where stormwater pipes convey runoff from distances much further than 100 meters.

The condition of inland flowing waters is highly influenced by geology and anthropogenic activity. In this regard, there is logic to subdividing these waters according to basin and sub-basin soil types and land uses. An additional challenge is incorporating groundwater hydrologic/nutrient dynamics, which also have been altered, but are likely to be very important in determining nutrient sources and impacts. The proposed classification scheme appropriately incorporates surface and subsurface flow regimes and flow lines, as well as soil types and human agricultural and urban impacts (i.e., land use). Inland water regions should be classified according to soil order, color of water, or a combination of several such characteristics.

As mentioned above, legacy N and P loads from past management and from natural sources also must be considered. The EPA document appears to minimize the importance of legacy effects of past management (e.g., the statement on the top of page 40 in reference to Huang and Hong 1999). However, soil nutrient levels vary greatly as a function of past management, within and among fields and within areas with uniform LDIs for which specific criteria concentrations will be set. Additionally, geologic rock deposits vary within areas assumed to have similar nutrient concentrations. There is a wealth of data on soil nutrient levels (particularly P) available from NRCS and land-grant university extension offices. EPA should evaluate these, and other, data to better support the regional classification of South Florida inland flowing waters.

3.4.3. Assessment Endpoints

> <u>*Charge Question 4(b).*</u> *Are the assessment endpoints identified in Section 5.4 (balanced faunal communities, i.e., aquatic macroinvertebrates, and balanced phytoplankton biomass and production) appropriate to translate Florida's narrative nutrient criteria (described above) into numeric criteria for South Florida's inland flowing waters, given currently available data? Does the SAB suggest modification or addition to these assessment endpoints?*

Philosophically (but with practical implications), one can question whether any assessment endpoint is appropriate for systems that have been artificially created. How does one establish an appropriate reference condition for such systems, especially when they are heavily managed? There are no easy answers for these questions, although this has certainly been done for reservoirs. Furthermore, nutrient inputs are not the main drivers of habitat quality in the canals of South Florida.

South Florida canals have been constructed continuously over the last century, so it is not clear how reference conditions can be assessed for these highly variable systems that are designed to be dynamic and flashy during wet periods (to get water off the landscape quickly) but are managed during dry periods to be slow or non-flowing. Least-disturbed sites tend to be in one region only and may not be transferable to other identified regions. Because canals are unique aquatic ecosystems, more information needs to be presented on how balanced natural populations are to be assessed. An initial inventory of science for South Florida canals, provided by SFWMD (2010), summarizes data on water quality and biological conditions in the canals. The closest analog to South Florida canals would be in The

Netherlands, where much of the inland waters flow through canals (locally called ditches). There is some literature on assessment endpoints from Netherland ditches (e.g., see Verdonschot 1987) that may be of use in developing methods for assessing the status of flora and fauna in Florida canals.

If nutrient criteria are to be developed for South Florida inland flowing waters, the SAB recommends further consideration and assessment of both the response variables and the form of the nutrients being assessed. For example, distinction is needed among nutrient forms that are immediately availability for biological uptake —i.e., short-term bioavailability and growth response, such as inorganic nitrogen (NO_3 and NH_4) and phosphorus (PO_4)—compared with losses, such as particulate and organic forms of N and P (i.e., long-term availability).

For assessment endpoints, both Chl-*a* and invertertebrate measures have conceptual appeal, but their utility is not straightforward. Some freshwater and estuarine ecosystem studies have shown that Chl-*a* can be a function of grazing pressures rather than, or in addition to, nutrient concentrations. For example, increasing nutrient concentrations in inland flowing waters can increase the number of grazers, which can lead to a lower Chl-*a* concentration; i.e., a top-down regulation of primary production (Cloern 1982; Cohen et al. 1984; Hilton et al. 2006; Thompson et al. 2008; Lewis and McCutchan 2010). Aquatic macroinvertebrate community structure and/or traits have been shown to be reliable bioindicators in other aquatic ecosystems. Hence, they are a reasonable starting point for South Florida's inland flowing waters. However, these systems are poorly understood, highly managed, and heavily modified. As a consequence, it is unclear at present if these proposed assessment endpoints can be applied effectively.

The SAB identified areas of uncertainty that need further attention before a reasonable level of scientific confidence can be applied to the use of balanced faunal communities and/or balanced phytoplankton biomass and production. We elaborate on these below.

Faunal Communities

The macroinvertebrate index used by Snyder et al. (1998), provided as Figure 5-8 in the EPA document, shows a good relationship between land use and macroinvertebrate community structure. However, macroinvertebrate data provided in a presentation to the SAB reveal a much more tenuous stressor-response relationship between total P concentrations and macroinvertebrate indices (DeBusk 2010). It is important that EPA examine possible reasons for the lack of correspondence in these two data sets. Possible explanations include the use of different measures of stressor (land use vs. total P), different types of indices (e.g., emphasizing different taxa), or inclusion of inland flowing waters from different parts of south Florida (e.g., that experience different pressures). For example, the relatively high Stream Condition Index (SCI) score for the wetland sites shown in the Snyder et al. data may have more to do with habitat quality than nutrients. The summary of canal science prepared by the SFWMD (2010) notes that "additional research is needed to select sensitive (macroinvertebrate) metrics and a quality threshold applicable to low gradient streams and canals within the peninsula and Everglades bioregions." The SAB agrees with this statement. If the different macroinvertebrate patterns in these data sets can be explained and related to nutrients, aquatic macroinvertebrates may be a very useful assessment endpoint and one that the SAB recommends be given more attention. However, that relationship has not yet been established.

Phytoplankton Biomass

There is a relative paucity of phytoplankton data (either as Chl-*a*, species composition, or productivity) in these inland flowing waters. Data from SFWMD (2010) show geometric mean Chl-*a* concentrations ranging from 2 µg/L (Lower East Coast) to 8.0 µg/L (Everglades Agriculture Area) in canals within the South Florida region. However, these concentrations are not paired with data on hydrologic conditions, and it is impossible to assess if they represent actively growing algae populations (as might be expected in a non-flowing canal) or algae being transported downstream (i.e., in a flowing canal) and therefore not representative of local conditions. The hydrologic status of the canal (non-flowing, slow-flowing, fast-flowing) has enormous implications for the plankton community, and this needs to be accounted for in EPA's assessment. In addition, both present and antecedent hydrologic conditions need to be considered in any analysis, as the flow regimes are quite variable (and can be artificially controlled) in these systems. Hence, a canal that may be flowing when sampled may have been stagnant for weeks prior to sampling, and vice versa. These kinds of lags make relationship interpretation (and accurate modeling) complex. At this point, it is unclear if there are sufficient data to know what a "protective" level of Chl-*a* should be for these systems; as a consequence, it is currently not possible to assess whether or not phytoplankton can be used as an effective assessment endpoint.

The inventory of the inland flowing waters, and subsequent screening of water bodies, is an important step and may help in the selection of appropriate assessment endpoints. The approach provided in the technical document is a good starting point, but the SAB has identified some issues and suggestions with respect to the classification procedure. The SAB identified several factors that EPA may want to consider with respect to the chlorophyll endpoint:

- EPA proposes a classification of inland water regions according to soil order, land management systems or color of water (see below). Some combination of these factors should be considered, taking into account covariates.
- Currently, EPA does not appear (at least explicitly) to consider the potential influence of humic soils in their classification of inland flowing water types, with respect to their role in discoloration of waters; phytoplankton response will be very different in waters that are naturally colored (i.e., influenced by humics) vs. those that are not.

Dissolved oxygen concentration reflects the relative amount of photosynthesis (DO production) and respiration (DO consumption) in aquatic ecosystems, so DO might be an alternative endpoint in this geographic domain; however, new studies would be needed to determine if DO levels are linked to nutrient loads or concentrations, and not to other factors (such as light), and if groundwater influx (low DO) confounds the use of this assessment endpoint.

3.4.4. Approaches

> <u>Charge Question 4(c).</u> *EPA describes two approaches in Section 5.4 (reference conditions and stressor-response relationships) for deriving numeric criteria in South Florida inland flowing waters. Compare and contrast the ability of each approach to ensure attainment and maintenance of balanced natural populations of aquatic flora and fauna in different types of flowing water or geographical areas, given currently available data?*

The two approaches that EPA is considering for determining numeric criteria for South Florida inland flowing waters are discussed in Section 5.4 of the EPA document. The first is based on reference conditions and the second is based on stressor-response relationships. Based on the available data, the SAB recommends against the establishment of instream protection values for nutrients in the human-controlled canal systems; these inland waters are more appropriately thought of as hydrologic conduits designed to rapidly remove storm water from the landscape, while at the same time delivering nutrients to downstream estuaries. The SAB does recommend that EPA evaluate both approaches for the natural flowing lotic systems, but recognizes that data availability may severely limit their ability to develop rigorous criteria at present. As such, the SAB recommends that, at least for the present, South Florida inland flowing waters be addressed through downstream protective values. We comment on the problems with EPA's proposed approaches below.

Reference Conditions

Briefly, under the approach based on reference conditions, a set of least-disturbed sites would be identified using the Land Development Intensity (LDI) index. The total LDI for each site would be calculated as an area-weighted sum of the LDI coefficients for all land uses within an area of influence. Sites with total LDI below 2.0 or another specified threshold would be classified as least-disturbed and would form the reference set. The historical annual values of TN and TP for these sites would be used to fit lognormal distributions of TN and TP under least disturbance and specified quantiles of these fitted distributions – the EPA document mentions the 0.75 and 0.90 quantiles – would be used as the numeric criteria.

On the bottom of page 107, the EPA document discusses the question of the frequency with which these numeric criteria could be exceeded. This discussion is difficult to follow, but the general point appears to be this: Consider that the estimated 0.75 quantile for one nutrient is exceeded *k* or more times in *n* years. Commonly used values are 1 in 3 and 2 in 5. Under the assumption that values in different years are independent and have the same distribution as the reference set (and ignoring any error in the estimation of the 0.75 quantile), the probability of this event is given by:

$$p(k,n) = \sum_{j=k}^{n} \binom{n}{j} 0.25^{j}\, 0.75^{n-j}$$

For fixed *k* and *n*, this formula essentially provides a one-sided significance level for testing the null hypothesis that the nutrient distribution is the same as that of the least-disturbed sites. So, for example, under this null hypothesis, the probability $p(1, 3)$ of at least 1 exceedance of the 0.75-quantile in 3 years is 0.58, while the probability $p(2, 3)$ of at least 2 exceedances in 3 years is 0.16.

The SAB notes the following:

- The choice of quantile, *k*, and *n* can have a profound effect on the performance of criteria derived in this way and some discussion is needed about how this choice will be made.
- The probability calculations sketched here pertain to exceedances of a single nutrient criterion. If the same rule is applied to both nutrients (and assuming that nutrient levels are independent) then, under the null hypothesis that both nutrient distributions are the same as those for least-disturbed sites, the probability that either or both nutrients exceed their respective 0.75-quantiles in at least *k* of *n* years is $1-(1-p(k,n))^2$. Thus for both nutrients, the probability of at least 1 exceedance of the 0.75-quantile of either or both nutrients in 3 years is 0.82, while the probability of at least 2 exceedances in 3 years is 0.29, i.e., much greater than for each nutrient considered individually

As noted, these calculations assume that the relevant quantile of the annual nutrient levels in least-disturbed sites are estimated without error. An assessment of the impact of estimation error – including non-normality of the log of annual nutrient levels – on the accuracy of these calculations is needed.

Although these calculations provide information about the rate of Type I error (i.e., the exceedance of the criterion when the underlying distribution is the same as that for least-disturbed sites), they provide no information about the rate of Type II error (i.e., the non-exceedance of the criterion when the underlying distribution is different from that for least-disturbed sites). In the jargon of hypothesis-testing, this analysis provides no information about power. To gain such information, it is necessary to consider also the distribution of nutrients in disturbed sites.

To some extent, variability of nutrient levels in the least-disturbed sites will reflect heterogeneity in hydrology, geology, etc. Failure to account for such heterogeneity, which is also present in disturbed sites, may result in numeric criteria that are under- or over-protective for some sites. It would, therefore, seem preferable to develop criteria that account for such factors. The EPA document briefly notes (on p. 108) that EPA also is considering following the reference conditions approach using all sites as a reference set (and not only least-disturbed sites as discussed above). With the exception of the identification of least-disturbed sites, the mechanics of these approaches are the same. However, the underlying logic seems rather different – loosely speaking, one approach aims to reproduce conditions in least-disturbed sites and the other aims to maintain conditions within a specified quantile of the distribution of all sites, whatever their level of disturbance – and this needs to be discussed.

Another Possible Approach

The SAB briefly discussed another statistical approach to determining numeric criteria for TN and TP. The ultimate goal of this determination is to ensure that waterbodies meet their designated uses. If information is available about whether or not waterbodies with the same designated use are, in fact, meeting this use, then it should be possible to construct logistic or other binary regression models relating the probability that designated use is met to levels of nitrogen and phosphorus (and possibly to other regressors such as rainfall).

Consider that for years Florida DEP scientists examined water quality data on Florida surface waters and then made the judgment as to whether or not a waterbody was in compliance with the narrative nutrient criteria. In effect, these scientists created a binary response variable (compliance or noncompliance) for each “data row” of water quality data for each Florida waterbody. These data rows for each waterbody type (e.g., lakes, rivers, estuaries) could be the basis for development of logistic or other binary regression models with the water quality variables as predictors and the DEP scientists’ classifications as the response.

For example, if initial analyses indicated that TN and TP were clearly the best predictors of compliance response in estuaries, then a binary regression model could be fitted with TN and TP as the two predictors of the compliance response. Then new TN and TP data could be inserted into this binary regression model to determine the probability of compliance with the nutrient criteria. So, for example, with a 50:50 cutoff for compliance as the transition point, if an estuary’s TN and TP result in greater than 50% probability of compliance with the nutrient criteria, the estuary would be classified as not impaired.

This approach can be undertaken with little cost and time, and it makes direct use of the State’s interpretation of the existing narrative criteria. This approach is similar in spirit to the one based on reference conditions. However, unlike the approach based on reference conditions, the statistical analysis discussed here would use information about both unimpaired and impaired cases. Although the results of this statistical analysis will be only as good as the underlying categorization of waters as impaired or unimpaired, the approach may offer additional insight for interpreting proposed criteria.

Stressor-Response Relationships

The second approach that EPA is considering for developing numeric criteria for South Florida inland flowing waters is based on stressor-response relationships. This involves developing a statistical model relating the level of Chl-*a* to TN or TP. The EPA document presents examples involving linear, nonparametric, and quantile regressions of log Chl-*a* (as response) and log TN or log TP (as stressor).

The SAB notes the following:

- A fundamental question that the EPA document leaves unanswered is how such fitted regression models will be used to determine numeric criteria; i.e., how they will determine the level of Chl-*a* that will be considered protective of balanced phytoplankton and faunal communities. This is a serious shortcoming that needs to be addressed.
- As the EPA document notes, it has not been possible to develop stressor-response relationships in which a biological endpoint other than chlorophyll serves as the response. However, if there is a clear relationship between Chl-*a* and TN, say, and a clear relationship between another biological endpoint (e.g., a faunal community metric) and Chl-*a*, then there would ordinarily be a clear relationship between that biological endpoint and TN. The fact that it is difficult to identify this latter relationship may reflect limitations of the statistical models considered so far. For example, the effect of TN or TP on a biological endpoint may be modulated by other factors. This effect could be obscured by omitting these factors from the regression model.
- As with the approach based on reference conditions, the relationship between Chl-*a* and TN or TP is likely to be modulated by the effects of hydrological, geological, and other covariates. Failure to account for such factors may lead to criteria that are over- or under-protective at some sites, and it would again seem preferable to include such covariates in developing numeric criteria. Furthermore, should TN and TP be considered simultaneously (i.e., is a multiple or simple regression most appropriate)?
- Some of the variability in the stressor-response relationship could be a result of season. This should be investigated, and it may lead to the formulation of different criteria for different seasons.
- A substantial amount of effort will be put into identifying and quantifying stressor-response relationships in these waters using correlative/regression analysis. Considering the difficulty of working across the surface-subsurface interfaces in deriving nutrient loading estimates, as well as effects of these loads, the authors have done a good job of addressing these challenges. This section could however benefit from closer process/response connections (including applying modeling approaches) to receiving estuarine and coastal waters.
- Reference conditions established using a distribution approach (p. 108) will be sensitive to the distribution of sites along the disturbance gradient. If a larger proportion of the samples are from more disturbed sites, then using the lower percentile to set the criteria will result in a higher number than if a larger proportion of the samples are from less disturbed sites. Some requirements for the distribution of sites along the disturbance gradient should be specified.

3.5. South Florida Marine Waters

3.5.1. Delineation and Data Sources

> *Charge Question 5(a). Are the data sources identified in Section 2.4 and 5.5 appropriate for use in deriving numeric criteria in South Florida's marine waters (as discussed in Chapters 2 and 5)? Is the SAB aware of additional available, reliable data that EPA should consider in delineating or deriving criteria for South Florida's marine waters? Please identify the additional data sources.*

One general recommendation is that the waters currently termed "marine waters" in the EPA document be changed to "South Florida coastal and estuarine waters" to be consistent with the use of the terms throughout the rest of the document.

The southern part of Florida has a different nutrient regime than other parts of the state: it is highly oligotrophic and conditions can be rapidly altered by upstream water management (versus nutrient regulatory) decisions. In addition, embayments with calcareous sediments are highly phosphorus (not nitrogen) limited. The SAB agrees that these waters should be considered separately for purposes of nutrient criteria development. However, the proposed subdivision/subclassification of South Florida estuarine and coastal waters does not clearly relate to the oceanographic circulation and degree of connectivity in the region, particularly on the seaward side of the Keys and the southeast and southwest interior coasts. Alongshore circulation and interconnection is much more vigorous than across shelf except for highly restricted intertidal exchange passages (Lee and Mayer 1977; Lee et al. 2002).

The data identified in the report seem appropriate for use in this exercise. There also are water quality data from NOAA's Atlantic Oceanographic Meteorological Laboratory (AOML) that have been collected for Florida Bay, Biscayne Bay, the Florida Keys and SW Florida Shelf for more than a decade as part of the NOAA South Florida Program (www.aoml.noaa.gov/sfp). There are some possibly significant differences between these data and the Southeast Environmental Research Center (SERC) data, which covers the same domains. For some periods in some subregions, the NOAA data were temporally more dense (bimonthly versus quarterly) in larger domains and the nutrient methodologies were more sensitive (long path length liquid wave guide) in accordance with oceanographic practice for oligotrophic open ocean waters (as established in JGOFS, GLOBEC and other international programs).

3.5.2. Approaches

> *Charge Question 5(b). EPA describes two methods in Section 5.6 for using a reference condition approach for deriving numeric criteria in South Florida marine waters (least-disturbed sites or bionomial test). Compare and contrast the ability of each approach to ensure attainment and maintenance of balanced natural populations of aquatic flora and fauna in South Florida marine waters, given currently available data?*

Two approaches to nutrient criteria are being considered for South Florida coastal and estuarine waters. The first is to identify criteria that are inherently protective based on a statistical evaluation of data from least-disturbed sites. In some of these zones, least-disturbed sites may be those most distant from land-based sources; this is not a result of a significant different in nutrient loading but rather a result of dilution with naturally highly oligotrophic waters. Hence, by including sites being diluted by highly oligotrophic ocean waters, the criteria may be overly protective. Moreover at such sites it is not atypical that the limiting nutrient can change. A second proposed approach is also based on a statistical evaluation, but in this case raw data are analysed using a binomial test and two criteria are generated –

an average concentration and an upper percentile concentration that is more sensitive to higher concentrations. Both approaches have merit and the SAB encourages the application of both to provide a more robust evaluation of criteria.

A third alternative has been suggested by Briceño et al. (2010), based on statistical analysis of long-term monitoring data for Chl-*a* and nutrient concentrations in South Florida coastal and estuarine waters. While that approach has some merit in subregions where sufficient time-series data are available, it is not applicable in many other areas. Moreover, an inherent lagtime is introduced in that analysis which may make it insensitive to ecologically significant deleterious changes if they occur too rapidly.

It is also critical to address how the statistical approaches would be applied. For example, if a baseline (i.e., reference) condition is established using the median or geometric mean of a decade of data for the undisturbed condition, there still remains the major issue of how concentrations that exceed the criteria will be determined. Will each year be assessed against the baseline (the approach taken with the CERP System Status Report and the South Florida Ecosystem Restoration Task Force, SFERTF, Scientific Indicators) or will five years of data be required to determine if 2 (or 3) had “exceeded” the baseline? How would the variability in the two data sets (baseline and evaluation) be incorporated? Given how variable some of these numbers are, it is a lot less powerful (less chance of seeing a change) to ask if the means of the two datasets (in the example above, 10 and 5 yrs) differ versus whether a particular year was significantly above the baseline mean. Furthermore, there may be major ecological differences between two successive years of concentrations that exceed the criteria versus two years separated in time, and the document does not discuss this. The SAB recommends that more thought be given to these implementation issues.

The SAB recommends a reconsideration of the rationale for doing both a principal component and cluster analysis. EPA proposes to use a combination of principal component analysis (PCA) and cluster analysis to define coastal regions based on multivariate measurements with sites. As the goal of cluster analysis is precisely to identify groups of similar sites, it is unclear why PCA is also being proposed in this context.

Past Alterations

The coastal and estuarine waters of South Florida have experienced enormous changes over the last century. For example, the Florida Bay of the early 1900’s was a true estuary with low and highly variable salinities for most of the year. Following widespread damming for the Flagler railroad, salinities were lowered throughout much of the Bay; the effect on salinity was relatively minor, but the effect on residence time was significant. Then, after canal construction from the 1920s to mid-1960s, the vast majority of the water flowing out of Lake Okeechobee is now shunted out to sea before reaching the southern-most waters of the state (Steinman et al. 2002b). Although there were a number of animal studies conducted, there were few nutrient or chlorophyll measurements made because the water was so clear that light penetrated to the bottom. In the 1970s, *Thalassia* covered Florida Bay, believed to be a result of the artificially high salinities resulting from the eastward and westward shunting of water that used to flow south into Florida Bay. A major drought in the mid-1980s resulted in Florida Bay salinity going as high as 70 ppt, which killed off *Thalassia* and other sea grasses. Although nutrients were not a cause of the sea grass dieoff, the result was that enormous amounts of nitrogen and phosphorus that had been sequestered as detritus in the sediment were no longer protected by the dense sea grasses. A subsequent large storm event then mixed large amounts of sediment nutrients into the water column. The result was eutrophication, yet the ultimate cause was a change in salinity that killed off sea grasses years before. Based on this brief history, the SAB has the following recommendations:

- When setting reference conditions, EPA should consider historical water management and structural changes and regional climatic variability that have affected water delivery to South Florida estuaries and coastal waters, recognizing that current conditions do not reflect historical conditions.

- In particular, salinity should be considered a covariate because of its role in maintaining the water quality necessary for seagrasses. We note, however, that salinity is relevant (and in fact variable as a result of water management) only in a very restricted part of this domain.

- Seagrass coverage and the extent of epiphytic colonization should be considered as endpoints, in addition to water column chlorophyll (see also 3.2.2).

Geographic Areas to be Included

South Florida contains a number of parks and marine protected areas. Management jurisdiction in the region has been clarified to a large degree by the formation of the National Marine Sanctuary. The document should clarify which coastal and estuarine areas will be under the jurisdiction of the EPA document under review vs. other regulations. We note that the Florida Keys National Marine Sanctuary (FKNMS) domain (and that of the three national parks: Biscayne, Dry Tortugas and Everglades – a.k.a. Florida Bay) are not the only federally protected waters, and there are also state-protected waters of various types. It is our understanding that what is set by EPA will constitute a “de minimus” standard for these areas, which could receive additional protection. Similarly, the EPA document should clarify the relationship of the South Florida coastal and estuarine nutrient criteria to the relevant indicators and performance measures already established by the Comprehensive Everglades Restoration Plan (CERP) through its Restoration, Coordination and Verification (RECOVER) program.

3.6. Downstream Protection Values

3.6.1. DPVs for Estuaries

<u>Charge Question 6(a).</u> *Are the methods EPA is considering for deriving downstream protection values (DPVs) for estuaries (excluding marine waters in South Florida) as described in Section 6.1-6.4 appropriate to ensure attainment and maintenance of downstream water quality standards, given available data? Please describe additional approaches and their advantages and disadvantages that EPA should consider when developing numeric criteria to protect these downstream estuarine waters (excluding marine waters in South Florida), given available data?*

Rationale for DPVs

The 1972 Clean Water Act (CWA) states that:

> In designating uses of a water body and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters.

This provision has been the basis for ensuring that water quality standards in one state provide for attainment and maintenance of water quality standards of downstream states and Tribes. The recently published nutrient criteria for Florida's lakes and flowing waters (75 FR75762-75807, December 6, 2010) explicitly included the concept of downstream protection values (DPV) as a concentration or loading value in a stream at the point of entry into a lake, set at a value to ensure that lake nutrient criteria are attained. The rule also notes that wasteload and/or load allocations from an approved total maximum daily load (TMDL) may be used as the DPV.

In the present document, the concept of DPV is included as a means of ensuring that upstream N and P water quality criteria will be set at levels that will protect downstream estuarine designated uses. This is particularly important because freshwater and estuarine systems may be sensitive to different nutrients. However, the SAB had concern with the overlap between DPV and the TMDL process. To illustrate this, consider Figure 2 below. Water quality criteria (WQC) are required for all waterbodies in this figure – the estuary and the streams. If streams A1, B1, and C1 meet their WQC, yet the estuary does not, additional pollutant load reductions to the estuary are required. These reductions could come from direct loading, the atmosphere, or the tributaries (A1, B1, C1). Standard practice in the TMDL process is to model the estuary and watershed to determine the additional pollutant load reduction needed, and then to allocate the load reduction based on input from state and local officials. One possible result of implementation of the required load reduction is that one or more streams may require WQC more stringent than those initially established in order to attain WQC in the estuary. Regardless, this regulatory-driven analysis achieves compliance with all WQC without the additional regulatory entity of DPV criteria.

The drawback of relying on TMDLs, rather than the DPVs, is that the TMDL process is not triggered until impairment has occurred in a waterbody. However, the TMDL process includes the opportunity to consider socio-economic factors when selecting an allocation scheme for load reduction. In principle, in an environment with no water quality impairment, the DPV concept could be captured within the designated use for each tributary and correspondingly reflected in the water quality criteria for each tributary. However, in situations where impairment exists, the DPV enforces rigidity that likely will not accommodate variations in natural and human factors affecting nutrient loading. Of particular note, nutrient trading between tributary watersheds, which might be viewed favorably from a social and an economic perspective, may be prohibited due to *a priori* nutrient load restrictions imposed by the rigidity of the DPVs. Therefore, if the DPV approach is pursued, the SAB urges that selected apportionment strategies not preclude flexible nutrient allocation across tributaries to achieve the necessary load reductions.

The EPA document includes an example of DPV developed using an equal load reduction for each tributary to a waterbody. The SAB notes that this equal allocation approach ignores the possibility of different background nutrient concentrations in upstream segments, and other characteristics of segments that would make nutrient load reductions impractical. In response to a SAB request for further information, the Agency described four options for distributing loads for calculation of DPV (Appendix C). Each of these options presents some issues, as discussed below.

- **Option A** distributes the load based on discharge, making the assumption that high nutrient loads are associated with higher flow rates. This option could present several unresolvable issues. For example, a stream with a low discharge but high nutrient load may be required to reduce its load to unachievable values. This could occur if a stream drains an area with elevated natural background, and would result in criteria that would require load reductions below background. Conversely, a stream with a high discharge may not be required to reduce its load even if there were some relatively simple approaches for reducing it load.

- **Option B** would distribute load based on watershed area drained. This would appear logical if the export of nutrients from all land uses were nearly equivalent, which it is not. As with Option A, this option might result in reduction targets that are unreasonable or unachievable in small subwatersheds while missing opportunities for reductions in larger watersheds. An integrated approach to load reduction should focus on watersheds, rather than on individual segments.

- **Option C** would distribute load based on natural or background loading. This approach seems reasonable if it is possible to accurately arrive at the natural background nutrient load for a segment or watershed. Essentially, an estimate of the natural background for each segment, given a set of criteria (slope, soils, etc), would set the achievable “DPV” for the stream segment. Such an approach is intellectually appealing, but may not be practical in the time frame given for the project. It does, however, strongly suggest the need to have a GIS-based model such as SWAT developed for the project and later implementation.

- **Option D** would distribute load based on average background, as described in Option C, or natural background, but include anthropogenic loading using existing data. The difference between natural and anthropogenic load would be the load that could be targeted for reduction. In the description of this option, it is suggested that average load for a stream/segment could be divided by the average discharge. This is the concentration, and makes one question the need to calculate loads or DPVs if we can simply express a maximum concentration for a stream or segment.

The SAB notes a few additional points to think about when considering the wisdom of DPVs:

- There are other sources, such as direct (e.g., groundwater and atmosphere) loadings to the estuary. How might those be addressed in the determination of tributary DPVs?

- Referring to Figure 2 (below), why should there not be DPVs for streams B2a and B2b in order to protect stream B1?

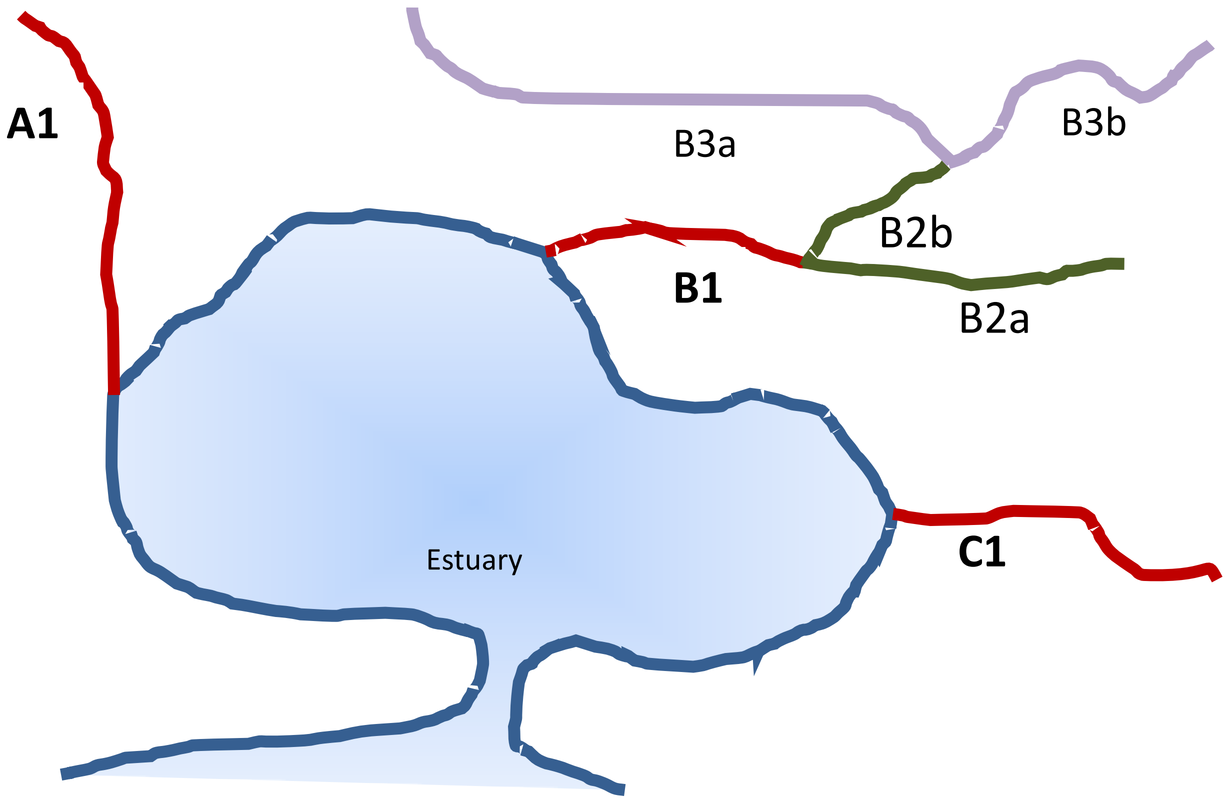

Figure 2. Example stream and estuarine segments.

Approach to Setting DPVs

EPA's proposed assessment of DPVs is based on watershed modeling (to be undertaken using the LSPC model) which results in an apportioned pollutant load reduction for each tributary to the waterbody (e.g., estuary) of interest. In an example in the review document, EPA proposes to apportion the pollutant load reduction (required to achieve compliance with the waterbody water quality criterion) as an equal fractional load reduction for each tributary to the waterbody. As noted above, this approach would formalize, and unnecessarily restrict, the more flexible pollutant load allocation process that occurs for TMDL pollutant load allocation when a water quality standard violation occurs. That said, the SAB has the following suggestions for the modeling of load reduction apportionment for upstream segments:

1. ***The watershed segment approach is valid, but care should be taken in selecting segments to take into account available data and other watershed characteristics such as predominant land-use.***

Given a need to complete watershed modeling for the purpose of determining DPVs, the division of the watershed into segments for the purpose of predicting loadings at the "pour point" into the estuary or marine receiving waters should not be limited to simple hydrologic division of the watershed. This may conflict with the premise of using a 12-digit HUC, but the segmentation process needs to take into account predominant land uses for a segment, and those land uses that may be significantly different. For example, urban areas, with high impervious surface cover and altered stream channels, are likely to behave in a way that is distinctly different than less developed areas. Therefore, a simple model delineation of subwatersheds may not be suitable and some expert analysis and adjustment of the segments would be more appropriate.

2. The impacts of urban environments should be considered.

Urbanized areas have a distinct influence on normal stream processes given their large areas of impervious cover. In addition to changes in stream habitat, runoff from impervious surfaces as well as municipal and industrial discharges may contribute to stream nutrient loads. For this reason, the SAB recommends that large urbanized areas be given special consideration in any modeling approach that might be used to generate DPVs.

3. Given that a complete uncertainty analysis cannot be accomplished, it is essential that, in all text in the revised report where uncertainty is mentioned, readers are clearly told what is included (excluded) in any uncertainty analysis undertaken or contemplated.

4. EPA should provide justification for the choice of the LSPC model and explain why it is the most applicable model for this case.

The LSPC model is an updated version of the older HSPF program. While the model can be integrated with a Geographic Information System (GIS), it is not a GIS-based approach. Numerous models exist for watershed management, physical flow, and water quality modeling that may better utilize the strengths of current GIS platforms. For example, the SWAT (Soil and Water Assessment Tool) model is commonly used in the development of TMDLs and is run within a GIS. Given the complexity of watershed modeling at the proposed scale and the complex nature of the problem being addressed, it may be prudent to build watershed models that can take advantage of a wider array of GIS-based tools and data for the current project and in future applications during implementation. This would not be a significant increase in work load, as the development of the GIS and SWAT model would replace the development of the LSPC model.

5. The time frame of modeling is important and should be linked to the response of the endpoints in the receiving waters.

In the EPA presentation on development of DPVs, it was indicated that adjustments for seasonal effects and flow levels are being considered. This is a very important consideration and the EPA is encouraged to analyze available data in the context of seasonal changes in the watershed and for the differences between baseflow and storm event conditions. Seasonal changes in the watershed may result from both natural processes (e.g., biotic activity) and from anthropogenic factors (e.g., agricultural practices). The differences in loadings seen during baseflow and storm events may be dramatic, with the majority of loading of TN and TP coming during a few large storm events. This is particularly true for N and P species associated with suspended sediment. Using an annual average value may grossly underpredict the impact of large storm events. Therefore, EPA should evaluate the sensitivity of the selected biological endpoints to the potential influences of shorter-term (e.g., days to weeks) events that may result in high levels of TN and TP loading to determine if annual or seasonal averages are sufficient to protect estuarine biota.

6. ***In-stream/watershed P transformations should be considered in greater depth for streams, lakes and canals.***

Species/fractions of N and P are often a part of TMDL modeling. If DPVs are to be developed in Florida, expressed as loads, and serve in a TMDL-like role, then DPVs might be expressed as nutrient fractions (for a biotic estuarine water quality criterion). In the discussion of nutrients, EPA correctly identifies the role of N species/fractions, but does not consider P species/fractions.

The dynamics of P in watersheds, lakes and canals is important to any effort to produce DPVs or similar water quality criteria. Foremost is the need to recognize the mobility, reactivity and bioavailability of the different P species: soluble reactive phosphorus (SRP); dissolved phosphorus (DP), which is the sum of SRP and total hydrolysable P (THP); and total phosphorus (TP), which is the sum of DP and particulate phosphorus (PP). These phases exist in natural waters in varying degrees that are dependent on processes within the waterbody and on external inputs. Furthermore, transitions among forms occur during transport within watersheds and within sediments in streams, lakes and canals. Although the modeling effort will evaluate TP for DPVs, the transport and fate of P should not be oversimplified. A brief overview of some of the extensive literature on P cycling and transformations within watersheds is provided in Appendix B.

7. ***How are nutrients, especially P, from natural or geologic sources separated from anthropogenic sources?***

Further complicating apportionment and determination of DPVs is the issue of background values for nutrients, especially P. Given that some areas of Florida have bedrock geology with high P concentrations, understanding background is critical. In watersheds where high P loadings are the result of natural factors, DPVs may not be applicable.

8. ***The continuum of fresh to saline waters in going from watersheds to the receiving estuarine or coastal marine waters must be considered in the process of determining DPVs.***

In many instances, fresh water systems are P-limited with respect to nutrient balance and the potential for the development of eutrophic conditions. The opposite is often the case for estuarine or marine waters, where N and P can be co-limiting or N is the limiting nutrient. This raises the potential where the application of upstream water quality standards that may be focused at reducing P inputs could be protective of the watershed, but create a situation in the downstream brackish or saline receiving waters that creates a nutrient imbalance (Elmgren and Larsson 2001; Paerl et al. 2004). This issue should be recognized during development of DPVs and implementation of recent inland water criteria.

3.6.2 DPVs for South Florida Estuarine and Coastal Waters

> <u>Charge Question 6(b).</u> *Are the methods that EPA is considering for deriving downstream protection values (DPVs) for marine waters in South Florida as described in Section 6.5 appropriate to ensure attainment and maintenance of downstream water quality standards, given available data? Please describe additional approaches and their advantages and disadvantages that EPA should consider when developing numeric criteria to protect downstream marine waters in South Florida, given available data?*

Unlike for estuaries in other parts of the state, the EPA document is not proposing an upstream apportionment of load reduction by stream segment because of the highly managed hydrology in South Florida. Instead, the document proposes setting a protective load at the terminal reach of each tributary, i.e., at the point where the tributary empties into estuarine or coastal waters. The EPA document discusses several schemes for allocating acceptable estimated nutrient loads among tributaries, including allocation based on flow-weighted concentration, flow-only, or total load for each tributary. The Panel's thoughts on various possible allocation schemes are presented in the previous section.

As discussed in section 3.4.1, the SAB recommends that nutrient criteria for canals be focused on downstream, rather than instream, protection from nutrient impacts. The SAB has the following additional comments:

1. ***Provide more information on how canals will be evaluated.***

A number of primary canals empty directly into coastal waters, so it will be important to incorporate all available data on N and P species for the terminal reach of these canals and to provide a more detailed approach on how DPV criteria will be developed.

2. ***The time frame of modeling is important and should be linked to the response of the endpoints in the receiving waters.***

Given the wide variation in flow conditions for canals, the concentrations of nutrients in canal waters are likely highly variable. Hence average nutrient concentrations in canal waters when released to estuarine and coastal marine waters may not adequately represent the concentrations needed to protect receiving waters. If additional information is not available for nutrient concentrations in the canals, discharge of canal waters to the receiving waterbodies needs to take into consideration loading rates on a daily basis that will ensure the receiving waterbodies meet their water quality standards.

3. ***In-stream/watershed P transformations should be considered in more depth for streams, lakes and canals.***

Although less is known about P transformations within the canals of South Florida than for streams, the physical and chemical processes that control P transport within a watershed should be the same for canals. Additional consideration, however, must be given to the special situations that result as a function of the wide-ranging flow situations for the canal system. Furthermore, it is important to understand the temporal parameters and their range of variability. These factors will determine, in part, the mechanisms that are most important under different sets of flow conditions.

4. ***The continuum of fresh to saline waters must be considered in the process of determining DPVs.***

For canal waters discharging to estuarine and coastal marine waters, the issue of the continuum of fresh to saline water is the same as discussed earlier in the Panel's response to charge question 6(a), above.

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APPENDIX A. CHARGE TO THE PANEL

Charge to the
Science Advisory Board
Nutrient Criteria Review Panel

Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters

Background

In 2011, EPA will propose numeric criteria for nitrogen/phosphorus pollution to protect estuaries, coastal areas and South Florida inland flowing waters that have been designated Class I, II and III[1], as well as downstream protective values (DPVs) to protect estuarine and marine waters. This is the second phase of a rulemaking effort as EPA has already established numeric criteria for Florida's lakes, flowing waters[2] and springs within the State of Florida, including DPVs for lakes.

As part of this current effort to derive chlorophyll-a, total nitrogen (TN) and total phosphorus (TP) criteria to protect estuarine and coastal water bodies, EPA must also develop additional criteria to assure that upstream criteria will meet standards established for downstream estuarine and marine waters in Florida. These DPVs, will supplement the existing inland water TN and TP stream criteria, if the applicable DPV is more stringent.

Overall, these numeric criteria are being developed to translate and implement Florida's existing narrative nutrient criterion, to protect the designated use that Florida has previously set for these waters, at Rule 62-302.530(47)(b), F.A.C. which provides that

> *"In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna."*

Under the Clean Water Act and EPA's implementing regulations, these numeric criteria must be based on sound scientific rationale and reflect the best available scientific knowledge.

EPA has previously published a series of peer reviewed technical guidance documents[3] to develop numeric criteria to address nitrogen/phosphorus pollution in different water body types. EPA recognizes that available and reliable data sources for use in numeric criteria development vary across estuarine and coastal waters in Florida and flowing waters in South Florida. In addition, scientifically defensible approaches for numeric criteria development have different requirements that must be taken into consideration in the context of the specific application and

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[1] Class I Potable water supplies; Class II Shellfish propagation or harvesting; Class III Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife.

[2] In the November 2010 rulemaking, EPA did not establish numeric criteria for inland flowing waters in South Florida. For the purpose of this effort, EPA has distinguished South Florida as those areas south of Lake Okeechobee and the Caloosahatchee River watershed to the west of Lake Okeechobee and the St. Lucie watershed to the east of Lake Okeechobee.

[3] U.S. EPA. 2000. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002;
U.S. EPA. 2001. Nutrient Technical Guidance Manual: Estuarine and Coastal Marine Waters. EPA-822-B-01-003;
U.S. EPA. 2010. Using Stressor-response Relationships to Derive Numeric Nutrient Criteria. EPA-820-S-10-001;

available information. This document describes the scientific approaches EPA is considering the derivation of numeric criteria to address nitrogen/phosphorus pollution in Florida estuarine and coastal waters, and inland flowing waters in South Florida, given the available data currently available.

Review Document: The SAB is asked to review the draft document, *Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters*, and respond to the following charge questions.

Charge Questions:

1. General Approach

a) EPA has introduced a general conceptual model in Chapter 2, including the selection of assessment endpoint and indicator variables. What is your perspective of the general conceptual model?

b) EPA has delineated the State of Florida into 4 general categories of waters—Florida estuaries, Florida coastal waters, South Florida inland flowing waters, and South Florida marine waters—for purposes of considering approaches to numeric nutrient criteria development . Are these categories appropriate and scientifically defensible? (Note that the details of segmentation of waters within these categories is addressed in subsequent charge questions.)

Florida Estuaries (Chapter 3)

EPA is considering three approaches: (1) reference conditions, (2) stressor/response models, and (3) water quality simulation modeling that could be used independently or in combination to develop numeric criteria for estuaries (exclusive of marine waters in South Florida that are covered in Chapter 5). Estuarine waters are defined as "a part of a river or stream or other body of water that has an unimpaired connection with the open sea and where the sea water is measurably diluted with fresh water derived from land drainage"[4].

2. Estuaries

a) Are the data sources identified appropriate for use in deriving numeric criteria in Florida's estuaries (as discussed in Sections 2.4 and 3.2)? Is the SAB aware of additional available, reliable data that EPA should consider in delineating estuaries or deriving criteria for estuarine waters? Please identify the additional data sources.

b) Are the assessment endpoints identified in Sections 2.3 and 3.2 (healthy seagrass communities; balanced phytoplankton biomass and production; and balanced faunal

[4] U.S. EPA. 2000 Estuaries and Clean Waters Act of 2000, http://water.epa.gov/type/oceb/nep/320.cfm (accessed 11/1/2010)

communities) appropriate to translate Florida's narrative nutrient criterion (as cited above) into numeric criteria for Florida's estuaries, given currently available data? Does the SAB suggest modification or addition to these assessment endpoints? A literature review of endpoints considered can be found in Appendix B.

c) EPA describes potential approaches in Section 3.3 (reference conditions, stressor response relationships, and water quality simulation models) for deriving numeric criteria in Florida's estuaries. Compare and contrast the ability of each approach to ensure the attainment and maintenance of natural populations of aquatic flora and fauna for different types of estuaries, given currently available data?

Florida Coastal Waters (Chapter 4)

EPA is considering a reference-based approach to derive numeric criteria for most of Florida's coastal waters. Coastal waters are defined as marine waters up to three nautical miles from shore[5]. Specifically, EPA is considering the use of a remote sensing method to develop numeric Chl_{RS}-a criteria for the Northwest Gulf Coast, West Gulf Coast, and Atlantic Coastal areas. Due to interference from colored dissolved organic matter and bottom reflectance on satellite measurements, EPA is not considering the derivation of Chl_{RS}-a criteria using remote sensing data in coastal waters from Apalachicola Bay to Suwannee River (Big Bend) and South Florida.

3. Coastal Waters

a) Are the data sources identified in Sections 2.4, 4.1.1 and 4.2 appropriate for use in deriving numeric criteria in Florida's coastal waters? Is the SAB aware of additional available, reliable data that EPA should consider in delineating coastal waters or deriving criteria for coastal waters? Please identify the additional data sources.

b) Is the assessment endpoint identified in Section 4.2 (chlorophyll-a to measure balanced phytoplankton biomass and production) appropriate to translate Florida's narrative nutrient criteria (described above) into numeric criteria for Florida's coastal waters, given currently available data? Does the SAB suggest modification or addition to this assessment endpoint?

c) Does the approach EPA describes in Section 4.2 appropriately apply remote sensing data to ensure attainment and maintenance of balanced natural populations of aquatic flora and fauna in Florida's coastal waters? If not, please provide an alternate methodology utilizing available reliable data and tools, and describe the corresponding advantages and disadvantages.

[5] Based on the Clean Water Act definition of "Waters of the United States"

South Florida Inland Flowing Waters (Chapter 5)

EPA is considering a reference-based approach to derive numeric criteria for South Florida inland flowing waters using least-disturbed sites that support balanced natural populations of aquatic flora and fauna. Alternative methods of criteria derivation for inland flowing waters include stressor-response relationships between chlorophyll-a and TN and TP, and a distributional approach using all sites. South Florida inland flowing waters are defined for this effort as free-flowing, predominantly fresh surface water in a defined channel and include, streams, rivers, creeks, branches, canals, freshwater sloughs, and other similar water bodies located in the South Florida nutrient watershed region[6].

4. South Florida Inland Flowing Waters

a) Are the data sources identified in Section 2.4 and 5.4 appropriate for use in deriving numeric criteria in South Florida's inland flowing waters (as discussed in Chapters 2 and 5)? Is the SAB aware of additional available, reliable data that EPA should consider in delineating or deriving criteria for South Florida's inland flowing waters? Please identify the additional data sources.

b) Are the assessment endpoints identified in Section 5.4 (balanced faunal communities, i.e., aquatic macroinvertebrates, and balanced phytoplankton biomass and production) appropriate to translate Florida's narrative nutrient criteria (described above) into numeric criteria for South Florida's inland flowing waters, given currently available data? Does the SAB suggest modification or addition to these assessment endpoints?

c) EPA describes two approaches in Section 5.4 (reference conditions and stressor-response relationships) for deriving numeric criteria in South Florida inland flowing waters. Compare and contrast the ability of each approach to ensure attainment and maintenance of balanced natural populations of aquatic flora and fauna in different types of flowing water or geographical areas, given currently available data?

[6] The South Florida nutrient watershed region is the area *south* of Lake Okeechobee and the Caloosahatchee River watershed to the west of Lake Okeechobee and the St. Lucie watershed to the east of Lake Okeechobee. EPA is not deriving criteria that would apply to waters located on the Seminole Indian Reservation or the Miccosukee Indian Reservation, waters located in stormwater treatment areas (STAs), wetlands, or marshes; or Class IV canals. EPA is also not establishing new TP criteria for the Everglades Protection Area (EvPA) in deference to the Everglades Forever Act (EFA).

South Florida Marine Waters (Chapter 5)
EPA is considering a reference-based approach to derive numeric criteria in South Florida marine waters using least-disturbed sites that support balanced natural populations of aquatic flora and fauna. South Florida marine waters include estuarine and coastal waters extending three nautical miles offshore. Estuarine and coastal waters in South Florida are considered together because the watershed based approach for delineating water bodies is less suited in South Florida due to its highly managed inland flows and open-water dominated systems (i.e., Florida Bay and Keys)

5. South Florida Marine Waters

a) Are the data sources identified in Section 2.4 and 5.5 appropriate for use in deriving numeric criteria in South Florida's marine waters (as discussed in Chapters 2 and 5)? Is the SAB aware of additional available, reliable data that EPA should consider in delineating or deriving criteria for South Florida's marine waters? Please identify the additional data sources.

b) EPA describes two methods in Section 5.6 for using a reference condition approach for deriving numeric criteria in South Florida marine waters (least-disturbed sites or bionomial test). Compare and contrast the ability of each approach to ensure attainment and maintenance of balanced natural populations of aquatic flora and fauna in South Florida marine waters, given currently available data?

Downstream Protection Values for Florida Estuaries and South Florida Marine Waters (Chapter 6)

The approach that EPA is considering for developing stream DPV criteria is to adjust upstream limits on TN and TP loading rates that are needed to support balanced natural populations of aquatic flora and fauna in downstream estuarine waters. The loading limits will be determined as part of the criteria development effort for estuarine and marine waters (as described in Chapters 3 and 5) and are scaled based on the average streamflow entering the estuary to determine criteria for TN and TP concentrations in streams as they discharge into estuaries or marine waters.

DPVs can be determined for upstream reaches within watersheds by accounting for expected loss or permanent retention of TN and TP within the stream network. Because of the complexities associated with the managed flows in South Florida inland flowing waters that are covered in Chapter 5, the fraction of TN or TP from the upstream tributary reach that eventually flows into the marine waters in South Florida cannot be estimated or predicted. Therefore, EPA is considering expressing DPVs at the terminal reach of the tributary into a South Florida estuary as protective concentrations or, alternatively, protective loads.

6. Downstream Protection Values for Florida Estuaries and South Florida Marine Waters

a. Are the methods EPA is considering for deriving downstream protection values (DPVs) for estuaries (excluding marine waters in South Florida) as described in Section 6.1-6.4 appropriate to ensure attainment and maintenance of downstream water quality standards, given available data? Please describe additional approaches and their advantages and disadvantages that EPA should consider when developing numeric criteria to protect these downstream estuarine waters (excluding marine waters in South Florida), given available data?

b. Are the methods that EPA is considering for deriving downstream protection values (DPVs) for marine waters in South Florida as described in Section 6.5 appropriate to ensure attainment and maintenance of downstream water quality standards, given available data? Please describe additional approaches and their advantages and disadvantages that EPA should consider when developing numeric criteria to protect downstream marine waters in South Florida, given available data?

APPENDIX B: Phosphorus Transport and Fate in Freshwater Systems

While streams are often viewed as simply a transfer mechanism for P, recent work has investigated processes that occur during transport. There are mechanisms that transform P within different physico-chemical fractions within the stream channel (Melack, 1995; Evans and Johnes, 2004; Evans et al., 2004), and the speciation of soluble P phases and fractionation of P are critical for any evaluation of transport or retention within a watershed. Various processes transform P including sorption, co-precipitation, and redox reactions (e.g., House 2003), and SRP interacts with stream sediments. Stream sediments act as both sinks and sources for SRP within the stream depending on the SRP concentration in the stream water and may change both temporally and spatially within a watershed (e.g., Jarvie et al., 2006; Ryan et al., 2007). This would suggest that EPA should evaluate existing data sets with regard to SRP and TP concentrations.

In comparing rural versus urbanized watersheds, Owens and Walling (2002) found that PP increased in stream sediments receiving point source discharge high in SRP, and that PP (inorganic and organic) may be the most significant mechanism for P transport. Up to 20% of the PP in stream sediment is likely to be easily bioavailable as inorganic P phases dominate. These mechanisms may also be active in lake or canal sediments. Given the short-term bioavailability of some fraction of the PP, it is important to evaluate TP in the context of SRP, DP and PP with some evaluation of the immediacy of the impact of each fraction.

Phosphorus retention within watersheds is typically dominated by calcite co-precipitation within bed sediment and physical trapping of sediment by reduction of flow velocity. Lake sediments may act as both sinks and sources for P cycling, with a large fraction of the inorganic P in surface sediments in equilibrium with the water column (Golterman 1995). The cycling of P is most prevalent in stratified lakes with anoxic hypolimnion, but significant cycling of P also occurs from oxic sediments (Bostrom et al., 1989; Jensen and Andersen, 1992; Rydin and Brunberg, 1998) found in nearshore environments, stream sediments and likely in canals.

P mobilization occurs under both oxic and anoxic conditions, and exchangeable and Fe-bound P are generally mobile (Rydin 2000). Organic-associated P is about 60% mobile, with greater mobility in anoxic sediments. P associated with Al and Ca is immobile and may be considered permanently bound. P release from aerobic sediments may deplete the Fe-bound P despite Fe remaining in the solid phase (Jensen and Andersen 1992). The release process involves a complex relationship between nitrate concentrations and microbial activity resulting in seasonal effect of increasing sediment P retention during winter with subsequent release during late summer and autumn. Biota also play a role in P cycling in lake sediments (e.g., bioturbation, rooted macrophytes that alter the sediment biogeochemistry). The likely lack of available data on the fractionation of P between the various physico-chemical phases will limit a detailed evaluation; however, it is important that modelling of P transport include some recognition of the biogeochemical processes involved in P cycling.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF WATER

MEMORANDUM

SUBJECT: Science Advisory Board Nutrient Criteria Review Panel Request for Information

FROM: Elizabeth Behl, Director
Health and Ecological Criteria Division
Office of Science and Technology

TO: Stephanie Sanzone, Designated Federal Official
Science Advisory Board

This memorandum is in response to the request for information from the U.S. Environmental Protection Agency Science Advisory Board (SAB) on the proposed methods and approaches to derive numeric criteria protective of downstream estuaries in Florida. In the SAB teleconference call on February 7, 2011, we indicated that there were several approaches that could be used to allocate nutrient loads among stream reaches within an estuarine watershed for the purpose of computing downstream protective values (DPVs). We provided one of those approaches to the Panel as an illustrative example at the SAB meeting in December (Option A below). EPA also is considering several other options, described below, including two (Options C and D) which take into consideration initial feedback EPA received from the SAB in December 2010.

Options for Distributing Loads

Option A: Distribute Load in Proportion to Flow. This option would distribute the watershed load among stream reaches according to the fraction of the total watershed discharge contributed by that reach, thereby addressing the fact that higher nutrient loading is often associated with higher freshwater flow. In developing this option, EPA also considered in-stream processing of nutrients, computing the aggregate loss and/or retention of nutrients within the stream network. Criteria derived using this approach could be higher for streams for which a significant quantity of transported nutrients are lost or retained before reaching estuaries. EPA described this approach in the Methods and Approaches document submitted to the EPA SAB for review.

Option B: Distribute Load in Proportion to Area. This option would distribute the watershed load among stream reaches according to the fraction of the total watershed area that is drained via that reach. DPV concentrations could be computed by dividing the loading limit for each reach by the average freshwater discharge from the respective reach. EPA does not intend to consider this approach further, recognizing that it does not take into account differences in freshwater yield (i.e., runoff per area), an important factor affecting nutrient transport from watersheds. Freshwater yield varies significantly among watersheds due to both natural and anthropogenic causes. For example, a watershed with high relief (i.e., slope) or significant impervious surfaces may have higher freshwater yield than a low-relief, forested watershed. DPV criteria derived using this approach could be much lower for high-runoff watersheds, and in some cases could be unreasonably low.

Option C: Distribute Load In Proportion to Natural or "Background" Loading. This option distributes the load among terminal reaches in a watershed in proportion to an estimate of the loading that would occur from each watershed in the absence of anthropogenic influence, which we refer to as "background loading." These estimates could be derived using the Loading Simulation Program in C++, or LSPC. This option would enable EPA to consider a diverse array of environmental information (such as slope, natural land cover type, soil types, local rainfall) in deriving numeric criteria. As an example, if the watershed TN or TP loading rate for an estuary is, in aggregate, 20% more than the estimate of background loading, the watershed load distributed to each terminal stream reach would be 20% more than the respective background load. DPV criteria could be computed by dividing the distributed loading by the average freshwater discharge. Since the estimates of these loads consider hydrological and other landscape factors, the DPV estimates will also reflect these factors. DPV criteria for upstream reaches could be determined recursively using the same process. DPV criteria derived using this approach limit loading to estuaries to the watershed load and DPVs criteria reflect a range of natural factors that impact nutrient concentrations in watersheds.

Option D: Distribute Load in Proportion to Existing Loading. This option distributes the watershed load among the terminal reaches in a watershed based on both the average background loading (as described above) and average existing loading (e.g., 1997-2009), recognizing that the difference between the estimate of existing loading and background loading is an estimate of anthropogenic loading. For example, if the aggregate watershed loading to the estuary is 30% less than the current loading rate, DPV criteria would be computed based on 100% of the background loading plus a fraction of anthropogenic loading, such that the total loading is equal to the watershed load. DPV criteria would be computed by dividing the divided load by the average freshwater flow. DPVs for unmodified watersheds with low nutrient yields would be relatively low, whereas DPVs for sub-watersheds with developed or agricultural lands would be expected to be higher, but lower than existing concentrations. DPV criteria derived using this approach limits loading to estuaries to the watershed load and DPVs reflect both natural and anthropogenic factors that impact nutrient concentrations in watersheds.