

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

# FDEP Comments on EPA's Notice of Data Availability

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## **I. EPA's rulemaking process has not provided adequate opportunity for the Florida public to comment because data, information, and analysis was not disclosed for certain central provisions**

The Department has attempted to comment on the many provisions contained in EPA's Proposed Rule and its Notice of Data Availability (NODA), but the absence of data, studies, and methodologies used by EPA for supporting certain core components of the Rule has significantly hindered FDEP's ability to provide feedback. It is critical that those essential provisions be properly evaluated because of:

- Their significance in determining if Florida's water resources are being appropriately protected; and
- The adverse implications associated with imposing criteria that could be scientifically or procedurally flawed.

### **A. Deriving Stream Downstream Protection Values for the Protection of Lakes using Bathtub**

No data or analysis was presented for how a model would be used to "create" downstream protection value criteria. Nothing was contained in the proposal, NODA, or docket regarding the methodology or process for converting the application of a water quality model to water quality criteria. EPA must provide information on the following types of issues:

1. Which components of BATHTUB were being suggested or considered (nutrient balance or eutrophication response, or both);
2. How would output variables be used to derive the magnitude, duration, and frequency of the criteria;
3. Under what circumstances should the model be used to create the criteria; and
4. What is the administrative process that would be followed to finalize criteria for individual lakes and officially adopt them?

The mere inclusion of the Corps of Engineers guidance manual on the model does not answer these questions.

### **B. Duration and Frequency of the Proposed Criteria for Streams for the Downstream Protection of Lakes**

The docket associated with EPA's proposal and NODA contains no data or methods for deriving or supporting the duration and frequency components of stream water quality criteria for the downstream protection of lakes, otherwise referred to as Downstream Protection Values (DPVs). In fact, the NODA and its associated docket do not even mention duration and frequency. As stated in EPA's proposal, "Aquatic life water quality criteria contain three components: Magnitude, duration, and frequency." The Department suggests that each component is of equal importance and the data and information supporting EPA's analysis for duration and frequency should be made available for public comment as was the data and analysis for magnitude.

EPA's proposed rule using the Vollenweider equation appeared to apply the same duration and frequency used for in-stream protection values as the duration and frequency for downstream protection values. However, there is no discussion, analysis, data, or literature provided or cited to assist the public in the review of this proposal. The TSD does not even mention duration and frequency of DPVs, but simply talks about deriving the total phosphorus concentration (magnitude). Without providing any information or discussion, it is impossible to properly evaluate the proposal. The Department raised this issue in our earlier comments because the application of a steady state model is incompatible with the in-stream protection value's duration and frequency, a clearly unsupported and erroneous result. However, EPA has yet to provide any information for review.

### **C. Delineation of Nutrient Watershed Regions for Total Nitrogen**

EPA's proposed rule and associated docket includes one chapter of the TSD that discusses the methodology for developing a regionalization scheme; however that methodology only includes the data and analysis for regionalization of the total phosphorus criteria, not total nitrogen (TN). The NODA, and its associate docket, only contained the following statement, "EPA considered different approaches to classifying Florida's streams for application of TN criteria, such as the four Nutrient Watershed Regions discussed in the January 2010 proposal and two regions as originally suggested by FDEP. However, differences in the resulting TN criteria based on these stream classification schemes were minor and the approaches were comparable." There was no data or analysis that described how EPA came to this conclusion. As a result, the Department was unable to determine how EPA reached this conclusion. Without providing any additional analysis or explanation, the Department simply cannot comment on the proposed regionalization scheme for TN (other than opining that the scheme does not appear to be derived on any recognized scientific basis). FDEP notes the strong relationship between TN, color, and proportion of drainage basin wetlands, and suggests that EPA propose criteria based on these relationships.

### **D. Application of Lake Criteria to Streams without a Working Model**

The docket and record associated with the NODA and the proposed rule do not contain any data, methodologies, or analyses needed to evaluate or support EPA's proposal to require applying the lake criteria as stream DPVs, which makes the review of the concept virtually impossible. The docket does include a publication regarding the BATHTUB model [EPA-HQ-OW-2009-0596-2435] that describes all the variables that go into lake nutrient dynamics. Rather than supporting EPA's position, the information provided in this publication clearly demonstrates why EPA's reliance on this concept is a gross oversimplification of the science. EPA does not support or provide information related to their position that the lake criteria should be applied to the headwaters of upstream flowing waters, blatantly failing to acknowledge factors such as assimilation, uptake, and settling. EPA is on record as recognizing that TN reduces as it moves downstream, and FDEP has previously pointed out the complexities of TP fate and transport dynamics, including that significant reduction in TP may occur between upstream areas and downstream lakes. Since the contents of the docket do not contain any relevant data, analysis, or literature citations to support this concept, it is impossible to evaluate its merits.

## **E. Summary**

The above examples identify areas where EPA's rulemaking is proceeding in the absence of EPA providing data, analyses, or pertinent information. This deficiency significantly hinders the public's ability to comment. While some underlying data and reports may have been included in the docket (such as stream data and the Corps document on BATHTUB), it is the methodology used in creating the criteria proposals and the meaning to be inferred from the reports that should be part of the public record. Not disclosing these methods and interpretations prevents the public from making relevant comments.

## **II. Nutrient Watershed Regions**

### **A. Delineation of the TN Regions**

EPA proposed distinct Total Phosphorus (TP) regions based on geological evidence (areas where the presence of the high phosphate Hawthorne Formation influenced stream concentrations). With no further justification, EPA then used the same regions to establish Total Nitrogen (TN) criteria. FDEP has conclusively demonstrated that non-anthropogenic TN concentrations are most influenced by the percent area of wetlands in the drainage basin because wetlands naturally discharge water high in humic acid substances, color, and organic nitrogen. Therefore, TN regions should be based on percent wetlands or stream color, and should not arbitrarily follow the TP regions, which were most influenced by geology. FDEP conducted geospatial analysis to illustrate that the phosphorus regions were not appropriate. Figures 1 and 2 depict TP and TN concentrations in streams throughout Florida, respectively. [There were no sampling sites located in the South Florida Region so the Krige results should not be relied upon in that area of the State.] Note the lack of similarity between the TP concentrations (which are influenced by the Hawthorne Formation) and the TN concentrations (which are influenced by wetlands).

Generally, it appears that TN concentrations throughout much of the Peninsula are higher than to those in non-Peninsula regions. However, the Krige also identifies pockets of differing TN concentrations in small areas within those areas as well. When you observe each station, it appears that overall TN concentrations may be more driven by local, waterbody specific conditions related to wetland influence rather than overall geographic areas. The stream color map clearly shows locations of major wetland systems (Fisheating Creek and Peace River wetlands, Green Swamp, Okefenokee and Pinhook Swamps, San Pedro Bay, etc.) characteristic of certain areas of the State. As stated previously, wetlands contribute both color and TN to adjacent stream systems. It should be emphasized that the reference stream color and TN spatial distribution does not coincide with the TP regions based on the geologic Hawthorne Formation, and EPA needs to approach TN differently than TP to account for the influence of wetlands.

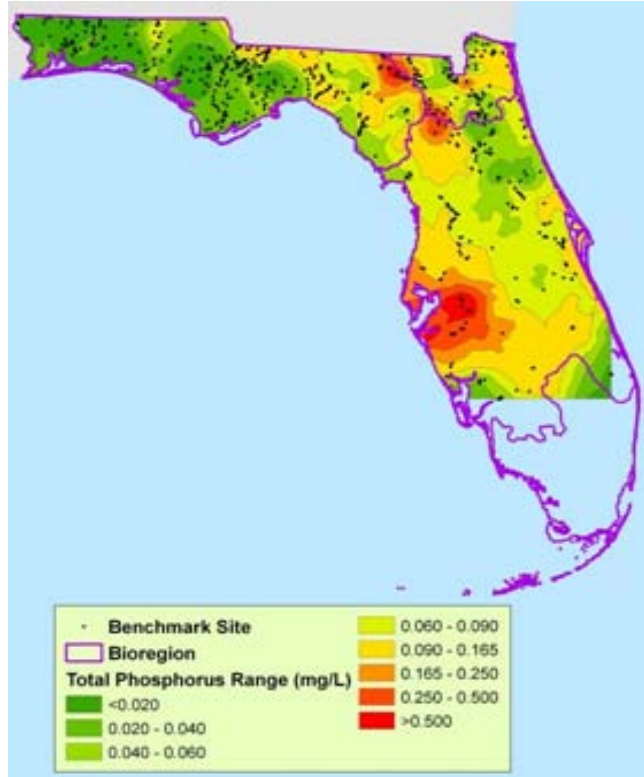


Figure 1. Kriged Total Phosphorus concentrations in Florida Streams.

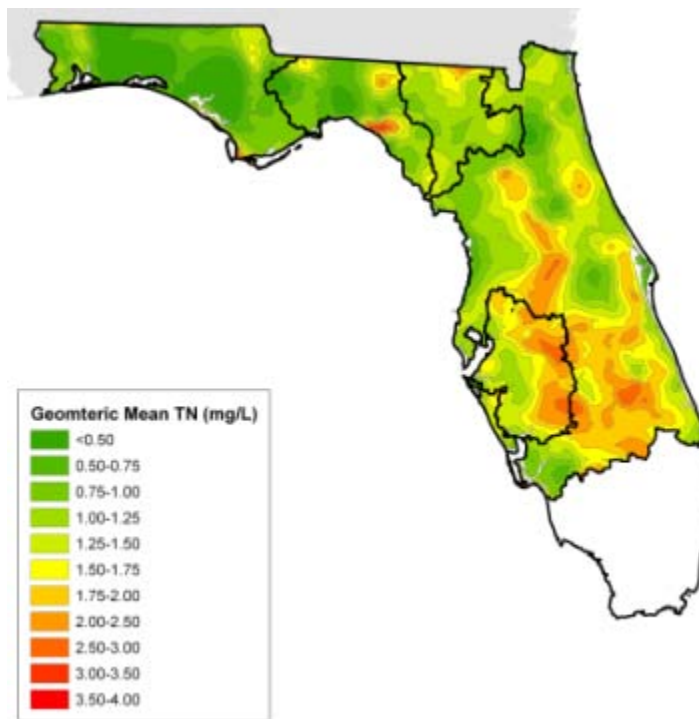


Figure 2. Kriged Total Nitrogen concentrations in Florida Streams.

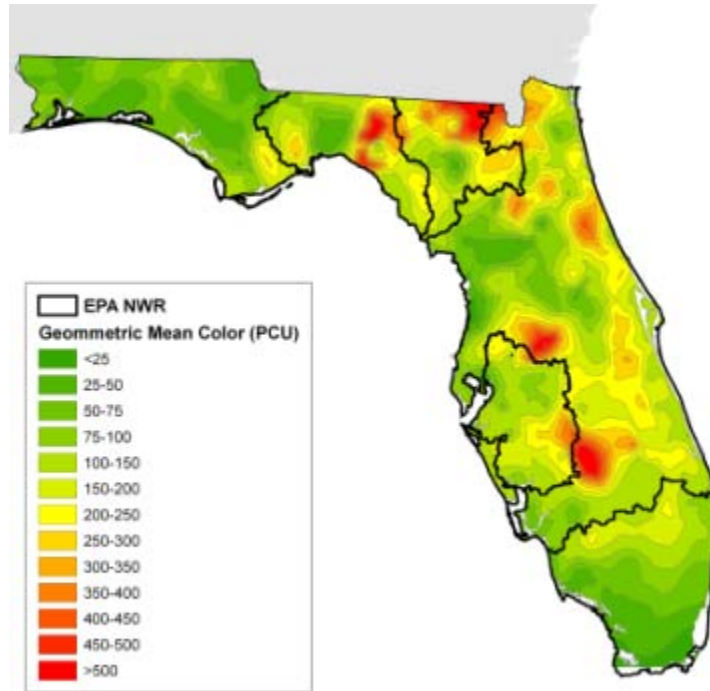


Figure 3. Kriging of stream color (PCU), which is largely influenced by wetlands.

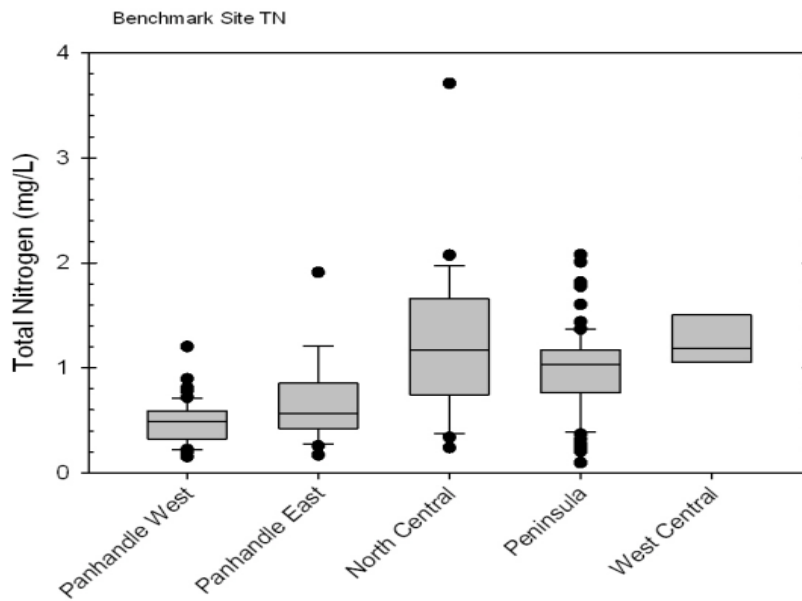


Figure 4. Box plots of benchmark TN values in EPA's proposed nutrient regions. Note overlap in values from North Central, Peninsula, and West Central regions.

Box plots of TN values in EPA's proposed nutrient regions (which are actually based on geologic formations that influence TP) are shown in Figure 4. Note that there is overlap in all regions with a general difference in the Panhandle. The data presented above indicate that EPA's decision to base TN regions on factors that only influence TP is clearly flawed. FDEP originally proposed that TN regions be aggregated to account for the generally lower concentrations in the panhandle, but now believe that is it more accurate to link criteria to the percent wetlands expected to affect the waterbody in question, which alternatively could be measured as color. The TN Krige might lead you to believe that there are geographic differences, but the more determinant factor is the local influence of wetlands on a given waterbody.

### **B. Delineation of the West Central Region**

EPA inappropriately modified the boundaries of the West Central (Bone Valley) TP region that were originally proposed by FDEP. EPA moved the boundary of the West Central region, an area of naturally very high phosphorus, to include portions of stream drainage areas that are outside of the Hawthorne Formation and that would be expected to have significantly lower natural TP concentrations than streams that actually drain the Bone Valley Hawthorne Formation. The decision to move the boundary to include streams with naturally lower TP could result in under-protective criteria for those streams if it were not for the fact that values above reference-based criteria have not been linked to impairment in Florida streams. It is our understanding that EPA made this change so that all portions of a watershed were in the same nutrient region, however we do not believe it is appropriate to do so given that the geology is different in portions of the watershed.

## **III. Methods for Criteria Development**

### **A. EPA's Updated Criteria contain in the NODA Are Incomplete**

Criteria must include magnitude, frequency, and duration components. EPA's NODA only included magnitude expressions for the SCI approach and benchmark approach. Without specified expressions of duration and frequency, the magnitude component of the criteria is inordinately vague, and it is virtually impossible to calculate the associated Type I or Type II errors.

As EPA is aware, magnitude is a measure of how much of a pollutant may be present in the water without an unacceptable adverse effect. Duration is a measure of the averaging period of the magnitude, and frequency relates to how often the magnitude/duration expression may be exceeded without adverse effects. It is preferred to derive the criterion through a cause-effect relationship. The magnitude, duration, and frequency can then be set at a level that would protect a majority of the sensitive aquatic organisms inhabiting the system. Absent a demonstrated cause-effect relationship and using a reference condition approach, the magnitude, duration, and frequency should be set at a level designed to maintain the data distribution of the reference system, accounting for natural temporal variability.

"Reference-based" approaches are predicated on the premise that the continued maintenance of nutrient levels (the data distribution) associated with healthy biological conditions will fully support the designated use and will

protect and support those uses into the future. However, it must be emphasized that exceeding a criterion derived from a “reference-based approach” **does not** automatically mean that deleterious biological responses, or use impairment, will occur.

A criterion derived using a reference distribution has no direct link to any observed cause and effect relationship, and as such, it generally has low Type II errors (assessing the waterbody as healthy when it is not). It can only be concluded that maintaining the reference distribution will preserve the uses associated with that distribution. Therefore, the frequency and duration components must be established as additional descriptors of the reference condition data distribution. Specifically, these components should be part of a statistical test designed to determine whether the long-term distribution has shifted upward from the reference distribution. It is critical to account for the natural variability surrounding the criteria expression and to control for statistical errors. Earlier FDEP comments suggested an appropriate magnitude, duration, and frequency for nutrient criteria derived using a reference stream approach.

Previous proposals, such as U.S. EPA’s January 26, 2010 proposal for Florida streams describe the frequency and duration component of a numeric nutrient criterion as, “the annual geometric mean for a waterbody shall not surpass the reference site 75<sup>th</sup> percentile more than one time in a three-year period.” The problem with this approach is that it results in an unacceptably high Type I error rate for waterbodies with long-term geometric mean concentrations near the 75<sup>th</sup> percentile. In fact, a waterbody with long-term geometric mean at the 75<sup>th</sup> percentile would be expected to exceed this test 50 % of the time.

EPA’s omission of frequency and duration expressions from the NODA prevents FDEP from further assessing the appropriateness of the criteria derived using the two approaches presented, and specifically, from calculating the Type I and Type II statistical errors associated with the magnitude expression.

## B. Reference Stream Approaches

### 1. Benchmark Approach Comments

Given the lack of a nutrient dose-response relationship, FDEP supports the minimally disturbed benchmark approach for criteria development, but **only if the shortcomings of the approach are adequately addressed through implementation provisions such as using a response based verification when assessing conditions.** Criteria derived using reference-based approaches are inherently protective of the resource, provided the following are true:

- Waterbodies within the population exhibit full support of a healthy, well-balanced community (which DEP demonstrated);
- The reference waterbodies are similar and comparable to the target population to which they will be compared (appropriate regionalization); and

- The nutrient regime (distribution) is sufficiently characterized, including the full range of temporal and spatial variability (appropriate frequency and duration, and data sufficiency).

Benchmark criteria proposed in draft regulations by FDEP were fully consistent with the above factors, with the exception of the frequency component because the Department proposed an exceedance frequency of no more than one exceedance in a three-year period. This frequency component was revisited in comments provided earlier by the FDEP on EPA's proposed rules. FDEP has determined that it is more appropriate to target a long term central tendency with an associated 40-60% exceedance frequency.

DEP's main concern with EPA's application of the "benchmark approach" for the development of stream nutrient criteria is that EPA did not fully acknowledge the basic limitation of the approach – that the resultant criteria **are not linked** to a cause-effect relationship indicating impairment.

With one exception (*i.e.*, nitrate in clear streams), the results of FDEP's comprehensive analyses indicated the statistical relationships between the biological response variables and nutrient concentrations were very weak, and therefore, neither DEP nor EPA could identify specific thresholds for establishing numeric TP and TN criteria due to the relative lack of a consistent dose-response relationship. Therefore, if the reference site approach is used, additional mechanisms must be included to avoid arbitrary and unnecessary regulatory actions. These mechanisms would include using an upper distribution of the data to establish a threshold to account for natural contributions from geology (TP) and wetlands (TN), controlling for Type I errors, and the incorporation of response based (biological) validation of nutrient impairments.

## 2. SCI Based Approach Comments

Beyond the lack of a duration and frequency component, the SCI based magnitudes proposed by EPA were inadequate due to data sufficiency issues and the omission of several healthy wetland-influenced reference sites (naturally low in DO and high in TN). Based on these factors, FDEP concluded that the resulting nutrient data distribution compiled using the SCI based approach is non-representative of the resource.

Figures 5 and 6 show the number and percent of the of TP and TN samples, respectively, that EPA used to develop the SCI data distribution. The fact that 60% of the sites were represented by only a single data point is a severe limitation of EPA's SCI approach. It cannot be demonstrated that a single nutrient data point is representative of a given streams nutrient condition, much less when extrapolated to be representative of an entire region. Earlier comments provides by FDEP demonstrated the volatility of nutrient conditions in minimally disturbed streams that occur due to natural conditions.

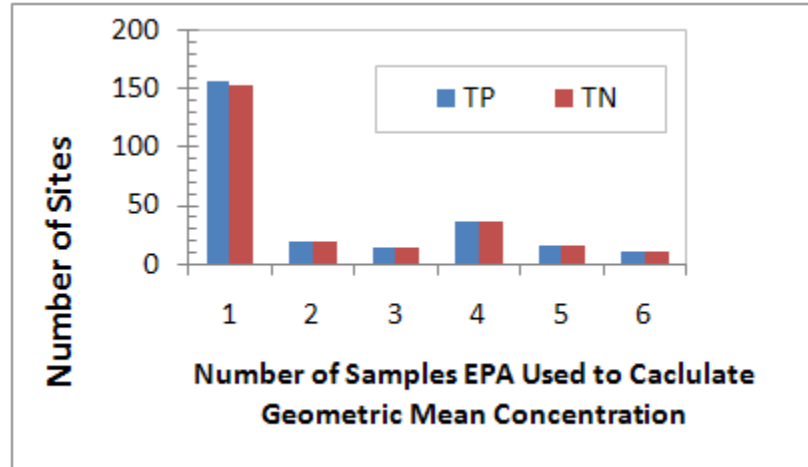


Figure 5. Number of samples EPA used to calculate geometric mean concentrations.

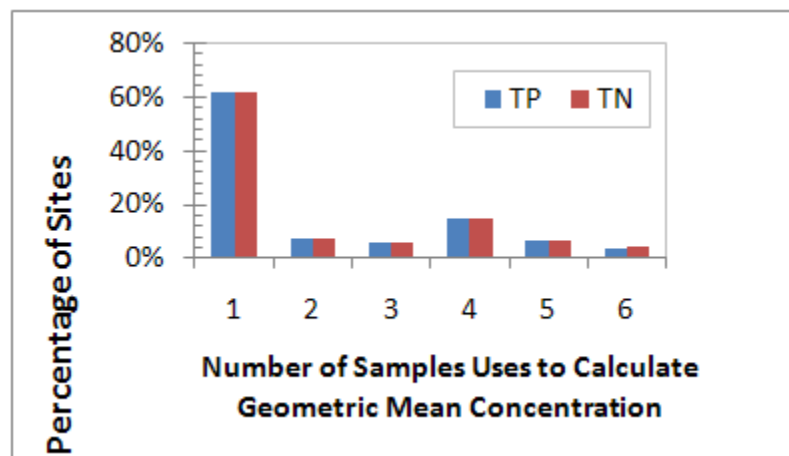


Figure 6. Percent of samples EPA used to calculate geometric mean concentrations.

Additionally, this construct makes it virtually impossible to derive a duration component to the magnitude of the criteria. One would assume that if the data distribution was derived using a long term average, then the criteria would be expressed as a long term average. However, given that the “long term average” was calculated using different amounts of data representing different time periods (some being a single sample), there is no logical means to derive a duration component to the criteria. This basic limitation makes it virtually impossible to derive nutrient criteria with all necessary magnitude, duration, and frequency components.

When deriving criteria using the benchmark approach, FDEP ensured that each WBID had a minimum of four data points per year and constructed the data distribution on annual geometric means. This decision was made after investigating the effect that the number of samples per station had on the overall data distribution, and FDEP concluded that four samples in a given year was appropriate. This also provides for a logical outgrowth of

the magnitude and duration component of the criteria. FDEP strongly recommends that EPA use the benchmark approach, providing for a minimum data sufficiency requirement, and including of all healthy sites (including those with naturally low DO and naturally high nutrients).

*Benchmark Criteria are Inherently Protective of Downstream Waters*

DEP moved forward with the “minimally disturbed reference site” approach with the logical assertion that nutrient concentrations characteristic of minimally disturbed streams would be inherently protective of downstream waters. Therefore, **Downstream Protection Values (DPVs) for lakes and estuaries are not necessary if EPA relies on the benchmark approach to establish stream criteria.**

**C. EPA Should Not Eliminate Sites Due to Natural Low DO**

EPA incorrectly excluded several of FDEP’s nutrient benchmark sites because they exhibited naturally low dissolved oxygen (DO), even though the sites passed the SCI and their respective watersheds primarily consisted of wetlands. As previously described to EPA, Florida’s fresh waters are exposed to temperate to subtropical climates, and many originate in low DO environments, such as swamps and groundwater aquifers. These sources are naturally low in DO, and have natural daily and seasonal fluctuations in DO that fall below 5.0 mg/L. Since these levels are the result of natural conditions and the native flora and fauna have adapted to this natural variation, they generally do not impact the designated uses.

DEP conducted a Dissolved Oxygen Study to characterize the causes of naturally low DO levels to more clearly define “natural conditions.” Counter to the premise that sites with higher human disturbance (and nutrients) are associated with lower DO, **the results of the DO Study demonstrated that reference streams and lakes (LDI < 2) actually exhibited higher frequencies of DO values < 5.0 mg/L than sites with higher human disturbance and higher nutrient levels** (see Table 1).

**Table 1. Summary statistics from DEP's DO Study.**

Waterbody Class I	Reference	Count	Average DO Conc	Average % Excursions	% of sites with >10% Excursions
Lake	Non-reference	69	7.72	6.5	17.4
Lake	Reference	82	6.55	20.9	52.4
Stream	Non-reference	84	5.55	38.6	67.9
Stream	Reference	81	5.55	39.8	70.4
Canal	Non-reference	29	5.26	48.8	75.9
Canal	Reference	3	4.87	54.7	100.0

It is the experience of DEP scientists that naturally low DO occurs when:

- Temperatures are elevated;

- Water velocity is low and stagnant conditions prevail;
- Waterbodies receive substantial leaf litter from forests and swamps, and natural decomposition processes reduces DO; and
- Morphological conditions, such as depth, promote depositional processes, which in turn lead to low DO.

EPA has historically acknowledged that Florida has naturally low DO, and has approved several Site Specific Alternative Criteria for DO in Florida waters. The Florida data show that EPA's assumption that low DO results from adverse nutrient enrichment, automatically eliminating them from reference status, is not supported by the data.

Unfortunately, when FDEP adopted its current DO criteria in 1986, EPA recommended ecologically relevant language regarding an acceptable departure (10%) from natural conditions was not included as it was for other natural stressors (e.g., conductivity, pH, temperature). The repercussions of this oversight did not become readily apparent until the implementation of the Total Maximum Daily Load (TMDL) Program. Without a specific natural background clause for DO, numerous natural waters were identified on the Clean Water Act (CWA) 303(d) list for low DO. However, EPA's 1986 Ambient Water Quality Criteria for Dissolved Oxygen document included language within the Conclusions section related to naturally-occurring low DO (EPA 440/5-86-003). Based this language, the 1986 Water Quality Criteria document logically did not intend for naturally low DO waters to be considered in violation of the DO criteria.

It follows then that these waters should not be excluded when developing a reference site population. By excluding perfectly healthy, but naturally low DO reference sites, the reference site distribution is no longer representative of the full range of Florida waters that support a healthy, well balanced aquatic community. Because many of these wetland influenced, naturally low DO waters also have naturally elevated levels of color, TOC, and organic nitrogen, exclusion of these sites can result in shifting the TN distribution downward, resulting in excessive Type I errors.

Figures 7, 8, and 9 illustrate the relationships between average DO levels and total organic carbon & color, respectively. As the TOC concentration increases, the natural level of nitrogen in the stream increases (see Figure 7). Also, as color from wetlands increases, the average DO condition of the water decreases. Therefore, to assure that the full range of natural nutrients is considered in the derivation of numeric nutrient criteria, sites with naturally low DO levels below the existing criteria, especially those strongly influenced by discharge from marshes and wetlands, **should not be omitted** from the analysis. On the contrary, EPA should include these naturally low DO sites and recalculate the criteria based on the full reference site distribution.

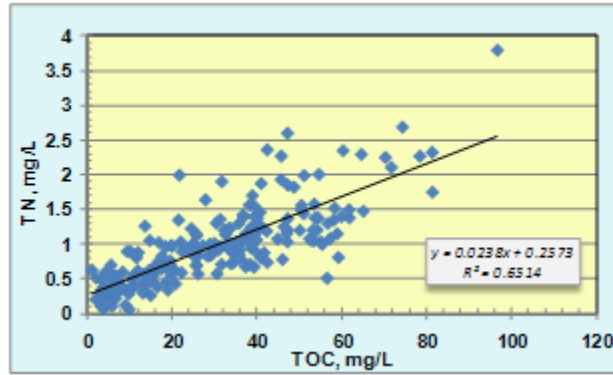


Figure 7. Relationship between TN concentration and TOC concentration.

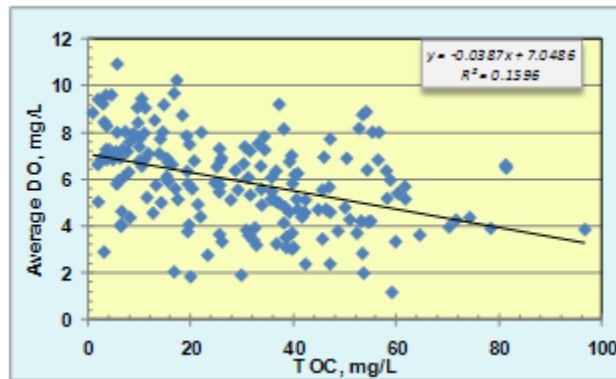


Figure 8. Relationship between TOC concentration and DO concentration.

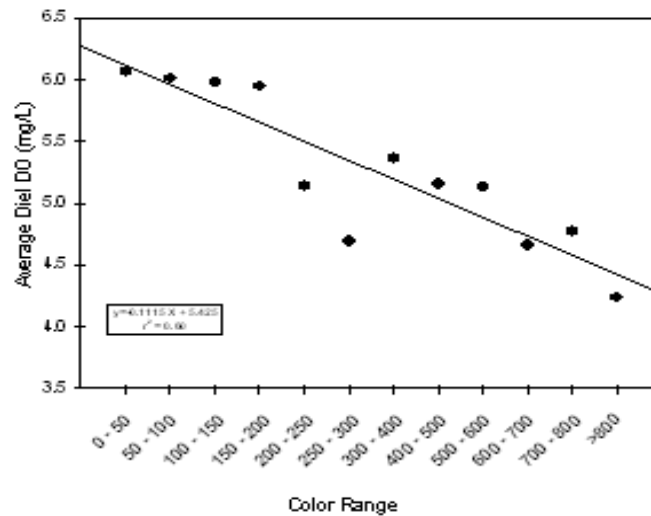


Figure 9. Relationship between average diel DO and color range.

## **D. Application of the Benchmark Approach in the Bone Valley Region**

EPA included only a single reference stream, which had very few observations, to derive TP criteria for the entire West Central Region, which is 4,845 square miles (12,572 square km). It is difficult to argue that this single stream, Deer Prairie Creek, is representative the entire region, especially considering that its location is peripheral to the main phosphatic deposits, meaning its TP concentrations would likely be lower than the rest of the region. Additionally, Deer Prairie Creek, a small second order stream, would not be representative of the larger systems in the area (third to sixth order streams).

USGS recently published a study entitled, "Mapping Watershed Potential to Contribute Phosphorus from Geologic Materials to Receiving Streams, Southeastern United States." The authors (Terziotta *et al.* 2010) demonstrated that the mean sediment bed concentrations of phosphorus were very high, in general, throughout the Florida peninsula to the Big Bend region, but were extraordinarily elevated in the West Central Region (up to 18,150 ppm). It has been well established that the leaching of sediment phosphatic material results in high water column TP concentrations. Rather than relying on only a single reference site for the area, FDEP suggests that EPA investigate this evidence and work with the USGS to develop "background" TP concentrations in the West Central region. TP criteria developed in this manner would be much more representative of the region than what EPA has proposed (a single reference stream). EPA should also evaluate whether the SCI approach given the data limitations could also be considered representative of the river/stream conditions in the West Central region.

## **E. Applicability of Benchmark Criteria to Intermittent Streams**

An issue has been raised as to whether it is appropriate to apply criteria derived using the Benchmark or SCI approaches to intermittent streams. To evaluate the significance of this issue, using the National Hydrography Dataset, FDEP counted 8,880 miles of intermittent streams and 20,967 miles of perennial streams/rivers. Intermittent streams comprise approximately 30% of all the stream miles in Florida. Appendix B contains a description of how stream miles were counted.

Intermittent streams tend to flow for only portions of each year, and therefore, chronic desiccation is a prime stressor that significantly restricts the resident aquatic community. Because of the influence of desiccation, there is currently no quantified biological expectation for intermittent streams. Also, there is not an applicable bio-assessment method for these streams since the SCI methodology requires a minimum of three months of verified antecedent flow conditions. This makes documentation of healthy condition virtually impossible.

Additionally, deriving criteria for intermittent streams from data collected from perennial systems may not be appropriate. Nutrient concentrations of intermittent streams are often reflective of different climactic

conditions and different sources (surface vs. ground water contributions) so information collected from perennial stream may not be sufficiently similar for application as a reference stream.

The averaging period of the criteria can also be a factor because applying a long term average concentration criteria to a waterbody that does not contain water over that term may not be appropriate. Using the SCI approach, the data set was representative of long term conditions. Using the Benchmark approach, the data set was representative of annual average conditions.

## **IV. DPV Approach to Lakes**

### **A. The Downstream Protection Value provision is legally and scientifically unnecessary.**

Federal regulations at 40 CFR 131.10(b) state, "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."

EPA has interpreted this provision to mean that each and every criteria established by a State must ensure the protection of downstream waters, however that interpretation is neither necessary nor possible to implement. A valid interpretation is that the State's collective standards (versus each component of its standards) as adopted must ensure the protection of downstream waters. When a State's water quality standards contain protective criteria for both upstream and downstream waters, then it can be argued that a State's standards provide for the attainment and maintenance of water quality standards of both the upstream and downstream waters. Once the criteria for lakes are promulgated, Florida will have standards for the downstream lake waters that provide for their attainment and maintenance and it is not necessary or reasonable to establish stream DPVs when the methods needed to create the link between upstream and downstream is lacking. This last part is critical because the scientific merits of any proposal must be weighed when deciding whether the perception of necessity to adopt DPVs outweighs the weaknesses contained in the science.

This provision can also be met if it is demonstrated that the upstream criteria does in fact provide for the attainment and maintenance of downstream waters. The In-Stream Protection Values (IPVs) as proposed by EPA in the notice of data availability using the Benchmark distribution approach were derived using minimally disturbed sites with respect to nutrients. Therefore, if streams attain the IPVs derived this way, then the nutrient delivery to the downstream lakes would be considered protective of the lake's minimally disturbed or naturally expected trophic state/condition. Nutrient concentrations in minimally disturbed streams will not cause increased eutrophication in downstream lakes, account for fate and transport in streams, and ultimately provide inherent protection. The Department strongly encourages EPA to review the literature and understand that all lakes that receive flow from streams are undergoing natural eutrophication. Therefore, stream contribution of nutrients that are not anthropogenically elevated would be a part of that natural process.

**B. BATHTUB is an improvement over applying the Vollenweider equation, but EPA did not provide any methodologies regarding when BATHTUB should and should not be used to create the DPV**

FDEP was supportive of moving towards a modeling approach to implement provisions like this in our earlier comments. FDEP stated, "Alternative models that could be applied to lakes with lake specific data will provide the most accurate results. Sophisticated models like WASP have the highest likelihood to produce accurate results if lake specific input variables are used. EPA should consider making this type of modeling approach the rule and the more erroneous formulas the exception. The Department is only interested in implementing scientifically justified water quality standards." However, using a model also has limitations. The State has used BATHTUB as a tool to address water quality issues in Florida lakes before, but there were times when BATHTUB did not work.

There are circumstances when BATHTUB cannot be used, such as lack of data and resulting simulation error. EPA included no explanation or methodologies in the NODA regarding when a DPV should and should not be calculated using BATHTUB. The docket did contain a document regarding model testing for BATHTUB, but did not provide any methods for analysis of when a model was sufficient for the establishment of downstream protection values. The Department has utilized BATHTUB numerous times when calculating Total Maximum Daily Loads and offers the following comments.

- 1) The BATHTUB model should not be used to establish nutrient targets if site-specific lake morphology and water residence time data are not available or if Submerged Aquatic Vegetation (SAV) covers more than 30 percent of the lake area (*Canfield, et al. 1983*).
- 2) BATHTUB should not be used to establish nutrient targets without conducting a successful calibration. A successful calibration would be when the relative percent difference between the predicted (P) and measured (M) concentrations are less than 30 percent, e.g.  $(((P-M)/M)*100)$ . Note that DEP does not have a specific literature reference for use of 30 percent, but is relying on the collective experience and judgment of staff.
- 3) BATHTUB should not be used to develop nutrient targets if internal fluxes (loading from sediment fluxes or nitrogen fixation) are a significant source until the information is developed that verifies the source of the material, the rate of the flux, and establishes how changes in external loading change the internal flux rate of phosphorous or the persistence of nitrogen fixation.

BATHTUB Background

BATHTUB is part of an interrelated set of management tools (Simplified Procedures for Eutrophication Assessment and Prediction) established by the U.S. Army Engineering Waterways Experiment Station. BATHTUB is not a model; it is a model suite that includes two major model sets: 1) a mass-balance model set that estimates the in-lake (reservoir) nutrient concentrations based on external nutrient loadings, morphology, hydrology, and sedimentation characteristics of the subject lakes/reservoirs, and 2) an eutrophication response

model set that estimates the chlorophyll concentration, Secchi depth, trophic state index (TSI), and hypolimnetic oxygen concentration based on the in-lake/reservoir nutrient concentrations. All the models included in these two model sets are empirical models developed from studies conducted on a diverse set of lakes and reservoirs or utilizing values obtained from published literature.

### Advantages

The advantage of the BATHTUB tool set is that it provides the flexibilities that any single one empirical model does not have in dealing with lakes with different characteristics such as;

- (1) different external loading characteristics (different inorganic to organic nutrient ratios),
- (2) different morphology (surface areas, mean depths),
- (3) whether the waterbody is a lake or reservoir,
- (4) deep or shallow,
- (5) waterbodies with thermal stratification versus well mixed conditions,
- (6) urban lakes with complex landuse interactions or lake/reservoirs in watersheds with balanced landuse types,
- (7) different hydraulics (different flushing rate and water residence time), and
- (8) to a lesser extent, the suite of tools can allow consideration of internal nutrient loading and nitrogen fixation, and different factors that limit the growth and accumulation of phytoplankton biomass (phosphorus limited, nitrogen limited, phosphorus and nitrogen co-limited, light limited, and flush limited).

These advantages provide lake/reservoir managers with multiple options when assessing the nutrient condition and establishing water quality targets for a particular lake/reservoir. While BATHTUB provides much flexibility in dealing with specific lake/reservoir case, the model suite should be used with caution so that the functionality of the model will not be abused, especially if the software is used to establish water quality targets or criteria.

### Use of BATHTUB to Establish Downstream Protection Values for Lakes

One very important issue is to calibrate the selected model based on waterbody specific data. Although BATHTUB was cited as an effective tool for lake and reservoir water quality assessment and management when local data were limited (Ernst et al., 1994), the BATHTUB user manual (Walker, 1996) indicates that the application of the model suite on U. S. Army Corp of Engineering reservoirs showed a 95-percent confidence factors of 1.72 and 2.00 for total phosphorus (TP) and chlorophyll *a*, which is a fairly broad confidence limit (without successful site-specific calibration, model predictions could be plus or minus two times the measured data). The user manual indeed indicates that this “error magnitudes refer to predictions which are made without the benefit of site-specific water quality information. In applications to specific lakes/reservoirs, prediction errors can be significantly reduced by calibrating the model. Calibration is especially important for:

- (1) lakes/reservoirs whose mean depths are larger than 30 meters (not an issue for most Florida lakes),
- (2) water residence time is longer than 2 years, and
- (3) overflow rates (mean depth divided by hydraulic residence time) is larger than 4 meters/year.

Under these circumstances, a non-calibrated model may produce large errors and should not be used to establish the water quality targets or criteria.

To reduce the model prediction error, the BATHTUB User Manual makes recommendations for the frequency and type of the monitoring data that should be used for calibration. The models included in the mass-balance model set for estimating the in-lake nutrient concentrations are primarily based on the following mass-balance equation (Equation 1):

$$\text{Inflows} = \text{Outflows} + \text{Increase-in-storage} + \text{Net Loss} \quad \text{Equation 1}$$

While the equation includes the “Increase-in-storage” item, based on the user manual, better modeling results were usually achieved when there was no significant net change of storage in lakes/reservoirs. Therefore, model calibration should avoid only relying on data collected during the extreme hydrologic condition such as too dry or too wet.

The User Manual makes the following recommendations related to model calibration:

- (1) That the model calibration takes into consideration the hydrology and hydraulic variations of different seasons and inter-annual variations from three or more years.
- (2) The monitoring data should include the in-lake/reservoir nutrients and chlorophyll *a* data, the tributary nutrients related data, and tributary flow measurements. In order to ensure that the loading into lakes/reservoirs are estimated accurately, the user manual recommends daily flow measurements for the tributaries and at least biweekly monitoring of the tributary water quality constituents supplemented with storm event sampling.
- (3) For lakes that receive significant amount of loading from nonpoint source areas, watershed models should be used to estimate seasonal and annual loadings to create inputs for BATHTUB.

When calibrating the BATHTUB model, being able to identify the major sources that contribute to the nutrient condition of the lake/reservoir is very important. Using BATHTUB to establish water quality targets is NOT recommended if the data regarding the following sources are not available for quantifying the contribution from each source:

- (1) Tributary discharge and nutrient concentrations
- (2) Nonpoint source loading directly into lakes/reservoirs through sheet flow (need to take into consideration of impacts from septic tanks and best management practice).
- (3) Possible ground water contribution (seepage rate and ground water nutrient concentrations. If tributaries appear in the drainage basin and measured daily flows are available, ground water input can be approximately estimated through baseflow separation analyses)
- (4) Direct atmospheric deposition onto the surface of lakes (this requires rainfall data and wet deposition concentration and dry deposition flux data)
- (5) Possible internal nutrient loading (further discussed in the following section)
- (6) Possible loading from nitrogen fixation (further discussed in the following section)

Use of BATHTUB model should not be recommended if the locally measured lake morphology and water residence time are not available.

One of the most important factors that influence the model simulation error for BATHTUB is the nutrient sedimentation rate. Direct measurements of nutrient sedimentation rate, in most cases, is not readily available. Therefore it is usually used as a parameter for BATHTUB model calibration. Sedimentation rate calibration is especially important for those waters that have relatively long water residence time (longer than 2 years) and small surface overflow rate (<4 m/year) because in these cases, flushing is no longer the dominant factor in controlling the nutrient concentration in the system. Sedimentation plays a more important role.

BATHTUB allows calibrating the nutrient concentration through adjusting a sedimentation calibration factor (SCF). It should be noted that, some BATHTUB mass-balance models have recommended ranges for the SCF. These ranges apply to the phosphorus Models 1 and 2 in BATHTUB, which are the Second-order Available P [default] and Second-order Decay Rate Function models, respectively, as well as the nitrogen Models 1 and 2, which are the Second-order Available N [default] and Second-order Decay Rate Function models, respectively. The recommended range of SCF is from 0.5 to 2.0 for phosphorus and 0.33 to 3.0 for nitrogen. SCFs beyond these ranges are not recommended.

When the SCF are used to the extreme of recommended ranges and nutrient concentrations are still not calibrated (e.g. model simulates are 30% or more different from the measured data), application of these models in establishing water quality targets is not recommended until the cause of the simulation errors is resolved. In this case, the following factors should be addressed:

1. Input nutrient composition:

The in-lake/reservoir nutrient concentrations simulated by mass-balance Models 1 and 2 mentioned above are sensitive to the inorganic nutrient to total nutrient concentration ratio. This is especially true for phosphorus. The Model 1 (Second-order Available P model) performs mass balance calculations on “available phosphorus”, a weighted sum of orthophosphorus and nonorthophosphorus, which places a heavier emphasis on the orthophosphorus (more biologically available component) instead of just using the tributary total phosphorus (TP) as the model input. In this case, without knowing accurately the inorganic to organic phosphorus ratios of all the external sources, the final in-lake phosphorus concentration may have sufficient uncertainty that it should not be used to establish nutrient targets. The similar concept also applies to Model 2 (Second-order Decay Rate Function model) except that, instead of calculating a weighted sum of “available” phosphorus, the model uses the total phosphorus as the input phosphorus and establishes an inverse relationship between the sedimentation rate and tributary orthophosphorus to total phosphorus ratio so that the sedimentation rate will be higher in systems dominated by organic and particulate (nonorthophosphorus) phosphorus loading. In this case, knowing the nutrient compositions of the external sources becomes essential for using BATHTUB to establish nutrient targets.

2. Possible internal loading:

If model simulated in-lake/reservoir nutrient concentrations are consistently lower than the measured in-lake/reservoir concentrations and measured tributary concentrations (if available) are also consistently lower than the in-lake/reservoir concentrations, internal nutrient loading should be considered as a possible factor in setting up the BATHTUB model. Because BATHTUB sedimentation models have been empirically calibrated, effects of “internal loading” or nutrient re-cycling from bottom sediments should have been inherently reflected to a certain extent in the model parameter values and error statistics. However, the BATHTUB user manual listed the following four conditions under which the “internal loading” may exceed the range covered by the empirical model and therefore need to be considered separately:

- A. High concentrations of ortho-phosphorus (or high ortho-P/TP ratios) in nonpoint-source tributary drainage (indicative of natural sediments that are phosphorus-rich and have high equilibrium phosphorus concentrations).
- B. Low surface overflow rates, typically < 10 m/year (indicative of low dilution potential for internal loadings generated on a mass per unit area basis and low external sediment loadings).
- C. Intermittent periods of stratification and anoxic conditions at the sediment/water interface (contribute to periodic release of soluble phosphorus from bottom sediments and transport into the mixed layer).
- D. Low iron/phosphorus ratio (typically <3 on a mass basis) in sediment interstitial waters or anaerobic bottom waters (permits migration of phosphorus into aerobic zones without iron phosphate precipitation).

The above conditions are often found in relatively shallow lakes and reservoirs. If these situations exist and simply adjusting the SCF to the extreme of the recommended range cannot achieve the satisfactory calibration, BATHTUB provides the option to users to define an internal loading flux rate in the model. But this option should be used very cautiously because the observed error may also be associated with:

- (1) Measured in-lake concentrations with large error
- (2) Missing external nutrient sources
- (3) Mistakenly quantified watershed loading
- (4) Lack of nutrient composition information for the input nutrient loading

It should be noted that, even if an elevated internal loading assumption is justified, measured internal loading flux is not available in many cases. In this situation, an internal flux rate can be set up for the model so that the model simulated in-lake concentration will match up with the measured in-lake concentration. This is a mass-balance approach. This approach, however, has the risk of covering up the true cause of the model error. In addition, even when a flux rate can be set up for the existing condition, without any data to show how the internal flux rate will change with the external nutrient loadings, using the model to predict the target condition will still cause uncertainties. Of course, literature published external loading – internal loading relationship studies can be used as surrogate to estimate the change of internal flux rate when external loading is reduced. However, it is still highly recommended that local studies should be conducted to quantify the internal loading. It is not recommended that the model be used for lakes systems dominated by the internal loading.

### 3. Possible nitrogen fixation:

There are cases when the model simulated in-lake/reservoir phosphorus concentration calibrates with the measured concentration reasonably well, but model simulated nitrogen concentration is consistently lower than the measured nitrogen concentration. In that circumstance, if the measured tributary nitrogen concentrations are also lower than the measured in-lake/reservoir nitrogen concentration and tributary phosphorus concentrations are similar to or higher than the in-lake/reservoir phosphorus concentrations, nitrogen fixation can be considered as a possible external source of nutrient to the subject lake.

BATHTUB models do not deal with nitrogen fixation explicitly. But the internal loading option of the model can be used to add nitrogen flux rate into the lake to mimic the nitrogen fixation. The uncertainties associated with this approach are the same as those associated with establishing the internal flux rate from the sediment. It is therefore highly recommended that this approach be used with caution. If this approach must be used, the following aspects of the lake should be carefully evaluated:

- (1) Comparing the tributary and in-lake reservoir water quality data to see if the high in-lake concentration is caused by the high tributary concentration
- (2) Examining the in-lake algal taxonomy to determine whether nitrogen fixers indeed exist in the system
- (3) Evaluating the inorganic nitrogen to inorganic phosphorus ratio of the lake/reservoir to determine if the phytoplankton communities is nitrogen limited
- (4) Conducting nitrogen fixation studies to quantify the actual rate of nitrogen fixation

Similar to the internal loading, even if a nitrogen fixation rate can be established for the existing condition, without any data showing how the nitrogen fixation will change with the external loading, predicting the target nitrogen concentration can still be problematic. Therefore, it is highly recommended that nitrogen fixation studies be conducted for lakes with nitrogen fixation as a significant source of nitrogen for the lake to determine the functional relationship between the nitrogen fixation rate and external nutrient loadings.

#### 4. Impact of submerged aquatic vegetation (SAV)

In some cases, model simulated in-lake/reservoir concentration may be significantly higher than the measured in-lake/reservoir. If the SCF has been used to the extreme of the recommended range, large error associated with the monitoring data in lakes and tributaries are excluded, and nutrient compositions of the inlet loadings are all confirmed, and a calibration still cannot be achieved, the Canfield and Bachman (1981) model (contained within BATHTUB) should first be considered in place of either Model 1 or Model 2. Canfield and Bachman's model include some artificial lakes in urban areas, which received high watershed nutrient loading. The portion of particulate phosphorus in these loadings was high and therefore high sedimentation rate is expected for these urban lakes.

Another thing to check to account for the model overestimation is whether the system is dominated by the SAV. Littoral zone vegetation and in-lake aquatic plants can contribute to the low nutrient concentration by reducing the water column turbulence, which increases the nutrient sedimentation rate, stabilize the lake sediment and reduce the sediment nutrient release, and provide habitat for periphyton and remove phosphorus directly from the water column (Gasith and Hoyer 1998, Haven 2003). If SAV dominates the lake system, for example,

covering more than 30% of the lake surface, BATHTUB is not recommended as the model to be used to set up the nutrient targets (*Canfield, et al. 1983*).

### **References**

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## **C. The application of lake criteria to streams in the absence of a working model is not scientifically sound.**

Nutrient dynamics in lakes and reservoirs is very complex, and fate and transport of TP and TN in streams leading to lakes is equally complex. A gross oversimplification of the science associated with numeric nutrient criteria, with far reaching cost ramifications to FDEP, EPA, and the Florida public, should not be adopted as a water quality standard.

The Department inquired with Dr. Roger Bachmann, a long time researcher of Florida Lakes from the University of Florida, regarding this concept and decided to include his analysis because it provides a very accurate summary. Dr. Bachmann wrote back in an August 23<sup>rd</sup> email:

“It would be overkill to apply the lake criteria directly to the inflowing stream. The reason for this is that most lakes have mechanisms to remove phosphorus or nitrogen from the open waters, so that the concentration in the lake water will be less than that in the inflowing streams. This will depend to some extent on the hydraulic flushing rate. With a very high flushing rate where the water is replaced every week or two as in a run-of-the-river reservoir the phosphorus concentration of the lake will be close to that of the stream. With a low flushing rate where the water is replaced every year or two, or more, the concentrations in the lake will be much less than that of the streams. The Vollenweider equation or the Bathtub model takes this into account.

In the case of phosphorus, removal comes about when P is attached to living or non-living particles that settle to the bottom sediments. While some may come back out,

almost always more enters the sediments than goes back out into the water. Lake sediments are storage places for phosphorus. Nitrogen is lost from lakes as one or more gasses. The decomposition of organic matter releases nitrogen to the water as ammonia. Some of this can be lost directly to the atmosphere and leave the system. If oxygen is present the ammonia can be oxidized to nitrates. When nitrates are present in areas of a lake without dissolved oxygen such as just below the surface of organic sediments or in the waters of an anoxic hypolimnion; there are microorganisms that can use the nitrates in their metabolism and transform the nitrogen from the nitrates into gasses like nitrous oxide and nitrogen gas. These gases can in turn be lost to the atmosphere. The long term concentration of total nitrogen in a lake will be less than that of the inflowing streams.

It would be very conservative to set stream standards to the concentration desired in the downstream lake. It would almost always have the effect of reducing the standard for the lake and would be hard to justify.”

The docket and record associated with the NODA and the proposed rule do not contain any data, methodologies, or analyses that are used to support this proposal, which makes the review of the concept against Dr. Bachmann’s assessment virtually impossible. However, the docket does include a publication regarding the BATHUB model [EPA-HQ-OW-2009-0596-2435] that describes all the variables that go into lake nutrient dynamics, including those mentioned by Dr. Bachmann. This serves as a good source of information demonstrating why this concept is an oversimplification of the science. As stated in Walker, W. W. (1996). “Simplified procedures for eutrophication assessment and prediction: User Manual,” Instruction Report W-96-2 (Updated April 1999), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS:

“The basis of the modeling approach described below is to relate eutrophication symptoms to external nutrient loadings, hydrology, and reservoir morphometry using statistical models derived from a representative cross section of reservoirs. When applied to existing reservoirs, the models provide a framework for interpreting water quality monitoring data and predicting effects of future changes in external nutrient loadings. The models can also be used to predict water quality conditions in a proposed reservoir.

Three basic phases are involved in applying the methodology to an existing or proposed reservoir:

- a. Analysis and reduction of tributary water quality data.
- b. Analysis and reduction of pool water quality data.
- c. Model implementation.”

This publication, and many other studies of lake eutrophication dynamics, recognize that evaluating the concentration of TN or TP in streams flowing to a lake will not sufficiently capture the nutrient dynamics associated with protection of a lake. As stated in EPA’s docket, external nutrient loading from all sources, including ground water and the atmosphere, the hydrology of the lake, and the reservoir morphometry (shape) are the key factors in assessing the protective nutrient needs of a lake. Therefore, simply applying the lake criteria to streams flowing into lakes is scientifically invalid and based on erroneous assumptions.

Again, there are no data or analysis that might support the proposal in EPA’s docket and the data and analysis associated with the NODA actually suggest that such a concept is not supportable. In either case, it is impossible to evaluate the merits of the concept.

#### **D. The Spatial Application of the Lake DPVs is not clear and the docket contains no data or methods that support a decision on the spatial application.**

The spatial application of water quality standards is a critical element of all water quality standards. To which waterbodies do these standards apply? The Proposal and the NODA for the spatial establishment of downstream protection values for the protection of Lakes is clear for phosphorus and the Department has provided comment on that aspect of EPA's proposal. However, the proposal and NODA for the spatial establishment of lake protection DPVs for TN is less clear. Based on the January proposal, EPA indicated that it will account for fate and transport of TN when establishing lake protection DPVs, but how that will be done is unknown.

In the development of the total phosphorus criteria for the protection of downstream lakes (Downstream Protection Values – DPVs), EPA spatially applied the DPV criteria into the upstream watershed up to the headwaters. EPA also assumed that there is no phosphorous loss or uptake in streams as they flow towards lakes. In other words, phosphorus loads and concentrations in the headwaters streams of the watershed do not attenuate at all as they move towards the lake, regardless of hydrology, distance, and ecological interactions. There was narrative reasoning in the preamble, but no citation, data, or methodology was provided in the docket to support this conclusion for either the proposal or the NODA. This conclusion is counter to findings in much of the literature regarding fate and transport of phosphorus, and is not consistent with practices embraced by water quality modelers across the country. A significant amount of research has been conducted to better estimate phosphorus fate and transport in streams in recognition of actual phosphorus loss and uptake. However, no phosphorus fate and transport data or research appeared to be utilized by EPA during the rulemaking proceeding, or was otherwise not provide to the public for review. The Department included fate and transport research in our comments on the proposal and will not reiterate them here.

Regarding the development of total nitrogen DPVs for the protection of downstream lakes, the NODA does not describe or make clear how the spatial factors will be applied. The public is left to either presume that EPA will apply the same approach to TN as was applied to TP for lake protection in the January proposal (i.e., no fate and transport) or to presume that the approach to TN was similar to what was applied for estuary protection in the January proposal (i.e., accounting for denitrification). Relying on the information in EPA's January proposal, we can assume that nitrogen loss will be taken into account. When discussing DPVs for lake protection, the proposal states, "However, unlike for nitrogen, there are no long-term phosphorus net removal processes at work in streams." When discussing DPVs for estuary protection, the proposal states, "In this way, higher DPVs may be appropriate in stream reaches where a significant fraction of either TN or TP is permanently removed within the reach before delivery to downstream receiving waters." While this statement is contrary to the previous statement regarding TP, it does acknowledge that there is nitrogen loss. The proposal goes on to State, "EPA's methodology accounts for in-stream losses of TN. EPA recognizes that not all the TN transported within a stream network will ultimately reach estuaries. Rather, some TN is permanently lost from streams."

EPA utilized fate and transport mechanisms in the SPARROW model to account for nitrogen loss. Presuming that EPA will also use SPARROW to account for the fate and transport of TN when applying lake DPVs, the State previously submitted comments to the proposal on the issues associated with the SPARROW model's ability to accurately account for fate and transport of TN in Florida waters.

The Department reiterates that EPA should rely on the inherent protection of downstream waterbodies provided by stream criteria derived based on minimal disturbance. This approach is technically defensible, easier and less costly to implement, and avoids the scientific weaknesses contained in the DPV provisions. If EPA

does not accept that path, the Agency should re-propose any lake DPV criteria and include information on the spatial application of DPVs, in addition to the duration & frequency of DPVs, so that the Florida public can better understand and evaluate EPA's data, methods, and rationale. Not providing such information prevents the public from making relevant comments on EPA's analysis.

**E. The Workload Generated by this Provision, given its legal and scientific necessity, does not justify its inclusion.**

The State of Florida has the National Hydrography Dataset (NHD) coverage at the 1:24,000 scale that can be used to estimate the number of lakes in the State that have a stream flowing into them. Using NHD, FDEP counted 18,006 lakes that have at least one stream flowing into them, with 15,414 lakes that are larger than ten acres, 1,910 lakes between five and ten acres, 623 between two and five acres, and 59 less than two acres. The method used to estimate the number of lakes is described in Appendix A.

To collect the data and build a calibrated model for each of these lakes is not a valid exercise and an inappropriate use of public resources given that it is unnecessary. The Data Requirements for BATHTUB are described on page 1-18 of docket number EPA-HQ-OW-2009-0596-2435. The Department estimates that this would conservatively cost more than \$180 Million (18,006 X \$10,000) to simply set up the models to calculate the DPVs. EPA's grant to the Department under Section 1256 of the Clean Water Act amounts to only a little over \$6 million annually and that is intended to cover implementation of many programs.

The \$10,000 cost figure is a gross estimate, but likely underestimates the actual costs of building the models given the data needs associated with such an exercise. The data necessary to build the BATHTUB model (the cheapest model to use) are divided into several groups based on the general model structure. We note that for some data (for example, precipitation, evaporation, and atmospheric loadings) regional information may be sufficient to utilize the model and in other cases flux rates or other coefficients could be based on reference conditions or studies from similar waterbodies. Highlighted text identifies data that must be collected site specifically versus using literature or regional values.

- (1) Global data requirements applied to all the model segments:
  - a. Precipitation: This is used to calculate the water balance regarding the rainfall directly onto the surface of the lake.
  - b. Evaporation: This is used to calculate the water balance. It should be adjusted pan evaporation rate.
  - c. Lake stage: Even though BATHTUB is a steady-state model, the model includes an item in the equation called "lake storage increase". Lake stage change is used in the model to calculate the change of lake volume, and in turn the change of total nutrient mass in the water column of the lake.
  - d. Atmospheric loads: This is used to calculate the direct atmospheric loadings onto the surface of the lake. Data should include TN, TP, inorganic P, and inorganic nitrogen. The data should be bulk flux rate and include both the wet and dry deposition. The unit for the data is mg/m<sup>2</sup>/year.
- (2) Lake Morphology data: Complete bathymetry information of the lake is preferred. But if the information is lacking, the following data can be used:
  - a. Lake surface area
  - b. Lake mean depth

- c. Lake length: This is the distance along major flow axis (km).
  - d. Mixed layer depth (for nonstratified Florida lakes, this depth could be the mean depth)
  - e. Hypolimnetic depth (only important if hypolimnetic oxygen depletion is an issue)
- (3) Observed in-lake Water Quality data:
- a. Non-algal turbidity: This can be calculated based on Secchi depth and Chla concentration. It is only important if phytoplankton is considered light limited.
  - b. TP
  - c. Inorganic P
  - d. TN
  - e. Inorganic N
  - f. Chla
  - g. Secchi depth
- (4) Watershed input: Multiple “tributaries” can be set up in the model to account for nutrient loadings from inlet stream, sheet flow, ground water, and point sources. The required data for each “tributary” should include:
- a. Flow rate
  - b. TP concentration
  - c. Inorganic P concentration
  - d. TN concentration
  - e. Inorganic N concentration
- (5) Internal Load: This is only needed for lakes that, after the sedimentation calibration factors are used to the extreme of the recommended range and model simulations still underestimate the measured in-lake nutrient concentrations:
- a. TP flux rate ( $\text{mg}/\text{m}^2/\text{day}$ )
  - b. TN flux rate ( $\text{mg}/\text{m}^2/\text{day}$ )
  - c. This model capability can also be used as a way to define the nitrogen fixation rate.

## Appendix A

### **Method Used to Count Lakes with inflow Streams/Rivers using the National Hydrography Dataset**

Objective: Identify all Lakes of Reservoirs that conformed to specific criteria for use in analysis.

Criteria:

1. Identify Lakes and Reservoirs that have one dimensional (1D) Stream/Rivers or 1D Canals flowing into them (known flow).
2. Identify Lakes and Reservoirs that are within or coincide with Swamps that have 1D Stream/Rivers or 1D Canals flowing into identified Swamps (known flow).
3. Identify Lakes and Reservoirs that coincide with two dimensional (2D) Stream/Rivers or 2D Canals.
4. Identify only freshwater Lakes and Reservoirs

Starting with a downloaded statewide file geodatabase (7\_30\_2010) from the USGS (<ftp://nhdftp.usgs.gov/DataSets/Staged/States/>).

Feature classes (FC) that were needed to complete the objective included: all lakes and reservoirs, all swamps, all 1D stream/rivers and all 1D canals, all 2D stream/rivers and all 2D canals. All of the mentioned FCs were created by querying out the selected feature types from their assigned feature dataset and exported into new FCs.

A single FC of just all 1D Streams and 1D Canals that had flow (with-digitized) was needed for the first part. Using the NHDFlowline attribute table, all 1D Streams and 1D Canals were queried that had flow and exported that data into a new FC (S\_C\_with\_flow). The next step was to identify the vertices that make up those lines and extract just the end vertices, the ones that dictate the portion of the line where water would be flowing out. The ArcToolBox tool 'Feature Vertices To Points' was used to select the type of vertices needed. Using this tool, a point FC for just the end vertices of streams and canals that had flow was used to create a FC called 'stream\_canal\_ends'.

To identify which NHD waterbodies had flow entering them, an intersect of the stream\_canal\_ends against a FC of all Lakes and Reservoirs (all\_L\_R) from the statewide database was created. The result of the intersect was called 'all\_L\_R\_intersect\_S\_C\_ends' and complies with criteria #1.

Using one of the FCs in the previous step, stream\_canal\_ends, another intersect with a FC of all Swamps in the statewide database was created. An intersection was created between that FC and the FC of all lakes and reservoirs resulting in a list of lakes and/or reservoirs that water might flow into from a stream/river via a swamp but were not traversed with a network flowline/artificial path. The resulting FC, L\_R\_intersect\_swamps, complies with what was needed for criteria 2.

The same process, intersecting, was used with 1D stream/canal ends and 2D stream/canals to create a FC of all 2D stream and 2D canals that had flow entering their 2D area. Using this FC (2D\_areas) and running another intersection against all lakes and reservoirs, all lakes and reservoirs that fit into the 3<sup>rd</sup> criteria were identified (L\_R\_intersect\_2d\_S\_C).

To comply with the final criteria, an intersection was run of all 3 resulting FCs against a saltline delineation to identify all those that were not considered freshwater, resulting FCs; L\_R\_S\_C\_ends, L\_R\_swamps, and L\_R\_2d\_S\_C. The saltline delineation is an approximation of the demarcation between Marine/Estuarine and Freshwater habitats and was created by extracting Marine and Estuarine polygon features from the U.S. Department of Interior Fish and Wildlife Service's National Wetland Inventory (1994) GIS data layer. Lakes that fell in this Marine-Estuarine polygon subset were removed from consideration.

The three resulting FCs; L\_R\_S\_C\_ends, L\_R\_swamps, and L\_R\_2d\_S\_C, fill the criteria for the objective, but small modifications still needed to be made. When using the same FCs for multiple intersections, there is a tendency to get duplicate lakes and reservoirs in each of the resulting FC. Duplications were identified and removed. Another issue is that the downloaded statewide database is comprised of subbasins with features that are both inside and outside the state of Florida. Removing the features that are in Georgia and Alabama was done by intersecting the three FCs with a statewide polygon and exporting the results.

The three resulting FCs were combined into a single shapefile (Lakes\_Reservoirs.shp) for reporting purposes and to generate a single spreadsheet (Summary\_of\_Reachcodes.dbf) of all reachcodes assigned to the Lakes\_Reservoirs.shp.

Identification of direct stream or canals that flow into lakes or reservoirs is relatively straight forward; from the final resulting shapefile, do an intersection to stream\_canal\_ends and export the resulting selections (9,939 NHDFlowlines) into a dbf spreadsheet to determine their Reachcodes (8,233).

The resultant numbers are:

- Lakes and Reservoirs = 18,006
- Waterbody Reachcodes = 17,855
- Flowlines Reachcodes = 46,223

## Appendix B

Using the statewide download (7/30/2010) from the USGS, a feature class of all Stream/Rivers was created from the database. Since features in the download extend into Georgia and Alabama and Florida, an intersect with a polygon of the just the state of Florida was used to create a single feature class (FC) of all NHDFlowlines in Florida. From this 2 feature classes were created, one of all the perennial streams and the other of all intermittent streams. With these different FCs, the number of records was counted totaling 34,499 intermittent streams and 99,273 perennial streams.

To count the length in miles, a projection from decimal degrees to albers was conducted and a field was created in both FCs where the distance in miles could be calculated and summarized. Intermittent = 8,880 miles and Perennial = 20,967 miles

The NHD Flowlines feature class that was used as a base for selection of intermittent and perennial features, in general, describes features that have a width of less than 15 meters. Many flowing rivers and larger streams have a width of greater than 15 meters and are captured in a separate polygon feature class and so were in effect not taken into account for this summary. Calculating lengths for these polygons would require an analysis that cannot be run as immediately as the summarization of flowline lengths. Streams that are captured as polygons would almost exclusively fall into a perennial classification. In sum, this analysis under-represents the Statewide miles of Perennial streams. It should be noted too that approximately 541 miles of streams and rivers within the State have no perennial or intermittent designation and so cannot be reported as such.