State of Florida
Numeric Nutrient Criteria Development Plan

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List of Acronyms and Abbreviations

AGP	Algal Growth Potential
BCG	Biological Condition Gradient
BMP	Best Management Practice
BMAP	Basin Management Action Plan
BioRecon	BioReconnaissance
BOD	Biochemical Oxygen Demand
CADDIS	Causal Analysis/Diagnosis Decision Information System
CWA	Clean Water Act
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
ERC	Environmental Regulation Commission
ETAC	Everglades Technical Advisory Committee
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FWCI	Florida Wetland Condition Index
GED	Gulf Ecology Division
GOMA	Gulf of Mexico Alliance
IWRM	Integrated Water Resource Monitoring
HA	Habitat Assessment
HAB	Harmful Algal Bloom
HA	Habitat Assessment
HDG	Human Disturbance Gradient
HUC	Hydrologic Unit Code
IRL	Indian River Lagoon
IWR	Impaired Surface Waters Rule
Km	Kilometer
LDI	Land Development Intensity
LOPP	Lake Okeechobee Protection Plan
LSD	Least Significant Difference
LVI	Lake Vegetation Index
kg N/ha/yr	Kilograms of Nitrogen per Hectare per Year
m	Meter
mg/L	Milligrams per Liter
mg/m^3	Milligrams per Cubic Meter
NASQAN	National Stream Quality Accounting Network
NAWQA	National Water Quality Assessment
NEP	National Estuary Program
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
PLRG	Pollutant Load Reduction Goal
QA/QC	Quality Assurance/Quality Control
RPS	Rapid Periphyton Survey
RTAG	Regional Technical Assistance Group
SAV	Submerged Aquatic Vegetation
SBIO	Statewide Biological Database
SCI	Stream Condition Index
sej	Solar Emergy Joule
SFWMD	South Florida Water Management District

SJRWMD	St. Johns River Water Management District
SOP	Standard Operating Procedure
SPI	Stream Periphyton Index
STORET	Storage and Retrieval (Database)
SWIM	Surface Water Improvement and Management
TAC	Technical Advisory Committee
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
WBID	Waterbody Identification Number
WRAP	Wetland Rapid Assessment Procedure
µg/L	Micrograms per Liter
µmho/cm	Micromohs per Centimeter

STATE OF FLORIDA NUMERIC NUTRIENT CRITERIA DEVELOPMENT PLAN

1. Background and Criteria Development Process

The state of Florida intends to adopt quantitative nutrient water quality standards to facilitate the assessment of designated use attainment for its waters and to provide a better means to protect state waters from the adverse effects of nutrient over enrichment. To that end, the Florida Department of Environmental Protection (FDEP) plans to develop numeric criteria for causal variables (phosphorus and nitrogen) and/or response variables (potentially chlorophyll *a* and transparency), recognizing the hydrologic variability (waterbody type) and spatial variability (location within Florida) of the nutrient levels of the state's waters, and the variability in ecosystem response to nutrient concentrations.

It is FDEP's intent to establish numeric nutrient criteria that are protective of designated uses and consistent with Florida's existing narrative nutrient criterion, which states that "in no case shall nutrient concentrations of body of water be altered so as to cause an imbalance in natural populations of flora or fauna." Therefore, FDEP's preferred approach is to develop cause/effect relationships between nutrients and valued ecological attributes, and to establish nutrient criteria that ensure that the designated uses of Florida's waters are maintained.

Nutrients are unlike any other "pollutant" regulated by the federal Clean Water Act (CWA). Most water quality criteria are based on a toxicity threshold, evidenced by a dose-response relationship, where higher concentrations can be demonstrated to be harmful, and acceptable concentrations can be established at a level below which adverse responses are elicited (usually in laboratory toxicity tests). In contrast, nutrients are not only present naturally in aquatic systems, they are absolutely necessary for the proper functioning of biological communities, and are sometimes moderated in their expression by many natural factors.

Therefore, the development of protective nutrient criteria is immensely more complicated than that for toxic substances. It must be recognized that nutrients should not be regulated at levels that are artificially lower than those concentrations required for normal ecosystem functioning. If humans were to reduce nutrients below the levels that natural aquatic systems are accustomed to, adverse biological effects (disruption of trophic dynamics, loss of representative taxa) would occur. This would be counter to the CWA charge in Section 101 to "protect the physical, chemical, and biological integrity" of the state's waters and, coincidentally, against Florida law, which prohibits FDEP from conducting remediation for natural conditions. Ideally, nutrients should be managed in a range of concentrations with some consideration of a margin of safety on both the upper and lower bounds of the range.

A memorandum from the Director of the U.S. Environmental Protection Agency's (EPA) Office of Science and Technology, Geoff Grubbs (2001), indicated that states are allowed the flexibility to develop and adopt nutrient criteria other than those currently proposed by EPA for waterbody types in specific Nutrient Ecoregions which were aggregated from Level III (EPA, 1998) (**Figure 1** and **Table 1**). As proposed, the EPA criteria recommendations that would include Florida (EPA, 2000a, 2000b, 2000c, 2000d, and 2000e) do not fully reflect localized conditions or specific waterbody designated uses within the State of Florida, FDEP proposes to undertake activities to develop criteria for lakes, streams, estuaries, coastal waters, and wetlands within the state, based on state-specific, subregional data. Upon issuance of §304(a)

Ecoregional Nutrient Criteria Recommendations, and since that time, EPA has encouraged states to refine their approach where possible in order to reflect more state-specific data and conditions.

Figure 1. Draft aggregations of Level III ecoregions for the national nutrient strategy in Florida

Table 1. EPA-generated nutrient criteria recommendations for nutrient ecoregions, including all or part of Florida

Lakes and Reservoirs

Parameter	Region IX [1]	Region XII [2]	Region XIII [3]
TP (μg/L)	20	10	17.5
TN (mg/L)	0.36	0.52	1.27
Chlorophyll *a* (μg/L)	4.93	2.6	12.35
Secchi Depth (m)	1.53	2.1	0.79

m – Meters.
μg/L – Micrograms per liter.
mg/L – Milligrams per liter.

Rivers and Streams

Parameter	Region IX [4]	Region XII [5]	Region XIII [6]
TP (μg/L)	36.56	40.0	N/A
TN (mg/L)	0.69	0.9	N/A
Chlorophyll *a* (μg/L)	0.93	0.40	N/A
Periphyton Chlorophyll *a* (mg/m^3) [7]	20.35	N/A	N/A
Turbidity (NTU)	5.7	1.9	N/A

mg/m^3 – Milligrams per cubic meter.
N/A – Not available.
NTU – Nephelometric turbidity unit.
TP – Total phosphorus.
TN – Total nitrogen.

[1] EPA, 2000a.
[2] EPA, 2000b.
[3] EPA, 2000c.
[4] EPA, 2000d.
[5] EPA, 2000e.
[6] EPA has not issued ambient water quality criteria recommendations in support of the development of nutrient criteria for rivers and streams in Nutrient Ecoregion XIII.
[7] Only the guidance for rivers and streams in Nutrient Ecoregion IX included recommendations for periphyton chlorophyll *a*.

The development of criteria for these subregions has been and will continue to be prioritized based on Florida's watershed program needs and the availability and order of EPA guidance documents. FDEP will evaluate both ecoregions and bioregions as potential subregionalization bases for numeric nutrient criteria. Florida ecoregions were delineated in the early 1990s as part of Florida's biocriteria development efforts for streams and lakes. Those efforts yielded 13 Level IV subecoregions (Griffith *et al.,* 1994) for wadeable streams (**Figure 2**) and 47 Level IV subecoregions (Griffith *et al.,* 1997) for lakes (**Figure 3**). Additionally, FDEP has analyzed stream reference site macroinvertebrate community patterns in all 9 ecological subregions north of Lake Okeechobee (Barbour *et al*., 1996). From that analysis, FDEP concluded that the data indicated the presence of 4 distinct bioregions, within which there were similar biological community composition and structure (**Figure 4**).

While FDEP plans to develop nutrient criteria that are applicable to specific regions which will serve to prevent impairment, the conceptual approach outlined in this document also incorporates the state's responsibilities to address existing nutrient impairment through the development of Total Maximum Daily Loads (TMDLs) or Pollutant Load Reduction Goals (PLRGs), as described in state laws and rules, both of which may serve to develop more site-specific nutrient targets that could supersede regional criteria, if subsequently adopted and approved as site specific alternative criteria. For example, FDEP has developed and received approval from EPA Region 4 for the Lake Okeechobee phosphorus TMDL, which established the phosphorus concentration that would address undesirable algal blooms in that system. Similarly, the Tampa Bay Estuary Program has adopted chlorophyll *a* targets for portions of Tampa Bay that were specifically designed to protect and restore seagrass communities within the bay. The program has established a protocol that considers the magnitude, frequency, and duration of changes to algal biomass in the bay and implemented through agreements, a program to control excess nitrogen in the watershed.

It should be noted that FDEP intends to develop numeric nutrient criteria for adoption in Chapter 62-302, Florida Administrative Code (F.A.C.), as water quality criteria, and in addition, is exploring the incorporation of numeric nutrient thresholds into the Impaired Surface Waters Rule (IWR) (Chapter 62-303, F.A.C.), which establishes the state's methodology to identify and verify impaired waters (waters not meeting applicable water quality standards). While the IWR already includes thresholds for response variables that serve as translators for Florida's narrative nutrient standard (a quantification of imbalance of flora and fauna) which are used in addition to consideration of other factors to assess waters for nutrient impairment the IWR does not currently include numeric causal thresholds for either streams or estuaries. Such additional numeric nutrient thresholds adopted in the IWR would serve as nutrient impairment thresholds for those waterbody types. Once developed, numeric nutrient criteria are intended to both protect healthy, well-balanced natural populations of flora and fauna from the effects of excess nutrient enrichment, as well as provide a basis to identify waters already impaired by nutrients.

Figure 2. Level IV subecoregions for Florida: Small/wadeable streams

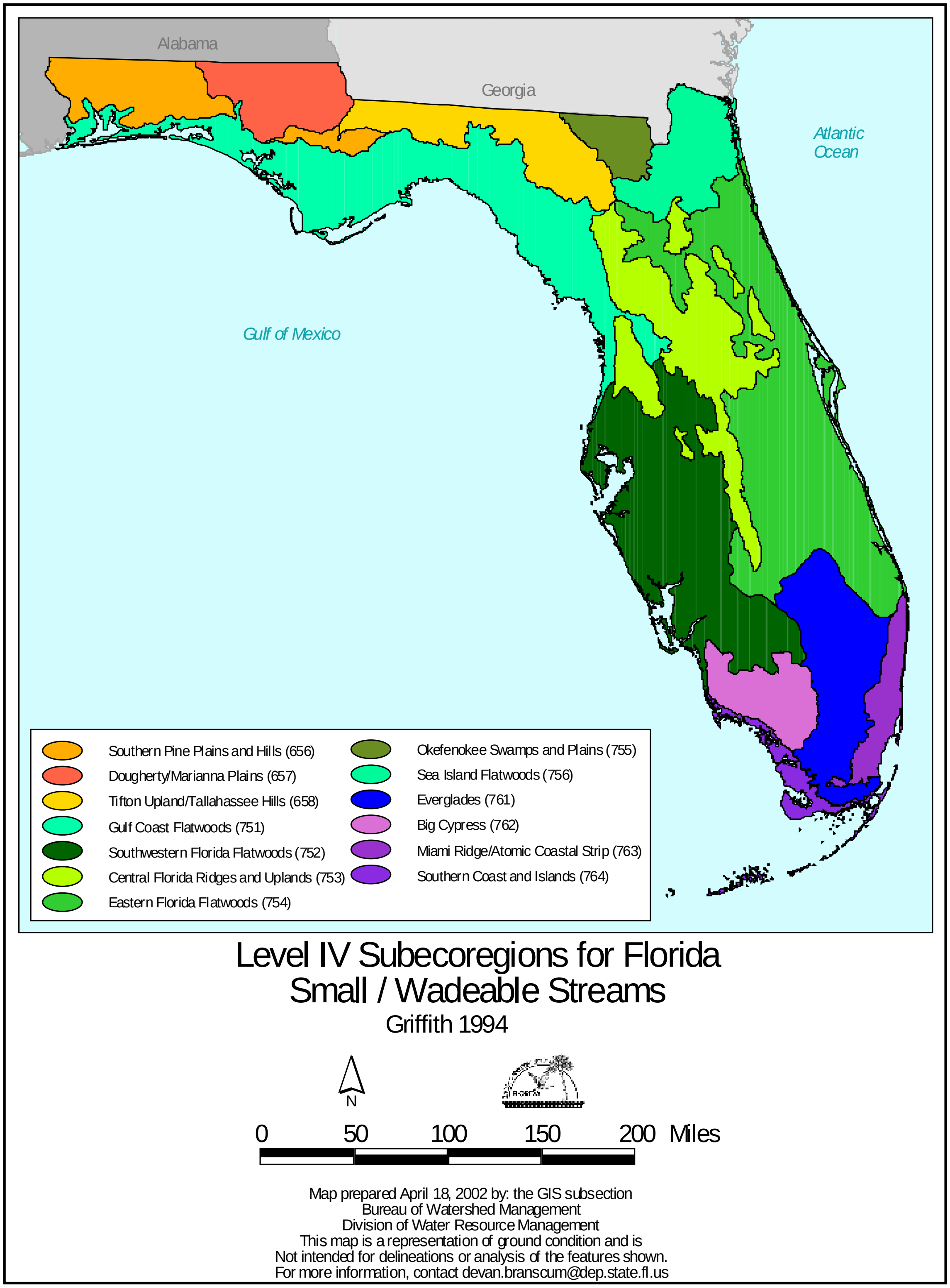

Figure 3. Level IV subecoregions for Florida lakes

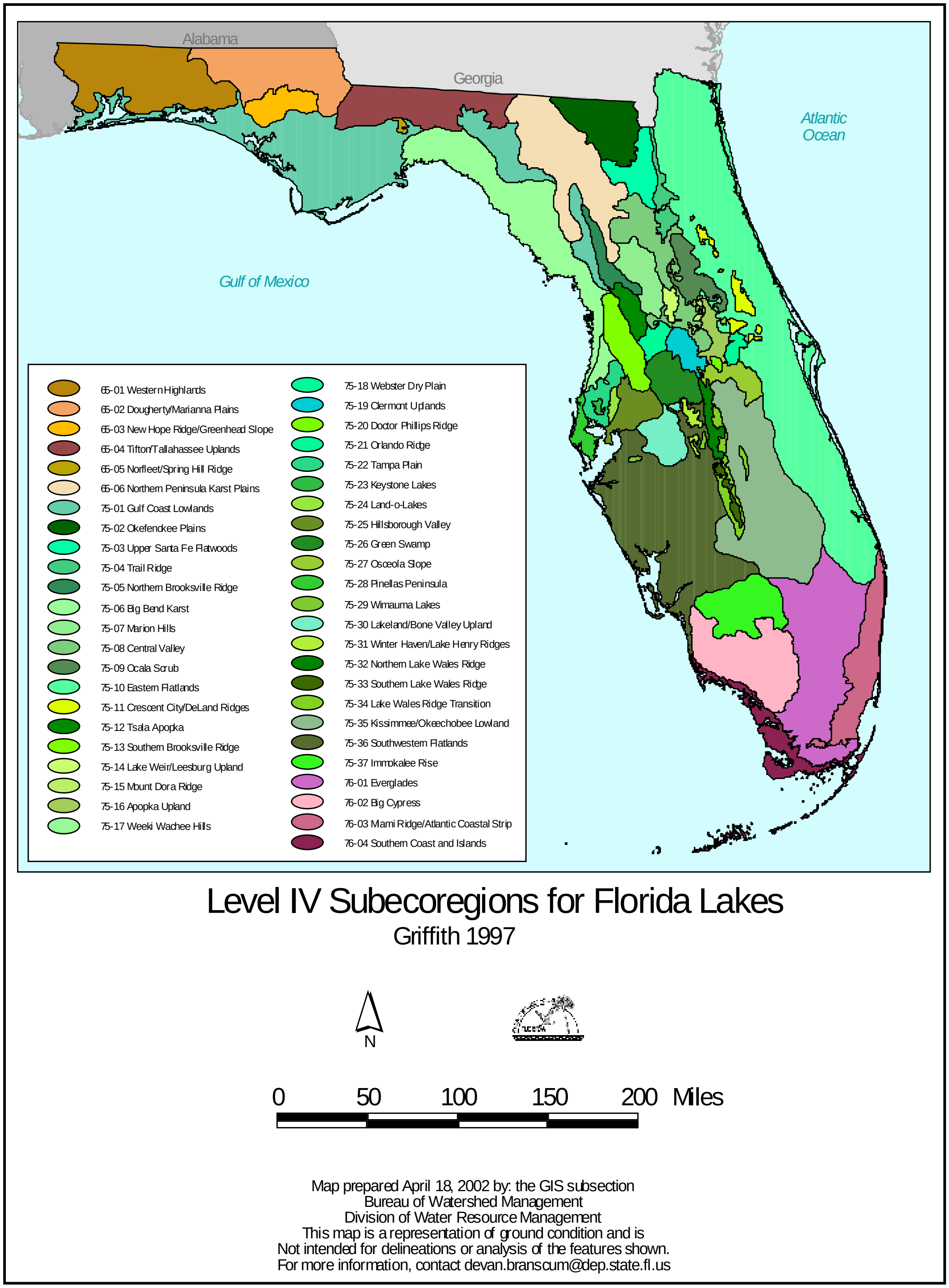

Figure 4. Stream bioregions of Florida

1.1 Use of a Technical Advisory Committee

To assist in the development of numeric nutrient criteria, FDEP convened a Nutrient Criteria Technical Advisory Committee (TAC) in 2003, comprising individuals with expertise in areas related specifically to water quality and biological community response to nutrients in Florida (**Table 2**). The TAC membership is diverse, consisting of representatives with significant experience in the ecology of specific aquatic systems (lacustrine, riverine, estuarine, and/or palustrine) and the interpretation of water quality data through the use of statistical modeling tools. These individuals were chosen for their ability to provide advice and guidance in the dynamics of these aquatic systems, as well as to represent the diverse parties in Florida interested in the development of nutrient criteria. They include representatives of academic and public institutions, along with individuals possessing significant technical experience who were drawn from industry, agricultural, and environmental groups.

The TAC is charged with reviewing the existing knowledge base related to these aquatic systems and developing recommendations to FDEP on numeric nutrient criteria. The TAC is supported by FDEP staff assigned to provide data assembly and analysis. The TAC process to date, along with further in-depth evaluations of available data and the existing knowledge base by FDEP staff have clearly indicated that there are numerous remaining technical complexities and limitations associated with the verification, analysis, and synthesis of the currently available data for the derivation of numeric nutrient criteria. Given these complexities, FDEP has decided to extend the TAC process through 2009 at a minimum. FDEP anticipates that smaller subgroups may need to be formed to consult with other experts in addressing specific waterbody types (*e.g.*, south Florida canals, or estuaries) for which criteria are under development.

FDEP has assigned a dedicated staff member to coordinate the development of numeric nutrient criteria. This nutrient coordinator is responsible for communicating with EPA, the TAC, and other interested parties on the development of nutrient criteria, and also ensuring that the process is properly integrated with other FDEP program areas.

In accordance with Florida's Sunshine Law, all meetings of the TAC have been and will continue to be open to the public. To further promote public awareness and involvement in the process, each TAC meeting incorporates designated periods for informal public participation and comment. In recognition of the large geographic span of the state, TAC meetings are held at different locations within Florida on a rotating basis. Also, a link on the FDEP website (http://www.dep.state.fl.us/water/wqssp/nutrients/index.htm) has been established to report all TAC activities.

Table 2. FDEP Nutrient Criteria TAC members

Name	Affiliation	Experience Relevant to TAC Appointment
Kevin Carter	South Florida Water Management District *Nominated by Florida League of Cities*	Estuarine systems Canals
Douglas Durbin, Ph.D.	Biological Research Associates, Inc. *Nominated by Florida Phosphate Council*	Riverine systems Lacustrine systems Wetland systems Canals
Mark W. Clark, Ph.D.	University of Florida, Department of Soil and Water Sciences	Wetland systems Nutrient dynamics and eutrophication
Ed Decker	EPA Region 4, Atlanta	EPA Regional Nutrient Coordinator Aquatic biology and chemistry Wastewater treatment Nonpoint source control Surface water monitoring & assessment
Anthony Federico	MacVicar, Federico and Lamb, Inc. *Nominated by Florida Department of Agriculture and Consumer Services*	Lacustrine systems Estuarine systems Riverine systems Water quality modeling FDEP Lake Okeechobee TAC
Robert Fisher, Ph.D.	National Council for Air and Stream Improvement, Inc. *Nominated by Florida Pulp and Paper Association*	Riverine systems EPA Gulf of Mexico Program Nutrient Enrichment Focus Team
John Hendrickson	St. Johns River Water Management District	Lacustrine systems Riverine systems FDEP Impaired Waters TAC (Alternate)
Mark Kraus, Ph.D.	Everglades Foundation	Wetland systems Estuarine systems
Frank Marshall, Ph.D., P.E.	Environmental Consulting & Technology, Inc. *Nominated by Florida Stormwater Association*	Estuarine systems Canals Water quality modeling
Scott McClelland	Camp Dresser & McKee, Inc.	Water quality modeling FDEP Impaired Waters TAC

1.2 Post-TAC Rule Development

After the completion of TAC activities and before the submittal of potential criteria to the state's Environmental Regulation Commission (ERC), FDEP will hold rule development workshops, share draft rule text with the public, and allow for public review and comment, as required by both state and federal regulations. The ERC is an unpaid citizenry board appointed by the Governor of Florida. In exercising its authority, it considers scientific and technical validity, economic impacts, and relative risks and benefits to the public and the environment of all proposed rules and standards related to environmental resources. It is anticipated that ERC activities can be completed in 6 to 12 months, barring major dissent or administrative challenge. However, the level of control that FDEP has over the schedule of the ERC's approval process for such rules is limited, making the establishment of a firm completion date for nutrient criteria adoption difficult. If there is an administrative challenge to the proposed criteria, the administrative hearing process would likely take at least another year. FDEP however, remains committed to a timely completion of this effort.

2. Nutrient Criteria Development and Implementation

2.1 EPA Guidance

EPA's *Nutrient Criteria Technical Guidance Manual: Rivers and Streams* (Buck *et al.,* 2000) described three general approaches, with certain options, for the development of numeric nutrient criteria for streams. The most comprehensive and scientifically defensible approach (the state's preferred approach) is to establish criteria to protect against dependably measured adverse biological responses. EPA suggests that an observed dose-response relationship could be described by a model (*e.g.,* trophic state classification, regional predictive model, biocriteria, etc.), which in turn would link nutrient concentrations to the relative risk of environmental harm.

FDEP supports this approach, since it establishes a cause/effect relationship between nutrients and valued ecological attributes, and is linked to maintaining designated uses. FDEP is currently pursuing response-based thresholds for use as water quality criteria for inclusion in the state's water quality standards rule, Chapter 62-302, F.A.C. In a series of studies (described in detail in Section 3), FDEP is investigating the relationship between nutrients and biological measures such as the Stream Condition Index (SCI), Lake Vegetation Index (LVI), Stream Periphyton Index (SPI) (currently under development), and phytoplankton chlorophyll *a*.

In the absence of data quantitatively describing biological dose-response relationships, EPA recommends as the next best alternative, setting criteria based on an inclusive distribution of values obtained from minimally disturbed reference sites in a designated ecoregion (based on climate and geology) and recommends projection an upper percentile value to represent a level of nutrient concentration that will inherently protect aquatic life. It should be noted that EPA's guidance for both rivers & streams, and lakes & reservoirs suggests using the 75th percentile (but only as a suggestion), and that a higher percentile might be chosen when associated with higher confidence in the reference set that can reduce uncertainty with regard to protection. EPA's more recent guidance for wetlands suggests that using the 75th to 95th percentile may be appropriate. According to published EPA guidance, reference reaches may be identified for each class of stream within a state based on best professional judgment. FDEP also supports this methodology, since it would ensure that nutrient concentrations associated with biologically healthy, well-balanced communities would be considered acceptable as protective of those communities.

However, this approach as described above is an inference model, and does not definitively demonstrate that exceeding the threshold established by the distribution of reference sites results in harm (impairment) to the aquatic life in a particular waterbody. Multiple factors can strongly influence the expression of biological responses to nutrients across waterbodies, such as water velocity, residence time, availability of the other nutrient, presence of grazers, availability of light (due to tree cover and/or water transparency), and availability of suitable habitat. In fact, FDEP has found in Florida waters that additional stressors (*e.g*., degraded habitat, unfavorable hydrology) often influence biological impairments more than the actual concentration of nutrients at a given point. The "minimally affected reference water approach" identifies concentrations that are presumed to be inherently protective of the waterbody (including downstream waters) because these concentrations are associated with demonstrated minimally disturbed systems with healthy biological communities. Actual biological thresholds can be site-specific and arguably more precise.

The third and least preferred approach of those suggested by EPA is offered for use in situations where sufficient known reference sites are unavailable, either absent or not identifiable. This approach is often referred to as the "all streams" approach, and involves establishing criteria using a lower distribution (*e.g.*, 5th to 25th percentile) of a pool of sites of undetermined ecological quality, as long as the pool is sufficiently large enough to represent all waters and can be presumed to reasonably reflect the full range of ambient conditions with a disturbance gradient from least to most impacted. Due to the intended scale of application and the availability of data, EPA used this method to develop and publish under CWA §304(a) recommended nutrient criteria for streams and lakes in Nutrient Ecoregions IX, XII, and XIII. However, after careful review of these recommended criteria, FDEP has concluded that they are not sufficiently defensible (see **Appendix B**). In FDEP's opinion, this "all sites data distribution approach" does not **directly link** nutrient concentrations to valued ecological attributes (healthy, well-balanced populations of flora or fauna), and consequently, FDEP believes that other options are preferable and more scientifically justified. For this reason, FDEP considers the "all sites data distribution approach" to have limited defensibility in Florida, and therefore does not intend to pursue it any further.

2.2 FDEP's Approach

The CWA provides states with three alternative paths for development of protective numeric criteria (40 CFR 131.11). Numeric criteria may be established based upon (1) published Section 304(a) guidance, or (2) 304(a) guidance modified to reflect site-specific conditions, or (3) by use of other scientifically defensible methods (referred to later in this document as "Option 3"). Based on extensive experience with the development of biocriteria, FDEP has gained significant knowledge and expertise in the objective quantification of human disturbance and characterization of biological response. Therefore, FDEP intends to pursue the CWA option that allows criteria to be based on a state-defined, scientifically defensible method (Option 3) for the purposes of developing numeric nutrient criteria to provide protection and maintenance of aquatic life use in Florida.

FDEP plans to develop numeric nutrient criteria using response-based relationships that are consistent with the existing narrative criterion for nutrients, which states "In no case shall nutrient concentrations of body of water be altered so as to cause an imbalance in natural populations of flora or fauna." The determination that an "imbalance" has occurred requires an evaluation of the relationship between nutrients and biological health (while attempting to control for confounding variables) and includes the following:

- *Defining the expected biological integrity (aquatic community structure and function) by examining minimally disturbed sites in the ecosystem. This is accomplished by developing and calibrating biological indices. FDEP has, or is developing, indices for stream invertebrates, lake plant communities, and stream algae.*
- *Sampling key water quality parameters and biological communities (e.g., algae, macrophytes, and invertebrates) across a nutrient gradient.*
- *Determining where along the nutrient gradient, and at what concentrations, significant departures in the expected community structure and function occur compared with acceptable conditions, using EPA's Biological Condition Gradient (BCG) approach (Davies and Jackson, 2006; Stoddard et al., 2006).*

The BCG concept definitively describes how the following ten ecological attributes change in response to increasing levels of stressors:

- *Historically documented, sensitive, long-lived, or regionally endemic taxa;*
- *Sensitive and rare taxa;*
- *Sensitive but ubiquitous taxa;*
- *Taxa of intermediate tolerance;*
- *Tolerant taxa;*
- *Non-native taxa;*
- *Organism condition;*
- *Ecosystem functions;*
- *Spatial and temporal extent of detrimental effects; and*
- *Ecosystem connectedness.*

Based on the above attributes, the BCG model segregates biological condition into six tiers, as follows, which FDEP believes are especially useful for nutrient criteria development efforts:

(1) Native structural, functional, and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability.

(2) Virtually all native taxa are maintained, with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

(3) Some changes in structure occur due to the loss of some rare native taxa; there are shifts in the relative abundance of taxa, but sensitive–ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system.

(4) Moderate changes in structure occur due to the replacement of some sensitive–ubiquitous taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; there is overall balanced distribution of all expected major groups; ecosystem functions are largely maintained through redundant attributes.

(5) Sensitive taxa are markedly diminished; there is a conspicuously unbalanced distribution of major groups from that expected; organisms show signs of physiological stress; system function shows reduced complexity and redundancy; increased buildup or export of unused materials occurs.

(6) Extreme changes in structure take place; there are wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions occur; organism conditioning is often poor; ecosystem functions are severely altered.

The BCG model is consistent with ecological theory and enables ecologically relevant interpretations of the response of aquatic biota to stressors. EPA has extensively tested the BCG model in various parts of the country with regionally diverse panels of biologists, (often including an FDEP representative), who typically converge on agreement in assigning specific taxa in samples of macroinvertebrates or fish to the six tiers as described above. This process has proved to be a very reliable and consistent to interpret stress on aquatic life and inform agency decision making processes. Based on two independent calibrations of Florida's biological indices, as well as input from several National BCG Workshops, FDEP has determined that sites associated with BCG scores of 5 and 6 do not meet the criteria for the state's designated use of "healthy, well-balanced communities of aquatic flora and fauna."

For numeric nutrient criteria development purposes, the use of the BCG has several implications. Its use may result in the determination that acceptable levels of nutrients may (or may not) be higher than historical background conditions, since well-defined biological response endpoints are used for the assessment. Also, because biological communities respond to all sources of stress (natural and anthropogenic), the model offers a mechanism to evaluate potential stressors and to control for confounding variables during the assessment process. Finally, since the BCG model is based on sound, nationally accepted ecological concepts, the ranges of nutrients deemed acceptable through its use will result in scientifically defensible criteria.

While FDEP has and will continue to pursue all scientifically defensible approaches to derive numeric nutrient criteria, it prefers to base criteria on dose-response relationships. In acknowledgement of the challenges associated with identifying statistically significant relationships between nutrient concentrations and biological responses, FDEP is also developing nutrient criteria using a "benchmark distributional approach" that will serve as potential "backup" criteria if that statistically sound dose response–based criteria cannot be initially determined. However, in addition FDEP may adopt criteria developed from the benchmark distributional approach in Chapter 62-303, rather than Chapter 62-302, F.A.C., and may require biological confirmation before listing waters as impaired.

The nutrient benchmark distributional approach builds on methodologies originally developed to quantify human disturbance for biocriteria development purposes. By FDEP's definition, nutrient benchmark sites are only influenced by low levels of human disturbance, enabling full support of the most sensitive designated use—*i.e.,* support of a healthy, well-balanced population of fish and wildlife. FDEP intends to use the upper end of nitrogen and phosphorus frequency distributions from benchmark sites to define nutrient thresholds that FDEP expects to be both defensible and reliable for protection of aquatic life in Florida waters.

If the benchmark-based nutrient thresholds are adopted in Section 62-303.300, F.A.C., these thresholds would be used to identify waters that are potentially impaired for nutrients. Waters with nutrient concentrations above these thresholds would be placed on the state's Planning List of potentially impaired waters and prioritized for additional monitoring. A subsequent biological confirmation linking biological impairment instream at that point, or possibly downstream, to excess nitrogen or phosphorus would be required for a waterbody to be included on the Verified List of impaired waters (Section 62-303.400, F.A.C.). If no biological impairment can be demonstrated for waters (or downstream of waters) placed on the Planning List for nutrients, or if the biological impairment is shown to be due to factors other than nutrients, then these waters would not be considered impaired due to nutrient enrichment.

FDEP believes that a site-specific biological confirmation is required to demonstrate a link between nutrients and adverse biological responses for nutrient benchmark approach–derived criteria. Multiple factors can strongly influence the expression of biological responses to nutrients across natural waterbodies, and multiple additional stressors (*e.g*., habitat, hydrology) are often more influential on biological impairments than nutrients. The benchmark distributional approach identifies nutrient concentrations that are presumed protective because these concentrations are associated with relatively low human disturbance and healthy biological communities instream at that point, and shown to be protective downstream. Actual biological thresholds will be site-specific and could occur at concentrations above or below the benchmark thresholds, depending on circumstances.

2.3 Implementation

The specific rules in which nutrient criteria are adopted affect the breadth of the CWA programs under which they are implemented. While nutrient thresholds adopted in the IWR may result in identifying waters to be addressed by the development of TMDLs which will establish effluent limitations via wasteload allocations, these thresholds would only apply for the purposes of assessment and listing under CWA Sections 303(d) and 305(b). In contrast, criteria established in Chapter 62-302, F.A.C., would be implemented in the IWR and would also be used to directly establish effluent limits and water quality targets for TMDLs.

Table 3 provides a basic overview of the regulatory structure in which criteria will be adopted in Florida and summarizes the progress made or planned for such adoption.

3. Technical Approaches

FDEP is committed to using technically defensible methods and the most robust dataset feasible to develop protective nutrient criteria for Florida's waters. Since there is a lack of data describing biological dose-response relationships for nutrients, FDEP initially pursued a nutrient benchmark distributional approach. However, the state's preference is to develop criteria linked to biological response. Given this preference, FDEP has continued efforts, including initiating studies in 2008, to develop response-based criteria for adoption in Chapter 62-302, F.A.C. FDEP's ongoing and planned studies are described below.

3.1 Initial Investigations

In 1999, FDEP's Division of Water Resource Management initiated the implementation of a watershed approach patterned after EPA guidance (EPA, 1991, 1995), including the prioritization of waterbodies for TMDL development. FDEP has drawn on the lessons learned and knowledge gained through these processes to prioritize the development of numeric nutrient standards. FDEP also managed five external projects, completed between 2001 and 2003, that focused on specific approaches outlined in EPA nutrient guidance documents (USEPA, 2000; USEPA, 2000). The idea was to see if these approaches would be feasible on a regional scale. The projects were as follows:

(1) *Paleolimnological characterization of predisturbance water quality in two Florida lake regions;*

(2) *Sedimented algal pigment profiles in the Florida paleolimnological study lakes;*

(3) *Development of stream diatom population indices for Florida streams;*

(4) *Comparison of nutrient criteria approaches for Florida lakes with recommendations for TN, TP, chlorophyll a, and Secchi depth criteria; and*

(5) *Another paleolimnological study with further resolution on the lakes in Studies 1 and 2 above.*

It was determined that some of these approaches, while excellent for a specific waterbody, were too time- and cost-intensive for a subregional approach. However, these efforts provided information and insight into both the causal and response aspects of waterbody nutrient status at both site-specific and ecoregional levels. FDEP also anticipates the possibility of applying for funding on additional projects.

Table 3. Summary of regulatory structure and progress towards adopting nutrient criteria in Florida

<table>
<tr><th colspan="2">Rule and Applicable Waterbody Type</th><th>Causal Variables
(Nitrogen and Phosphorus)</th><th>Response Variables</th></tr>
<tr><td rowspan="4">Section 62-303.300s, F.A.C.; Planning List</td><td>Rivers & Streams</td><td>Under Development (planned for 2010)
Will either revise rule to implement criteria adopted in Chapter 62-302, F.A.C., or will adopt benchmark-based thresholds in rule</td><td>Chlorophyll a (adopted*)
SCI (adopted)
Turbidity (adopted)</td></tr>
<tr><td>Lakes</td><td>Under Development (planned for 2010)
Will either revise rule to implement criteria adopted in Chapter 62-302, F.A.C., or will adopt benchmark-based thresholds in rule</td><td>Trophic State Index (TSI) (adopted*)
LVI (planned for 2009)</td></tr>
<tr><td>Estuaries</td><td>Kickoff in 2008 (planned for 2010)</td><td>Chlorophyll a (adopted*)</td></tr>
<tr><td>Wetlands</td><td>Lower Priority</td><td>Wetland Condition Index, which includes vegetation, algae, and invertebrates. This index still needs development, calibration and validation.</td></tr>
<tr><td rowspan="4">Section 62-303.400s, F.A.C.; Verified List</td><td>Rivers & Streams</td><td>Under Development (planned for 2010)
Will either revise rule to implement criteria adopted in Chapter 62-302, F.A.C., or will adopt benchmark-based thresholds in rule</td><td>Chlorophyll a (adopted*)
SCI (adopted)
Turbidity (adopted)</td></tr>
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LVI (planned for 2009)</td></tr>
<tr><td>Estuaries</td><td>Kickoff in 2008 (planned for 2010)</td><td>Chlorophyll a (adopted*)</td></tr>
<tr><td>Wetlands</td><td>Everglades phosphorus criteria via application of criterion in Chapter 62-302, F.A.C.
Lower Priority</td><td>Wetland Condition Index, which includes vegetation, algae, and invertebrates. This index still needs development, calibration and validation.</td></tr>
<tr><td rowspan="4">Section 62-302.500s, F.A.C.; TMDLs & Permit Limits</td><td>Rivers & Streams</td><td>Under Development (planned for 2010)

Proposed nitrate criteria for springs as part of ongoing Triennial Review (2009)</td><td>Transparency Criterion (adopted, with plans to specifically address submerged aquatic vegetation [SAV] in 2009)
SCI (planned for 2009)
Periphyton Index (planned for 2011)</td></tr>
<tr><td>Lakes</td><td>Under Development (planned for 2010)</td><td>Transparency Criterion (adopted, with plans to specifically address SAV in 2009)
LVI (planned for 2009)</td></tr>
<tr><td>Estuaries</td><td>Kickoff in 2008,
Under Development (planned for 2010)</td><td>Transparency Criterion (adopted, with plans to specifically address SAV in 2009)
Under Development (planned for 2011)</td></tr>
<tr><td>Wetlands</td><td>Everglades phosphorus criteria (adopted)
Under Investigation
(science incomplete, lower priority)</td><td>Wetland Condition Index, which includes vegetation, algae, and invertebrates. This index still needs calibration and validation.</td></tr>
</table>

* approved by EPA as “one-sided” thresholds which serve as translators for the state’s existing narratives in assessment activities by providing a threshold above which waters are impaired, but not by design, a threshold below which uses are known to be protected.

3.2 Biological Criteria Development

FDEP has made very significant progress in the development of biological indices specifically designed to assess the health of aquatic biological communities. Fore *et al*. (2007a) developed an SCI to assess the biological condition of macroinvertebrates in Florida streams. Additionally, Fore *et al*. (2007b) developed an LVI to assess the biological condition of aquatic plant communities in Florida lakes. FDEP plans to adopt both the SCI and LVI into the state standards as water quality criteria during its ongoing triennial review, which started in 2008.

In order to further strengthen its bioassessment capabilities, FDEP is adding another tool that can be expected to augment or compliment the SCI and LVI described above, and provide a potential indicator with increased sensitivity to nutrients. Work to develop a Stream Periphyton Index (SPI) for Florida began during the last quarter of 2007, and significant progress is expected by early 2009. FDEP also began using a Rapid Periphyton Survey (RPS) methodology for streams in early 2007 (FDEP Standard Operating Procedure [SOP] FS 7230) (FDEP, 2008). The RPS provides an assessment of the extent and thickness of periphyton in streams and the type of periphyton present (*i.e.*, diatom or filamentous). Both the SCI and LVI were successfully calibrated for Florida waters, and FDEP has actively worked with EPA to hold a BCG workshop for the SPI in late February, 2009, but it is too early to tell whether FDEP will have the same success with periphyton.

The biological criteria and indices developed for Florida provide measures of biological heath that can be used to support the derivation of protective numeric nutrient criteria. Nutrient concentrations associated with "healthy or exceptional" bioassessment index values would be compared to nutrient concentrations associated with "impaired" biological index scores to establish protective nutrient criteria (including adoption of an appropriate margin of safety). Biological health measures can be used to both demonstrate healthy, well-balanced populations of flora or fauna within benchmark waters and as thresholds of biological impairment for stressor response–based approaches. Additionally, the adoption of the SCI and LVI into state water quality standards will provide FDEP with additional measures of biological impairment that can be linked to violations of the existing narrative nutrient criteria[1] and thus provide an added level of protection against the anthropogenic nutrient enrichment of Florida's waters. FDEP's significant investment in the development of biological indices and criteria has put the state in a strong position to complete the development of highly defensible numeric nutrient criteria within the time frames described in Section 9 of this plan.

3.3 Nutrient Gradient Stream Study

As noted previously, the most comprehensive and protective approach to develop numeric nutrient criteria is to establish criteria to protect against scientifically determined adverse biological responses. EPA suggests that an observed dose-response relationship should be described by a model (*e.g.,* trophic state classification, regional predictive model, biocriteria), which in turn would link nutrient concentrations to the relative risk of environmental harm.

Although Florida will continue to work on the development of numeric nutrient thresholds using the benchmark distributional approach as a backup, FDEP is actively investigating approaches that more directly link nutrient levels to biological responses. A study designed to establish

[1] Nutrients must be identified as the causative or contributing pollutant prior to a determination that there is a violation of the narrative criterion. The impairment of biological criteria can also be linked to other stressors such as toxicants, habitat, or hydrologic modifications.

nutrient concentrations associated with adverse biological responses, called the Nutrient Gradient Study, was initiated in the spring of 2008.

3.3.1 Study Objectives

The study is specifically designed to provide information necessary to develop nitrogen and phosphorus criteria for streams, although chlorophyll and transparency measures will also be evaluated and considered. Its objectives are as follows:

- *Collect physical, chemical, and biological data on Florida streams to establish the relationship between nutrient levels and adverse biological responses; and*
- *Analyze the resulting dataset as one line of evidence in FDEP's effort to establish numeric nutrient criteria.*

3.3.2 Study Methodology

Unlike other pollutants, nutrients are not only naturally present, they are necessary at some level for the proper functioning of ecosystems. Biological communities evolve in response to the existing physical and chemical characteristics to which they are exposed. In the case of nutrients, the biological communities that develop are the ones best able to compete for and utilize the available nutrients in an ecosystem, given the other characteristics of the system. Changes in the natural nutrient regime—either increased or decreased nutrient levels—can cause shifts in the structure of the biological communities present and ultimately the function of the system. To derive appropriately protective nutrient criteria, this approach related nutrients to ecological health and biological response. Other factors that also affect biological health (*e.g.*, hydrologic modification, habitat, canopy cover) were measured to help determine their relative influence on the biological responses under the observed nutrient regimes.

Each of FDEP's six District offices sampled 12 to 15 sites from a list of 20 potential nutrient gradient sites. Two sampling events were conducted, one during spring/summer 2008 and the other during fall/winter 2008–09. All samples were collected according to FDEP-SOP-001/01. Sampling will be completed by January 2009. The Bureau of Laboratories in Tallahassee will analyze all samples.

The following were performed at each site:

- *Hydrologic Modification Scoring;*
- *SCI;*
- *Habitat Assessment (HA);*
- *Percent Canopy Cover;*
- *Rapid Periphyton Survey;*
- *Qualitative Periphyton Collection;*
- *Linear Vegetation Survey;*
- *Meter Readings (dissolved oxygen [DO], specific conductivity, pH, and temperature); and*
- *Water Chemistry (total Kjeldahl nitrogen [TKN], TP, ammonia, nitrate-nitrite, turbidity, chlorophyll a, color, total organic carbon [TOC], total suspended solids [TSS]).*

A majority of the sites were selected from a previous statewide intensive Dissolved Oxygen Study conducted in 2005 and 2006, and included sites with a variety of Land Development Intensity (LDI) Index scores and nutrient regimes. Additional sites were located near National Pollutant Discharge Elimination System (NPDES) point sources with known nutrient-enrichment issues. Sites were geographically diverse in an attempt to represent as much of the state as possible. The following two types of sites were sampled:

- *Sites located upstream and downstream from high-nutrient point source discharges; and*
- *Sites located along a nutrient gradient, with low, medium, and high nutrient regimes.*

Since the objective of the study was to emphasize the effects of nutrients on biota, attempts were made to minimize or account for confounding factors, such as poor habitat and highly modified hydrologic regime. This especially applied to the sites not affected by point sources. In an effort to reduce the effects of confounding variables, only sites with minimal to moderate levels of habitat or hydrologic modification, as determined by Florida's HA and Hydrologic Modification Scoring, were selected. For the sites upstream and downstream from point sources, the most important factor was to ensure similar habitat and hydrology at the paired sites to emphasize the nutrient influences from the discharge.

A primary purpose of this study was to determine the effects of nutrient concentrations on biological health. Habitat suitability (substrate diversity and abundance), flow, and length of inundation were taken into account when deciding appropriate sites to sample. An HA, Hydrologic Modification Score, and Percent Canopy Cover were obtained at all sites to adequately characterize these important variables. Additionally, staff carefully assessed the existing and antecedent flow conditions of each site to determine that conditions were appropriate for the purpose of the study. A site reconnaissance was also performed to make sure the sites chosen were appropriate for the study objectives.

Throughout the course of the study, each District collected one water chemistry blank and performed duplicate sampling at a site with adequate habitat in order to assess the variability in SCI, RPS, and Qualitative Periphyton Collection results.

3.3.3 Anticipated Study Outcomes and Statistical Approach

It is anticipated that this work, together with FDEP's existing extensive statewide biological database (SBIO), will provide information to establish causal links between water column nutrient levels and adverse biological responses in plant, algal, and macroinvertebrate communities. Nutrient concentrations associated with "exceptional" or "healthy" biological index scores (SCI, LVI, or SPI) will be statistically evaluated against the nutrient concentrations of sites with "impaired" index scores to determine potential dose-response relationships, including the exploration of responses in individual metrics or attributes. If such cause-effect relationships are discerned, the resulting criteria would include an appropriate margin of safety to ensure the protection of healthy, well balanced aquatic communities.

Furthermore, it is anticipated that the study will help to elucidate the effects of other variables (*e.g.*, habitat, flow, canopy cover) on the expression of nutrients. A concurrently planned study on stressor identification and the development of a statewide stressor identification model will complement this proposed work.

FDEP anticipates that the statistical analysis of the resulting data will be sufficiently rigorous to detect biological responses to nutrient enrichment. The ability to statistically determine patterns in the data depends on sample size, the degree of variability in the data, the level of significance used, and the desired power to detect differences among groups. FDEP will use the most robust statistics appropriate to the data characteristics generated from the study. It intends to investigate relationships between nutrient concentrations and biological response with several statistical tools, including the following:

- *Ordinary least squares regression;*
- *Quantile regression;*
- *Conditional probability analysis; and*
- *Change point analysis.*

FDEP will initially investigate biological responses to nutrient enrichment as univariate functions of either phosphorus or nitrogen, using the statistical tools listed above. However, because biological response to nutrients is complex and influenced by numerous other ecological, hydrological, and biogeochemical factors, simple univariate models may not be sufficiently rigorous to support numeric nutrient criteria. If this is the case, FDEP will investigate more complex multivariate techniques that will take into account the influence of factors other than nutrients on biological response. Under this scenario, FDEP will investigate statistical techniques such as the following:

- *Multiple regression;*
- *Classification and ordination;*
- *Cluster analysis;*
- *Principle components analysis; and,*
- *Canonical correspondence analysis.*

This study will fill significant informational gaps in the understanding of stream flora and fauna responses to excess nutrient enrichment. Thus, it will help the state continue to make progress towards the timely adoption of numeric nutrient criteria in the time frames presented in Section 9. Specifically, the state anticipates completing sample collection by January 2009 and data analysis and synthesis within an additional four to five months thereafter. FDEP anticipates deriving numeric phosphorus and nitrogen criteria for Florida streams by December 2009, assuming the successful completion of this project.

Note, however, that if the results from the study are of insufficient statistical rigor to promulgate scientifically defensible criteria, additional sampling and analysis may be needed, resulting in a time extension. The results derived from the study will be presented before FDEP's Nutrient Criteria TAC.

3.4. Development and Initial Application of the Nutrient Benchmark Distributional Approach

The TAC and FDEP staff discussed the benchmark distributional approach over the course of numerous meetings. The TAC indicated its support for FDEP's proposed application of the overall approach (which includes the option of requiring confirmation of biological impairment and use of the resultant thresholds in the IWR rather than in Chapter 62-302, F.A.C.) and recommended that FDEP needed to provide sufficient documentation substantiating low human disturbance levels and biological health (*i.e.,* supporting the designated use) of the selected benchmark sites.

Based on the direction provided during TAC discussions in 2006, FDEP staff conducted a pilot study to develop nutrient criteria for streams in the peninsula bioregion (**Figure 4**) using the benchmark distributional approach. FDEP developed and utilized an extensive multi-step evaluation of potential benchmark sites to ensure that the sites used in the derivation of nutrient thresholds for the peninsula bioregion truly represented low levels of human disturbance. This multi-step evaluation included the following:

(1) *Screening for sites with an LDI score less than or equal to 2.0;*

(2) *Screening to exclude waters on the state's 303(d) list of impaired waters;*

(3) *Verifying surrounding land use using high-resolution aerial photographs;*

(4) *Obtaining input from district biologists knowledgeable about the area;*

(5) *Conducting a statistical outlier analysis; and*

(6) *Carrying out an extensive field evaluation of approximately 10% of the remaining waterbodies (identified by* ***W****ater****b****ody* ***Id****entification number, or WBID*[2]*) containing benchmark sites.*

3.4.1 Identification of Candidate Benchmark Sites (LDI)

Candidate benchmark sites were initially selected based on an application of the LDI. Brown and Vivas (2005) developed the LDI as an estimate of the intensity of human land uses based on nonrenewable energy flow. The application of the LDI is based on the ecological principle that the intensity of human-dominated land uses in a landscape affects the ecological processes of natural communities. More intense activities will result in greater effects on ecological processes. Natural landscapes with little or no agricultural or urban development will likely have intact ecological systems and processes. The intended use of the LDI was as an index of the Human Disturbance Gradient (HDG).

The LDI is calculated as the area-weighted value of the land uses within an area of influence. Using the land use coefficients and the percent area occupied by each land use as determined by geographic information system (GIS) land use coverages developed from high-resolution aerial photographs, the LDI is calculated as follows:

$$\mathbf{LDI_{Total} = \Sigma\ (LDC_i * \%LU_i)}$$

where,

LDI_{Total} = LDI for the area of influence;

$\%LU_i$ = percent of total area of influence in land use i; and

LDC_i = LDI coefficient for land use i.

[2] WBIDs were originally developed for 303(d) assessment purposes and were based on drainage basins defined by the U.S. Geological Survey (USGS) eight-digit Hydrologic Unit Codes (HUCs).

For the purposes of candidate benchmark site selection, LDI values were calculated from land uses within a buffer area of 100 m on each side of the stream and 10 kilometers (km) upstream of the sampling point. Fore (2004) previously demonstrated that LDIs calculated using a 100 m buffer were slightly better predictors of biological health (*i.e.,* SCI) than LDIs calculated on the entire upstream catchment area (watershed).

The fact that an LDI calculated using the 100 m corridor was a better predictor of ecological health was most likely due to the demonstrated effectiveness of riparian buffer zones in removing pollutants, especially nutrients, from stormwater inputs (both surface and subsurface flow). Studies have shown that buffer zone widths of up to 60 m are sufficient to reduce the nutrient load by up to 95% before reaching the stream (Peterjohn and Corell, 1985). Additionally, buffer zones in the Coastal Plain areas are the most effective in retaining nutrients because of gradual slopes, permeable soils, and the abundance of roots that enter the shallow ground water zones (Lowrance, 1997). Since phosphorus is typically found bound to sediments, riparian zones retain most of the incoming phosphorus by capturing sediments. Similarly, nitrate in shallow ground water beneath riparian zones was removed by 85 to 90% due to plant uptake and denitrification in riparian zones 50 to 70 m wide (Lowrance, 1992; Jordan *et al.,* 1993; Jacobs and Gilliam, 1985; Lowrance*,* 1997).

While numerous studies have concluded that buffer widths of 50 to 70 m are sufficient to reduce stormwater nutrient loads to streams by as much as 95%, additional buffer width will provide additional protection to a waterbody. Based on these literature findings and the better correlations with biological health described above, FDEP concluded that an LDI calculated using a 100 m corridor is an appropriately rigorous method of selecting candidate benchmark sites with minimal human disturbance and healthy biological communities.

As discussed in **Appendix A**, the LDI was specifically designed as a measure of human disturbance. LDI values less than or equal to 2.0 within the 100 m buffer area indicate very minimal levels of human disturbance. Numerous studies and evaluation have demonstrated, across multiple waterbody types and taxonomic groups, that the LDI is an accurate predictor of biological health—*i.e.,* healthy, well-balanced biological systems are much more likely to occur at sites with low LDIs (≤ 2.0) than at higher disturbance levels (Fore , 2004; Niu, 2004; Brown and Reiss, 2006; Fore *et al.,* 2007a). Furthermore, it has been demonstrated that a LDI of 2.0 is a consistent and conservative biologically significant breakpoint that can be used to distinguish benchmark conditions from potentially disturbed areas.

Although it would be ideal to incorporate direct measures of biological health into the selection of benchmark sites, paired nutrient and biological data were not available for all sites in the peninsula bioregion. **Appendix A** provides a more detailed discussion of the LDI and its use at select benchmark sites. Since it has been demonstrated that the LDI is highly correlated with multiple measures of biological health, selecting benchmark sites based on an LDI threshold less than or equal to 2.0 is a conservative and ecologically reliable method.

The initial set of candidate benchmark sites in the peninsula bioregion, with available nutrient data of known quality and LDI values less than or equal to 2.0, identified by FDEP consisted of 379 sites distributed among 155 WBIDs. These sites were considered candidate benchmark sites pending further review to demonstrate that they do in fact reflect low levels of human disturbance and are representative of the region.

3.4.2 Additional Benchmark Site Evaluation

The candidate benchmark site list developed from the LDI was then further assessed to ensure that the final set consisted of only minimally disturbed sites capable of supporting healthy, well-balanced biological communities. And due to the nature of nutrients, it is also necessary to confirm that downstream biological communities are free from any impact of transported nutrients at these upstream levels. The following assessments were designed to capture recent land use changes and exclude sites that might not support the designated use—*i.e.,* sites within impaired waterbodies:

- *Sites located within waterbodies (WBIDs) placed on the Verified 303(d) Lists as impaired for nutrients or DO, where nutrients were identified as the causative parameters, were excluded as benchmark sites. Additionally, sites within WBIDs placed on the Verified or Planning 303(d) Lists for biological impairments, regardless of cause, were excluded from the benchmark population.*
- *It should be noted that, since the benchmark sites exhibit low LDIs and human disturbance, WBIDs identified as impaired for DO with factors other than nutrients as the cause likely represent natural conditions for those sites. Further, moderate DO excursions below Florida's current criterion of 5.0 mg/L have not been associated with any adverse biological impacts. Therefore, such sites were not initially excluded from the benchmark dataset for nutrient threshold development. However, FDEP further evaluated these sites using the Stream Condition Index (designed to measure healthy, well balanced communities) to ensure DO was not an adverse issue. For example, despite the naturally low dissolved oxygen at the Middle Prong of the St. Marys River at SR 125 (measured at 2.7 mg/L during the benchmark study) the SCI score was in the "Exceptional" category, exhibiting an unusually diverse assemblage of sensitive invertebrates and indicating the site is clearly meeting its Class III designated use.*
- *The low level of human disturbance of every candidate site was confirmed via a review of recent (2004) high-resolution (1 m ground resolution) aerial photographs. This review consisted of searching the photos for recent land clearing or development, with particular emphasis on identifying any disturbance that encroached into the 100 m buffer area used to calculate the LDI. Sites not representative of freshwater streams (e.g., tidally influenced or channelized) in the peninsula bioregion were also excluded.*
- *Twenty-seven sites were excluded based on the review of aerial photographs. Ten of the excluded sites appeared to be within canals or channelized streams and therefore were not considered representative of a minimally disturbed stream condition. An additional 7 sites were excluded because they were potentially estuarine or tidally influenced based on proximity to the coast and a subsequent review of specific conductance data. All potentially estuarine sites routinely had specific conductance levels above 1,275 micromohs per centimeter (µmho/cm) and episodic values above 4,500 µmho/cm. A conductivity of 4,500 µmho/cm is approximately equivalent to a chloride concentration of 1,500 mg/L, which is used in Florida as the threshold between predominantly fresh and marine waters.*
- *FDEP District staff familiar with streams within their area of the state were asked to provide feedback on the list of candidate benchmark sites. Specifically, they were presented with the following information and question:*

  "For ongoing nutrient criteria development, we are identifying sites with benign land uses in their upstream watershed (LDI < 2) to define the reference condition.

Ken Weaver has produced the attached table of low LDI peninsular reference sites. Can you please look over the list to determine if there are any human activities at particular sites, which may not have been captured by the LDI, that would disqualify the site from being used to define "reference" for nutrient criteria?"

Twenty-two peninsula pilot study sites were excluded from the benchmark set based on feedback and best professional judgment comments provided by District staff. Staff identified additional channelized streams, estuarine sites, and potentially disturbed sites. It should be noted that all the excluded sites were previously identified and confirmed as having a low LDI. In some cases, staff identified potential point source discharges or localized disturbances (e.g., cattle in a stream) that may not have been captured in the LDI calculation. In other cases, sites were excluded because the reviewer was aware of moderate to high levels of development in the watershed that were outside the 100 m buffer but potentially had an indirect (e.g., ground water) or minor effect on stream conditions; however, the sites may still be representative of low human disturbance levels. The exclusion of these potentially disturbed sites represents a conservative component of the FDEP approach designed to ensure that the benchmark set consists solely of sites with low human disturbance levels that are supporting the designated use.

3.4.3 Field Evaluation of Peninsula Bioregion Benchmark Stream Sites

In February 2007, FDEP initiated an intensive field study of the candidate peninsula bioregion benchmark sites to provide additional assurance that the sites truly supported healthy, well-balanced aquatic communities and had low human disturbance levels. A subset of the population of candidate benchmark sites was selected for additional review, with the objective of building additional confidence in FDEP's extensive multi-step validation process for identifying benchmark sites. Biological data were collected with the objective of confirming that the sites did in fact support healthy, well-balanced biological communities and to demonstrate that an upper percentile (*i.e.*, 75^{th} to 95^{th} percentile) was protective of this biological community.

Experienced FDEP staff visited a total of 30 candidate benchmark sites, representing 26 WBIDs, between February 5, 2007, and March 7, 2007, and assessed then for inclusion in the final set of benchmark sites. The candidate benchmark sites evaluated in this study were initially selected using an LDI less than or equal to 2.0 and other assessments described above. Study sites were selected to cover the range of phosphorus concentrations exhibited by the population of candidate benchmark sites. Sites were grouped by their geometric mean TP concentrations for the period of record (sites with means ≥ 90, < 90-60, and < 60 μg/L). At least 10 sites within each concentration range were visited and evaluated during this study. Overall, long-term geometric mean TP concentrations at study sites ranged from 30 to 140 μg/L, and long-term geometric mean TN concentrations ranged from 0.6 to 2.1 mg/L. Sites were also selected to be representative of most of the WBIDs in the candidate benchmark dataset. The site with the most extensive and longest period of record was selected to represent the WBID.

Site evaluations included a survey of anthropogenic inputs and surrounding land uses. The survey included both an on-site inspection of the stream channel at least 200 m upstream of the sample point and a driving tour of accessible areas in the watershed upstream of the sampling site. Field investigations of the watersheds were guided by high-resolution aerial photographs taken in 2004 and maps of the entire drainage basin. Investigators made observations concerning potential human disturbances in the watershed that might affect conditions within a given stream.

Additionally, experienced staff characterized the sites using both FDEP's standard HA and Hydrologic Modification Scoring systems as objective measures of human disturbance. FDEP biologists routinely calculate the HA index whenever stream macroinvertebrate samples are collected (FDEP, 2008). The index evaluates substrate condition and availability, water velocity, habitat smothering (*e.g.*, by sand and silt), channelization, bank stability, and the width and condition of riparian vegetation. The Hydrologic Modification Scoring system was originally developed to support the development of Florida's SCI and is scored based on knowledge of water removal, ditching and draining, control structures, impervious surfaces, and hydrographs for the sites under evaluation (Fore, 2004; Fore *et al.,* 2007a).

At each site, trained and experienced FDEP staff also collected and analyzed the biological, chemical, and physical parameters listed below following standard FDEP SOPs: (http://www.dep.state.fl.us/labs/sop). Water levels were evaluated both by reviewing hydrographs from the given stream or other streams in the general vicinity and by visual inspection of the stream habitats. Biological samples (*e.g.*, SCI) were not collected if, based on the judgment of the experienced investigator, a majority of the aquatic habitat was exposed to the air rather than being inundated.

Bioassessments could not initially be conducted at 17 out of the 31 sites visited due to protracted drought conditions prior to and following the study. However, significant rainfall occurred in August, 2008 (Tropical Storm Fay), and FDEP staff conducted follow-up biological assessments during December 2008 at the previously dry or low flow sites. Sampled parameters were selected both to verify the benchmark status of candidate sites and to support anticipated future efforts such as statewide numeric nutrient criteria and biological index (*e.g.*, RPS, periphyton index) development.

It should be noted that no calibrated interpretative tool existed for the periphyton parameters when these data were analyzed; therefore, the interpretation of results was primarily qualitative. Methods for the RPS are still under development and no interpretation framework for the method currently exists; thus, RPS results have not yet been evaluated. The RPS may be used as a response variable in the future to help refine nutrient thresholds, after more data have been collected and benchmark expectations have been established.

3.4.3.1 Parameters Monitored During the Survey

Information acquired during the site and watershed evaluations was used to provide final confirmation that the remaining candidate sites were in fact representative of the benchmark stream condition for the bioregion. Taken together with the LDI and other screening criteria, the results of the peninsula benchmark stream survey provide an extremely high level of confidence that FDEP's benchmark set represents a low level of human disturbance that is supportive of the designated use, and these facts are documented in the benchmark site summaries (**Appendex C**) attached as separate documents. **Table 4** lists the parameters monitored during the peninsula bioregion benchmark stream survey.

Table 4. Parameters monitored during the peninsula bioregion benchmark survey

Biological Parameters	Chemical and Physical Parameters
• SCI	• TP
• RPS	• Nitrite + Nitrate
• Natural Substrate Periphyton (*i.e.,* periphyton taxonomy)	• TKN
	• Ammonia

• HA	• Color
• Chlorophyll *a*	• Turbidity
• Phaeophytin	• Specific Conductance (*in situ*)
• Algal Growth Potential (AGP)	• DO (*in situ*)
	• pH (*in situ*)
	• Water Temperature (*in situ*)

Although FDEP staff were unable to collect biological samples at some sites due to low water conditions, the available data indicate that the benchmark sites support healthy, well-balanced populations of flora and fauna even at nutrient concentrations above the 90th percentile of the benchmark distribution (**Figures 5** and **6**). Exceptional biological communities (SCI≥ 68) were found at sites with TP concentrations as high as 350 μg/L and long-term mean concentrations up to 128 μg/L. Similarly, exceptional biological communities (SCI ≥ 68) were found at sites with TN concentrations exceeding 1.7 mg/L. After this preliminary analysis was completed, additional biological and water quality data were collected at the sites that could not initially be sampled due to low water (see Appendix C).

Therefore, it can be confidently concluded that TP concentrations at least as high as the 90th percentile, which is derived and discussed below, are protective of the natural populations of flora and fauna in streams with low human disturbance. Furthermore, the percent composition of major algal taxonomic groups (phyla) were very similar across the range of nutrient concentrations investigated (**Figures 7** and **8**). The periphyton communities at all the sites were highly dominated by diatoms (Bacillariophyta), with low percentages of green (Chlorophycota) or blue-green (Cyanophytcota) algae. Additionally, taxa richness was high (40–66) at all benchmark sites, except for Robert's Branch (SEM426LV).

Figure 5. Plots of SCI versus TP concentrations at sites visited during the peninsula benchmark stream survey

The dashed vertical line in each graph is the 90th percentile TP concentration of the benchmark distribution. Phosphorus values are given as both the sample concentration on the SCI collection date (A) and the period of record geometric mean (B) for the site. SCI values of 68 or above are considered to be indicative of an exceptional biological community, while values to 35 are considered healthy and well-balanced (Fore et al., 2007a). Values below 35 are considered impaired. The slopes on the regression lines are not significantly different from 0, indicating that there is no relationship between TP and SCI within this concentration range.

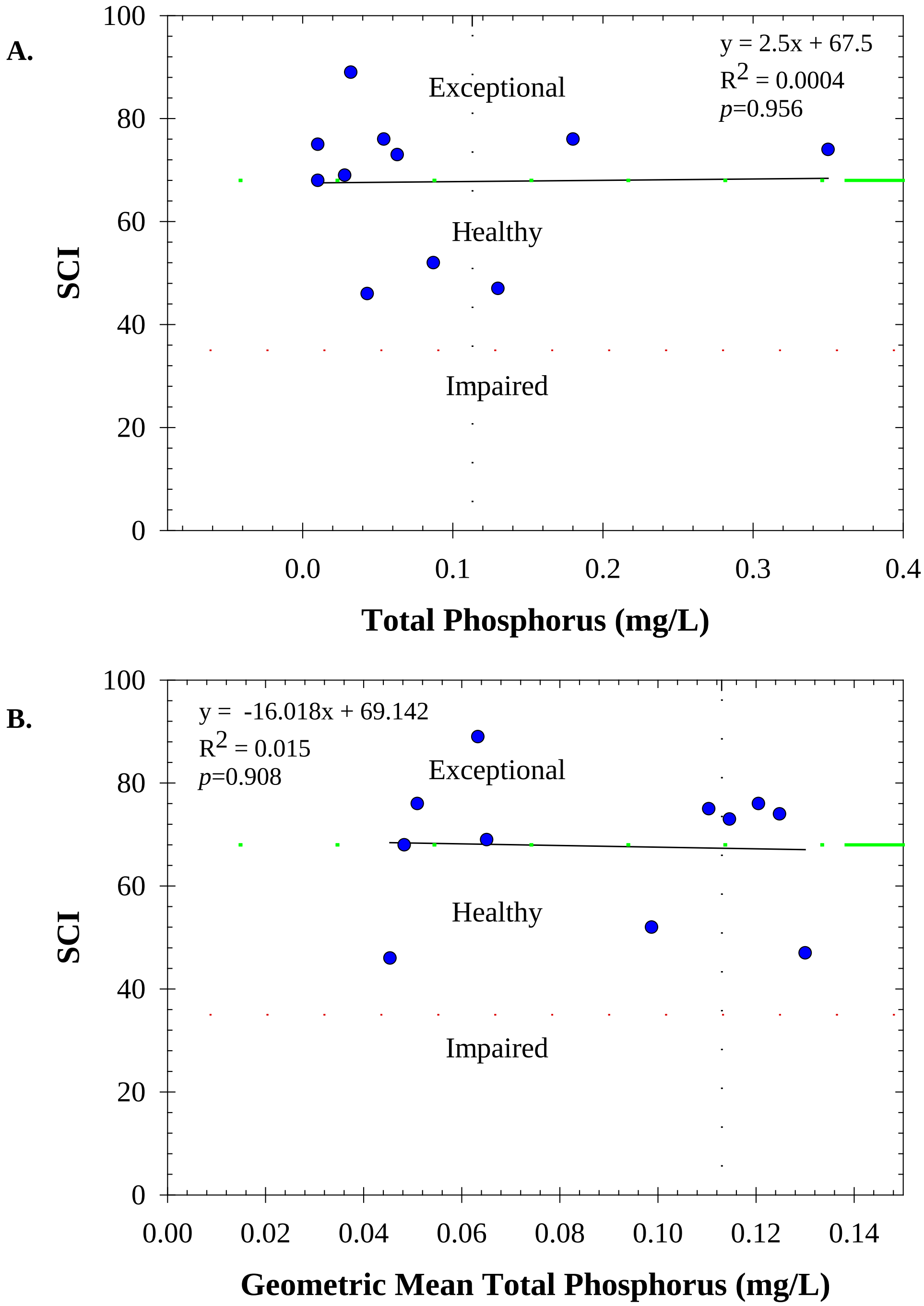


Figure 6. Plots of SCI versus TN concentrations at sites visited during the peninsula benchmark stream survey

The dashed vertical line in each graph is the 90th percentile TN concentration of the benchmark distribution. Nitrogen values are given as both the sample concentration on the SCI collection date (A) and the period of record geometric mean (B) for the site. SCI values of 68 or above are considered to be indicative of an exceptional biological community, while values to 35 are considered healthy and well-balanced (Fore et al., 2007a). Values below 35 are considered impaired. The slopes on the regression lines are not significantly different from 0, indicating that there is no relationship between TN and SCI within this concentration range.

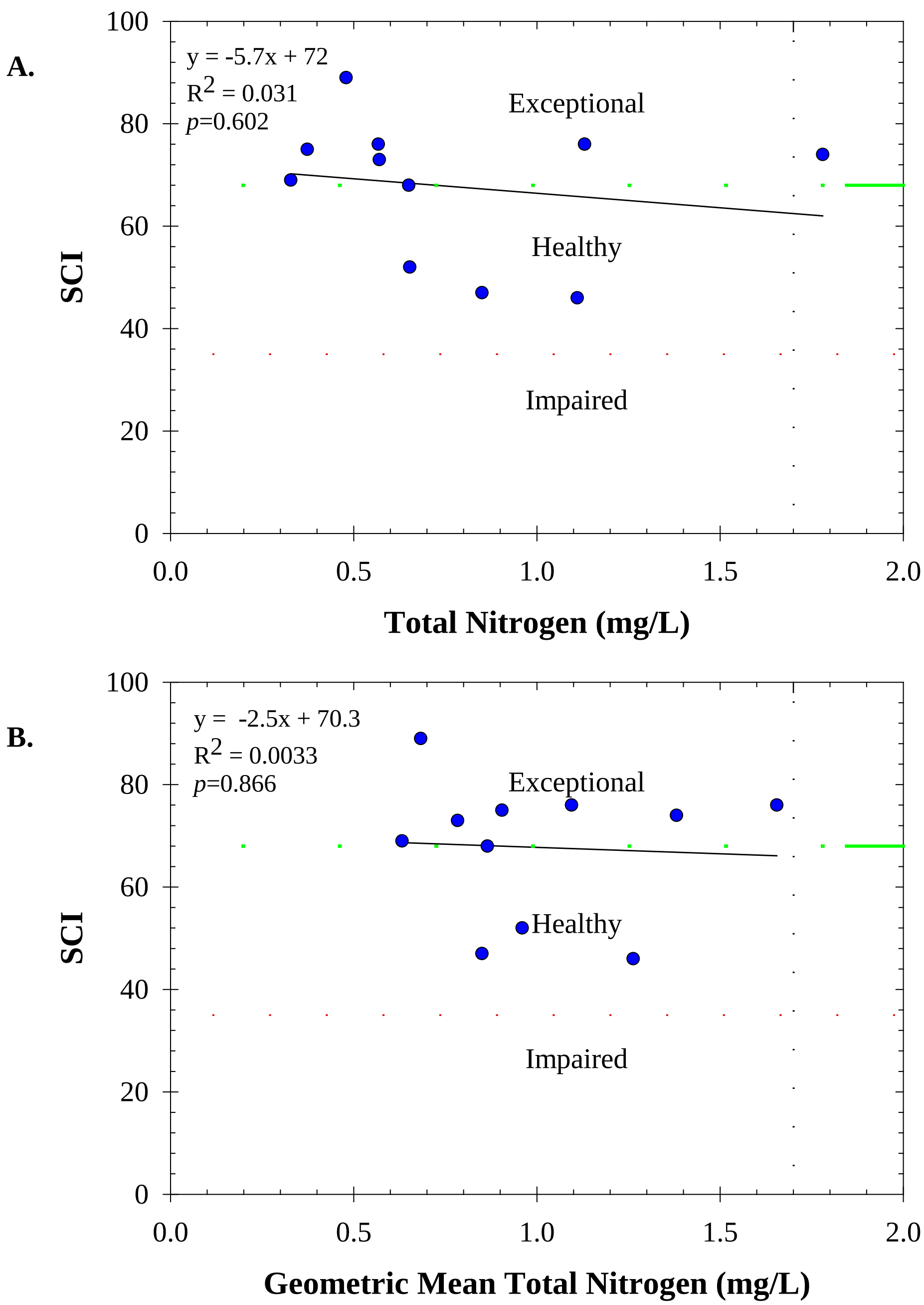


Figure 7. Plots of percent (A) Bacillariophyta, (B) Cryptophycophyta, and (C) Cyanophycota collected on natural substrates versus site period of record geometric mean TP concentrations

The dashed vertical line in each graph is the 90th percentile TP concentration of the benchmark site distribution.

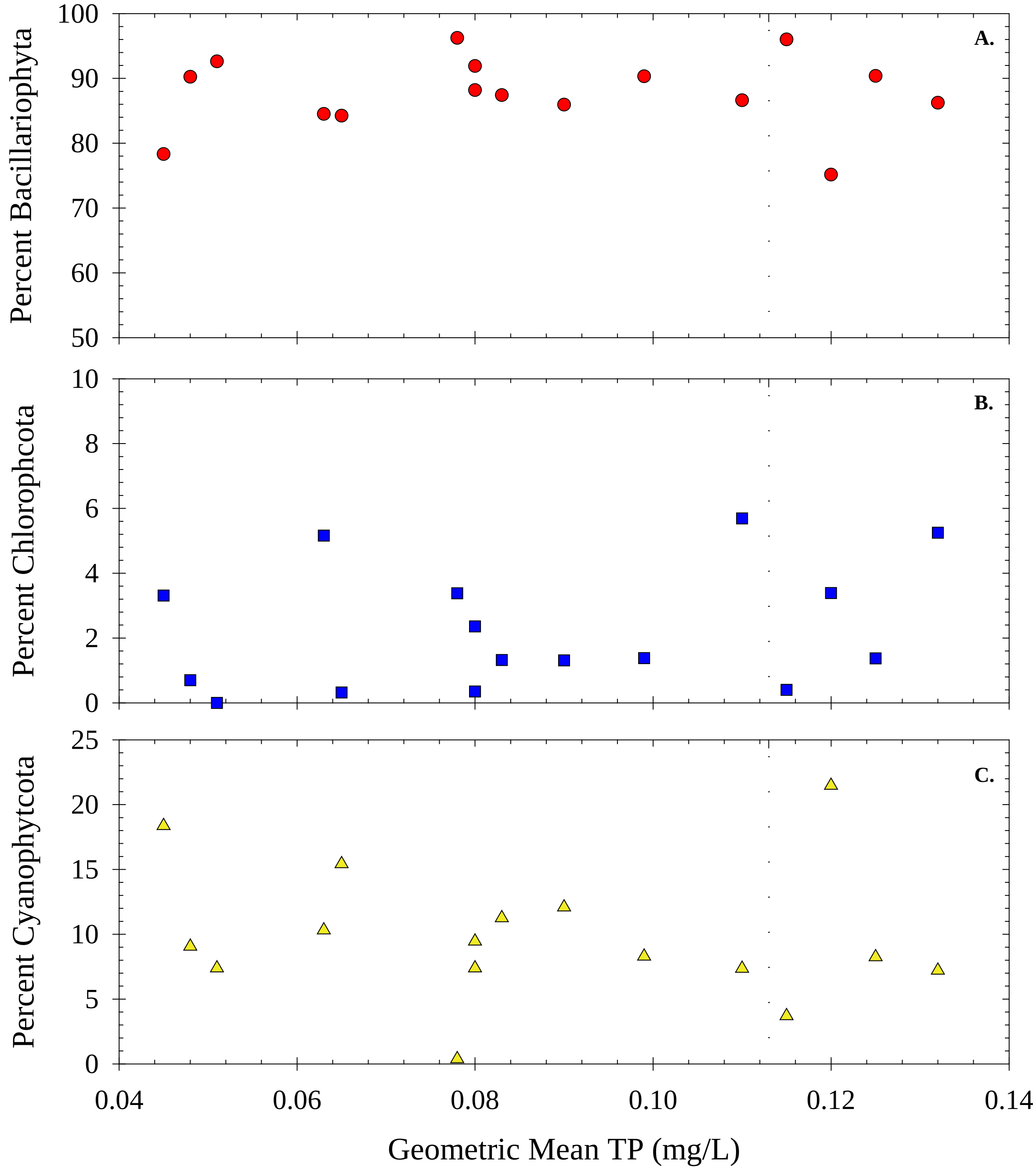
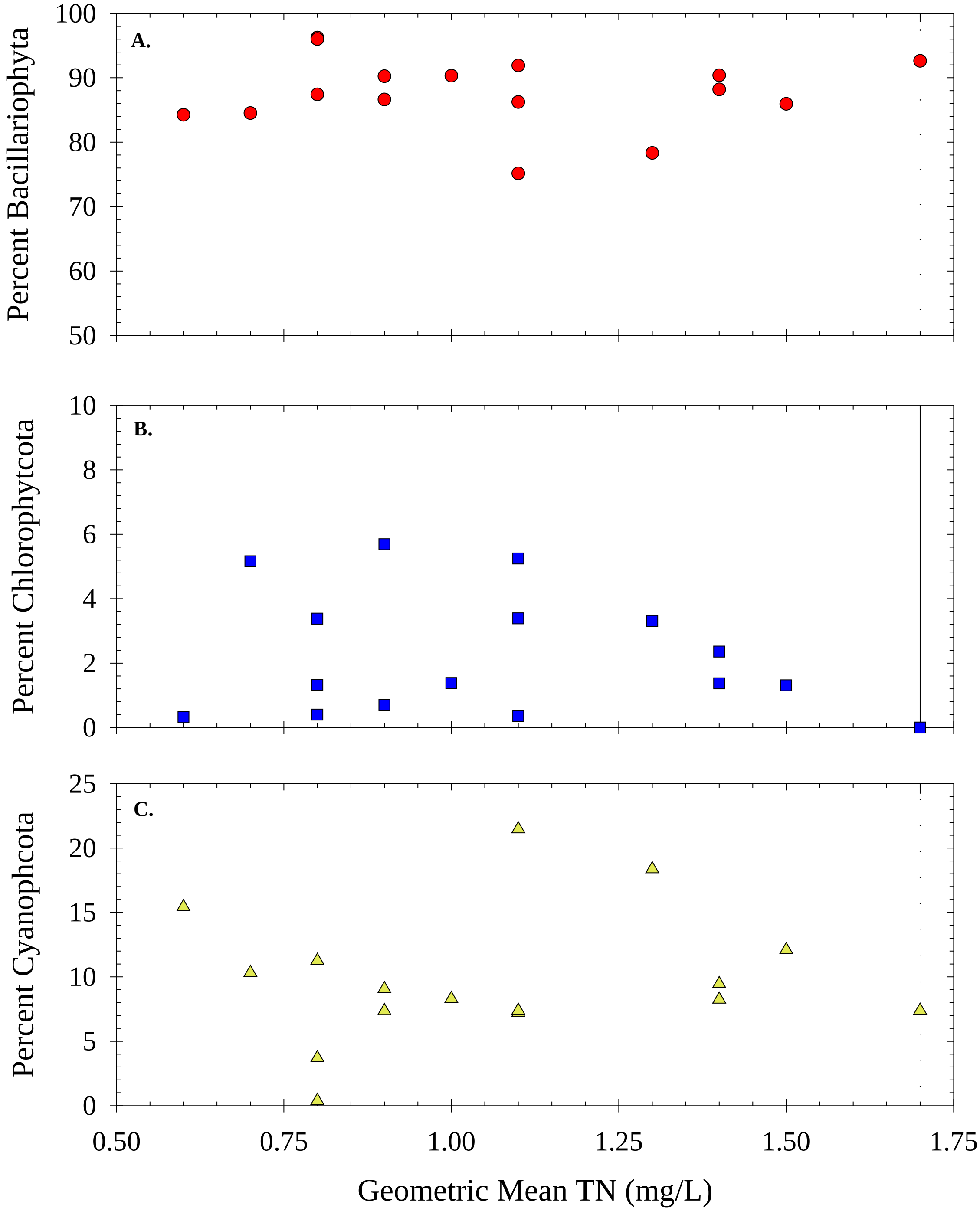


Figure 8. Plots of percent (A) Bacillariophyta, (B) Cryptophycophyta, and (C) Cyanophycota collected on natural substrates versus site period of record geometric mean TN concentrations

The dashed vertical line in each graph is the 90th percentile TN concentration of the benchmark site distribution.



3.4.4 Statistical Outlier Analyses

An analysis of statistical outliers was performed to identify data and sites that were uncharacteristic of the general peninsula dataset used to derive nutrient criteria for the bioregion. This was done to help evaluate the dataset and prevent the nutrient criteria for the bioregion from being unjustifiably biased by a small number of sites that are not representative of the peninsula bioregion (including data from areas affected by significant natural phosphate deposits).

The outlier analysis was performed using standard statistical methods by defining the outlier limit as:

75th percentile + 1.5 * Interquartile Range

Data points identified as outliers were excluded from the dataset. In addition, if more than 50% of the data for an individual site were identified as outliers, then all the data for that site were excluded, since the remaining data for the site cannot be considered representative of the site.

3.4.5 Calculation of Annual WBID Geometric Mean

A number of the benchmark waterbodies were sampled numerous times and by different agencies. The sampling sites used by the different samplers were often located within several hundred meters of each other. Therefore, to avoid biasing the analyses toward the larger waterbodies with multiple sampling sites near to each other, the station level data were aggregated by WBID.

The data were also aggregated over time through the calculation of the annual WBID geometric mean. An annual period was selected because elevated nutrient levels are not acutely toxic in the aquatic environment; instead, their effects are chronic and cumulative over time. Nutrient concentrations typically vary over time and exhibit a log-normal distribution in the aquatic environment. Therefore, instantaneous criteria are not generally considered practical or appropriate for nutrients, and are better expressed as an average over a longer period. Additionally, the geometric mean is often used to provide a more accurate representation, rather than an arithmetic mean, of the central tendency of positively skewed data (*e.g.*, log-normal), such as nutrients. The use of the annual geometric mean mutes short-term variability and provides a more reliable, long-term value for assessing the nutrient status in aquatic environments.

3.4.6 Defining Nutrient Limits

A key issue of the pilot study was the selection of the appropriate percentile to use for the numeric criterion. Since benchmark sites are optimally functioning systems supportive of the designated use, selecting a percentile at the upper end of the distribution (*i.e.*, 90th to 95th percentile) as a criterion is an appropriate decision. This method establishes the range of nutrients characteristic of these biologically healthy sites, with a necessary allowance for confidence in protection, balanced against the possibility of only 5 to 10% of these biologically healthy sites being potentially misidentified as impaired. The range of nutrient concentrations associated with benchmark sites is considered to represent nutrient levels expected in areas with low levels of human disturbance. An upper percentile distribution of the benchmark site population will yield an ecologically justifiable, inherently protective criterion.

Due to the high degree of confidence in the benchmark sites derived through FDEP's multi-step selection process, FDEP used the 90th percentile annual WBID geometric mean TN and TP concentrations for benchmark sites (grouped by WBID) in the peninsula bioregion as the basis for protective numeric nutrient criteria for streams in the bioregion. The extensive verification of the benchmark sites provided a high level of confidence that the resulting benchmark distribution truly represented low levels of human disturbance that fully achieved the designated use of the streams (supporting healthy populations of aquatic flora and fauna). Local use support can be confirmed via coincident nutrient and bioassessment sampling, with the hypothesis that nutrients associated with these minimally disturbed upstream reaches will be inherently protective of downstream waters. The “proof of concept” that downstream conditions still support healthy, well balanced communities will be demonstrated by the Longitudinal Study.

The use of the 90th percentile is further supported by the fact that numerous waterbodies with phosphorous concentrations up to and including this level of phosphorus were shown to support healthy populations of aquatic flora and fauna and fully achieved their designated use. Further, to ensure that the data used were of the highest quality, only data from sources in which the quality of the data could be verified were utilized in the analysis. The application of this method gives calculated criteria of 1.7 mg/L for TN and 113 μg/L for TP.

3.4.7 Ongoing and Future Efforts

During the fall and winter of 2008, FDEP conducted an intensive benchmark site validation process, developed and tested during the peninsular pilot study, to candidate benchmark sites in the panhandle and northeast bioregions. In addition, peninsular benchmark sites that could not be previously sampled due to low water levels were revisited in December 2008. Field reconnaissance and data collection trips for all benchmark sites were completed in December 2008. These statewide site evaluations were conducted for the following reasons:

(1) To confirm and build confidence that the benchmark sites are affected by only low levels of human disturbance;

(2) To support the use of an upper percentile nutrient concentration inclusive of the benchmark distribution as a numeric nutrient criterion; and

(3) To confirm that healthy, well-balanced biological communities (flora and fauna) are protected and maintained at or below a criterion established at the selected upper percentile (e.g., 90th percentile).

3.5 Stressor Identification Study

Historically, FDEP has focused on water quality as the predominant means for assessing water body integrity (*i.e*., impairment status). Through the use of EPA Section 319 funding, FDEP has developed biological assessment tools (*e.g*., Florida’s SCI, BioReconnaissance [BioRecon], and LVI) and habitat assessment procedures as additional means of identifying impairment, especially related to nonpoint source issues. Although bioassessments are useful in determining biological impairment, they do not identify the cause of the impairment, which is required under the Florida Watershed Restoration Act before listing a waterbody as impaired. Currently, a Best Professional Judgment methodology is used to identify the pollutant of concern. The development of a statistically based model(s) for the identification of impairment causes would improve the effectiveness and defensibility of FDEP decisions.

Additionally, identifying the primary causative factors most influential in contributing to biological failures would allow FDEP to focus its limited resources on properly mitigating the responsible stressor(s). Therefore, a legally defensible procedure to determine the causative factor(s) is needed. EPA has developed procedures for stressor identification (*e.g*., Causal

Analysis/Diagnosis Decision Information System [CADDIS]) that are useful only for selected sites after fairly substantial data collection efforts. Florida plans to build on these stressor identification concepts to develop a statistical model or multiple models (Statewide Stressor Identification Model[s]) that incorporates the major nonpoint source stressors widespread in Florida:

- *Hydrologic modification;*
- *Habitat alteration; and,*
- *Water quality issues (e.g., nutrients, sediments, and biochemical oxygen demand [BOD]).*

The development of a calibrated statewide model would prevent Florida from having to perform EPA-style, site-specific stressor identification studies at all biologically impaired sites (a cumbersome and expensive task). It is anticipated that the Statewide Stressor Identification Model(s) will allow FDEP to streamline restoration efforts by identifying the most pervasive human nonpoint stressors in Florida.

The overall approach for this project will involve the assessment and collection of a complex suite of data in order to develop the Statewide Stressor Identification Model(s). Initial emphasis will be on current FDEP tools used to measure the algal (periphyton and phytoplankton), invertebrate, and macrophyte community health of streams, and EPA's list of common candidate causes, which include the following:

- *Nutrient inputs,*
- *Flow alterations,*
- *Sediments,*
- *Metals,*
- *DO,*
- *Temperature,*
- *Ionic strength, and*
- *Habitat assessment.*

FDEP plans to use multivariate statistics to investigate the relationships between all available physical, chemical, and biological data, evaluating significant variables and their relative influence on a system. An iterative process will be employed, consisting of data analysis and the exploration of conceptual models, with discovered relationships used as inputs for developing even more effective models. FDEP will pose a series of hypotheses (conceptual models) and then statistically examine the relationship between stressor(s) and responses. Examples of hypotheses include the following:

- *Turbid runoff, leading to sediment smothering, will cause low SCI scores;*
- *High nutrients, coupled with sunlight and sluggish flow, will lead to excessive periphyton in habitats and reductions in periphyton community and invertebrate health; and*

- *Extreme hydrologic fluctuations, regardless of ambient water quality, will lead to low SCI scores, etc.*

Additionally, biological Stressor Indices (*i.e*., response signature metrics) may be developed that provide better resolving power in identifying specific types of stress. The Stressor Identification Model(s) will be constructed once significant stressor relationships are known. The model(s) will identify the relative influence of major stressors in contributing to biological impairments. From this more complex model, FDEP will investigate the possibility of a simplified model with reduced inputs. Finally, EPA-style stressor identification will be performed at a number of sites to verify the model(s).

The tasks associated with this project are anticipated to include but are not necessarily limited to the following:

- ***Analyze current data:*** *Review water quality and biological data and identification of data gaps for future data collection;*
- ***Evaluate and modify Stressor Indices as necessary:*** *Investigate response signature metrics for the construction of Stressor Indices;*
- ***Identify possible conceptual model(s):*** *Determine conceptual model(s) designed to predict the relationship between the stream Stressor Index and causative variables;*
- ***Collect additional data:*** *Collect data to fill data gaps identified in previous tasks;*
- ***Develop Stressor Identification Model:*** *Develop appropriate model(s) based on water quality and biological data; and*
- ***Validate Model(s):*** *Validate model(s) with an independent dataset and verify by comparing the model(s) output with the output of deterministic stressor identification (e.g., CADDIS).*

Once this model is developed, it can be used to better quantify the relationship between nutrient levels and stream health, given all the different factors influencing aquatic life.

3.6 Development of the Stream Periphyton Index

FDEP recently developed and validated a multimetric index based on periphyton samples from Florida streams (the SPI), but the index has yet to be calibrated. The following briefly describes this ongoing process.

(1) ***Evaluate algal distributional patterns:*** *FDEP identified patterns of taxonomic distribution for algal species. If needed, metrics will be calibrated separately within each region to ensure that the final index value represents the same level of biological condition independent of natural features.*

(2) ***Develop gradients of human disturbance:*** *The HDG combined measures of water quality, habitat condition, hydrologic condition, and LDI. In addition, a multimetric nutrient index based on probabilistic data was developed to combine measures of in-stream nutrient concentrations.*

*(3) **Identify and calculate candidate metrics for stream algae:** Appropriate biological metrics were identified and calculated from published taxa lists for both diatom and nondiatom (soft) algae taxa.*

*(4) **Test taxa against the HDG:** Using the HDG, this analysis tested the response of individual diatom and nondiatom taxa to an independently derived measure of site condition. The Florida sensitive taxa and the very tolerant taxa metrics were identified using this process.*

*(5) **Test metric response to human disturbance:** FDEP tested the association between the metrics and the HDG and the nutrient index. Metrics were evaluated for the influence of natural features such as stream size, latitude, and bioregion. After selecting the metrics with a reliable response to disturbance, the redundancy of individual metrics was evaluated. Effective metrics that will be incorporated into the SPI include the number of algal cells requiring high oxygen, the number of oligosaprobic cells, Van Dam's TSI, the percent Florida sensitive cells, and the percent Florida tolerant cells. Additional "soft algae" metrics are still be investigated.*

*(6) **Develop multimetric index:** Metrics were converted into a final index which scores from 0-100. Stream classification was evaluated to determine whether metric scoring rules should compensate for any underlying regional difference, such as pH. The index was tested against the HDG and outliers identified and evaluated for additional sources of disturbance.*

*(7) **Validate results:** FDEP used an independent dataset to validate results from the initial periphyton index analysis. The index and its component metrics were calculated for at least 50 new sites as an independent test of the observed algal response to disturbance.*

*(8) **Conduct power analysis:** Using repeat visits, the percentage of change that the multimetric index can detect was determined. FDEP also evaluated the influence of repeat sampling for increasing the precision of stream algal assessments.*

*(9) **Calibrate the BCG:** In conjunction with EPA, in February, 2009 Florida is convening a panel of national periphyton and ecological experts to calibrate the SPI via the BCG approach. It is anticipated that this may potentially provide a numeric target for the determination of an impairment threshold, which then would be used to establish protective nutrient criteria.*

It is anticipated that the resulting SPI will be an extremely useful response variable for determining impairment associated with nutrient enrichment in streams, and it may also be adopted as Biocriteria in Chapter 62-302, F.A.C. (water quality standards).

3.7 Downstream Effects of Nutrients in Selected Florida Rivers/Estuaries (Nutrient Longitudinal Study)

FDEP initiated a Nutrient Longitudinal Study during the summer of 2008 designed to evaluate downstream biological responses to naturally high nutrient levels. Biological responses to excess nutrients can be separated in space and time from actual enrichment sources—*i.e.,* an adverse response to nutrients may occur well downstream from the actual enrichment. FDEP's hypothesis is that within systems with low levels of human disturbance and intact ecological processes, naturally high levels of nutrients can be assimilated into biota and sediments without causing adverse biological responses, including downstream estuaries. The goal of this study is to demonstrate that nutrient concentrations representative of the upper portion of the benchmark site distribution actually support the designated use of downstream reaches.

3.7.1 Project Objectives

The objectives of the study were as follows:

(1) Collect physical, chemical, and biological data throughout the length of selected Florida river/estuary systems to establish the relationship between nutrient levels and adverse biological responses, including the most sensitive (generally downstream) reaches; and

(2) Analyze the resulting dataset as one line of evidence in FDEP's effort to establish numeric nutrient criteria, particularly relating to the protection of downstream waters.

3.7.2 Project Description

The study focused on relating the effects of nutrients on various biological systems, from upstream to downstream, including the most sensitive areas, which typically are slowly flowing lower reaches or estuaries. Two systems were studied: Waccasassa River and Estuary and Steinhatchee River and /Estuary.

Semiannual sampling was carried out for the biological components and water quality parameters. The first sampling occurred in summer 2008, and the second was done in January 2009. All samples were collected according to FDEP-SOP-001/01. The FDEP Bureau of Laboratories in Tallahassee will analyze water, biological, and sediment samples.

The following was performed at sites where appropriate (dependant on salinity, etc.); the location of sites in each system was established after a reconnaissance trip:

- *Water Chemistry (TKN, TP, ammonia, nitrate-nitrite, turbidity, chlorophyll a, color, TOC, TSS) (monthly);*
- *Meter Readings (DO, specific conductivity, pH, and temperature) (monthly);*
- *Phytoplankton Community Composition (monthly);*
- *Microcystin Analyses (if warranted from results of algal ID) (to be determined);*
- *SCI (quarterly);*
- *HA (quarterly);*
- *Percent Canopy Cover (quarterly);*
- *RPS (quarterly);*
- *Qualitative Periphyton Collection (quarterly);*
- *Linear Vegetation Survey (quarterly);*
- *Sediment Nutrients (semiannually);*
- *Sediment Nutrient Flux Experiments (semiannually); and*
- *Hydrologic Modification Scoring (once).*

Both systems were selected to represent conditions of relatively low human disturbance, especially with respect to nutrient enrichment. The nutrient regime at the Waccasassa ranges toward values that are less than the peninsular benchmark site distribution average, while the Steinhatchee ranges from near the average to the upper end (90^{th} percentile) of the benchmark site nutrient distribution average.

Since the objective of the study is to emphasize the effects of nutrients on biota, attempts were made to minimize or account for confounding factors during site selection. Habitat suitability (substrate diversity and abundance), flow, and length of inundation were examined when deciding appropriate sites to sample. An HA, Hydrologic Modification Score, and Percent Canopy Cover determination was performed at all sites to adequately characterize these important variables. Additionally, staff carefully assessed the existing and antecedent flow conditions of each site to determine that they were appropriate for the purpose of the study. There were some issues associated with extremely low flow during the first field sampling effort. It is anticipated that winter rains have increased water velocities, and those conditions will be reflected during the January 2009 sampling event.

3.7.3 Project Outcomes

FDEP hopes that this work will provide evidence that criteria developed using the benchmark distributional approach are protective of downstream waters. The knowledge that biota in downstream waters are sufficiently protected would help in establishing numeric nutrient thresholds or criteria using the benchmark distributional approach. Furthermore, it is anticipated that the study will help to elucidate the effects of other variables (*e.g.*, habitat, flow, canopy cover) on the expression of nutrients. FDEP will complete sample collection in January 2009 and will analyze/synthesize the results in an additional six to eight months.

3.8 Nitrate-Nitrite Analysis in Streams/Spring Runs

Florida springs are highly valued for their aesthetic and recreational attributes. The state has approximately 600 springs, which are visited by millions of people each year for swimming and boating because of their beautiful, clear waters. Human activities during the past 40 years have resulted in increased nitrate-nitrite concentrations in many springs, and anecdotal evidence suggests that this has contributed to the currently observed nuisance plant and macroalgal accumulations in many springs. FDEP recently evaluated nitrate trends at 22 Florida springs and determined that the mean nitrate-nitrite concentration in the 1960s was about 0.2 mg/L, while the average is currently around 1.0 mg/L.

Multiple lines of evidence indicate that reducing nitrate-nitrite concentrations in springs should substantially reduce macroalgal growth rates (Stevenson *et al.,* 2007; Niu and Gao, 2007). In turn, the reduced growth rate is expected to result in the reduced frequency, intensity, and duration of nuisance macroalgal growths in spring systems. Both nitrogen and phosphorus reductions in Florida springs should limit the growth of macroalgae species and subsequently reduce macroalgal accumulations. Such reductions should be effective as long as target concentrations (*e.g.,* nutrient criteria) are below nutrient concentration thresholds that promote excessive algal growth.

In almost all springs, however, nitrogen (*i.e.*, nitrate-nitrite) reductions may be the only practical restoration strategy because natural phosphorus concentrations (those not influenced by humans) are generally higher than the levels necessary to constrain algal growth. Results from experimental and *in situ* studies were used to establish the nitrate-nitrite concentration necessary to prevent biological imbalances (*i.e.*, to restrict the growth and accumulations of nuisance macroalgae and to preserve the native periphyton community structure).

The most accurate and conservative experimental results, those from micro-centrifuge tube experiments, suggest that nitrate concentrations less than 0.230 mg/L are needed to slow the growth of *Lyngbya wollei*. Similarly, to reduce the growth of *Vaucheria* under laboratory conditions, nitrate concentrations below approximately 0.261 mg/L would be required (Stevenson *et al.,* 2007).

The results of periphyton field surveys conducted at a large number of spring systems indicated that nitrate concentrations would need to be reduced below the observed 0.454 mg/L nitrate-nitrite threshold to reduce the nuisance abundance and cover of *Vaucheria* sp. in Florida springs (Pinowska *et al.,* 2007). Since the 0.454 mg/L threshold represents the lower range of nitrate concentrations for sites with excessive algal growth and cover, an appropriate safety margin would need to be applied to turn the threshold into a protective criterion.

In addition, nearly a decade of scientific results from periphytometers deployed in the spring-dominated Suwannee, Santa Fe, and Withlacoochee (north) Rivers clearly indicated an imbalance threshold (significant biomass increases and alterations in taxonomic community structure) at 0.441 mg/L of nitrate-nitrite. A margin of safety, derived from an analysis of the variability in the nitrate-nitrite concentrations in this system, resulted in the final 0.35 mg/L nitrate-nitrite criterion.

Based on the best, most comprehensive scientific data currently available, this criterion provides FDEP with reasonable assurance that imbalances of aquatic flora are unlikely to occur below this level. The data also indicate that imbalances do occur at nitrate-nitrite concentrations near 0.45 mg/L and above. Therefore, a nitrate-nitrite criterion of 0.35 mg/L for springs was proposed during the ongoing triennial review, which was initiated in July 2008.

3.9 Lake Algal and Macrophyte Response

FDEP intends to evaluate both algal and macrophyte response thresholds in Florida lakes. Staff presented preliminary conditional probability analyses between the LVI and TP and TN concentrations at the February 25, 2008, meeting of the Nutrient Criteria TAC (**Figures 9** and **10**). The analysis with phosphorus showed that the probability of occurrence of an LVI score less than 37 (the impairment threshold) increased up to a lake TP concentration of approximately 50 μg/L, at which point the probability of impairment leveled off. However, there was significant uncertainty at concentrations above 45 μg/L, given the small sample size for lakes with concentrations above this level. Similarly, the probability of occurrence of an LVI less than 37 increased with increasing TN concentrations.

These preliminary analyses demonstrate a likely relationship between in-lake nutrients and macrophyte community health. Because the paired LVI and nutrient dataset is currently limited, particularly in lakes with TP concentrations above 45 μg/L, FDEP conducted additional LVIs with paired nutrient samples during the summer and fall of 2008. A subset of lakes previously sampled as part of the state's randomized status and trends monitoring was targeted for LVI and water quality sample collection. Although samples were apportioned across the entire range of nutrient concentrations, priority was given to lakes with TP concentrations between 45 and 200 μg/L in an attempt to reduce the uncertainty (*i.e.*, confidence interval width) by increasing sample size in this range of nutrient concentrations.

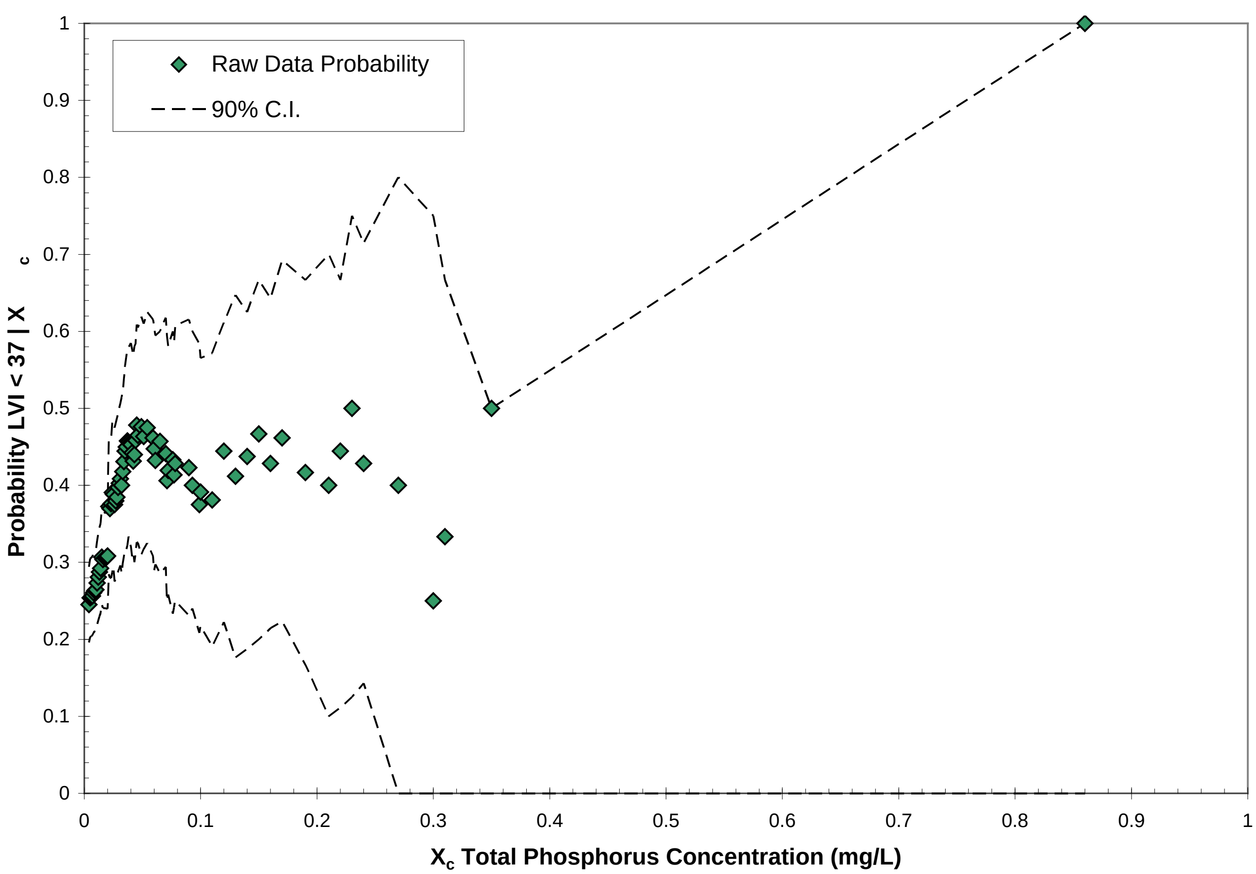
FDEP also intends to evaluate algal responses to nutrients. Initially, the evaluation will be based on relationships between nutrients and chlorophyll *a* concentrations. Secondarily, the evaluation will look for relationships between nutrients and metrics contained in the LVI. These analyses will include the evaluation of regression models as well as conditional probability using ecologically significant thresholds. Conditional probability analysis may include a joint analysis of the probability of exceeding either chlorophyll *a* or LVI impairment targets, since any given lake may be either algal or macrophyte dominated. Community-based analyses may follow if necessary and pending the development of a calibrated lake phytoplankton index.

3.10 Recreation-Based Criteria

The University of Florida LakeWatch Program conducted a study that correlated Florida lake residents' aesthetic perceptions with simultaneously measured nutrient and chlorophyll *a* data. In the study, residents perceived that lake water was less conducive to swimming and aesthetic enjoyment when chlorophyll *a* concentrations ranged from approximately 17 to 22 μg/L. FDEP may potentially use such information as a line of evidence when establishing appropriate lake chlorophyll *a* thresholds; however, it is not pursuing additional studies of this nature at this time.

Figure 9. Probability of observing LVI value less than 37 in Florida lakes if specified TP concentration is exceeded

Dashed lines are 90% confidence intervals from bootstrap estimation.



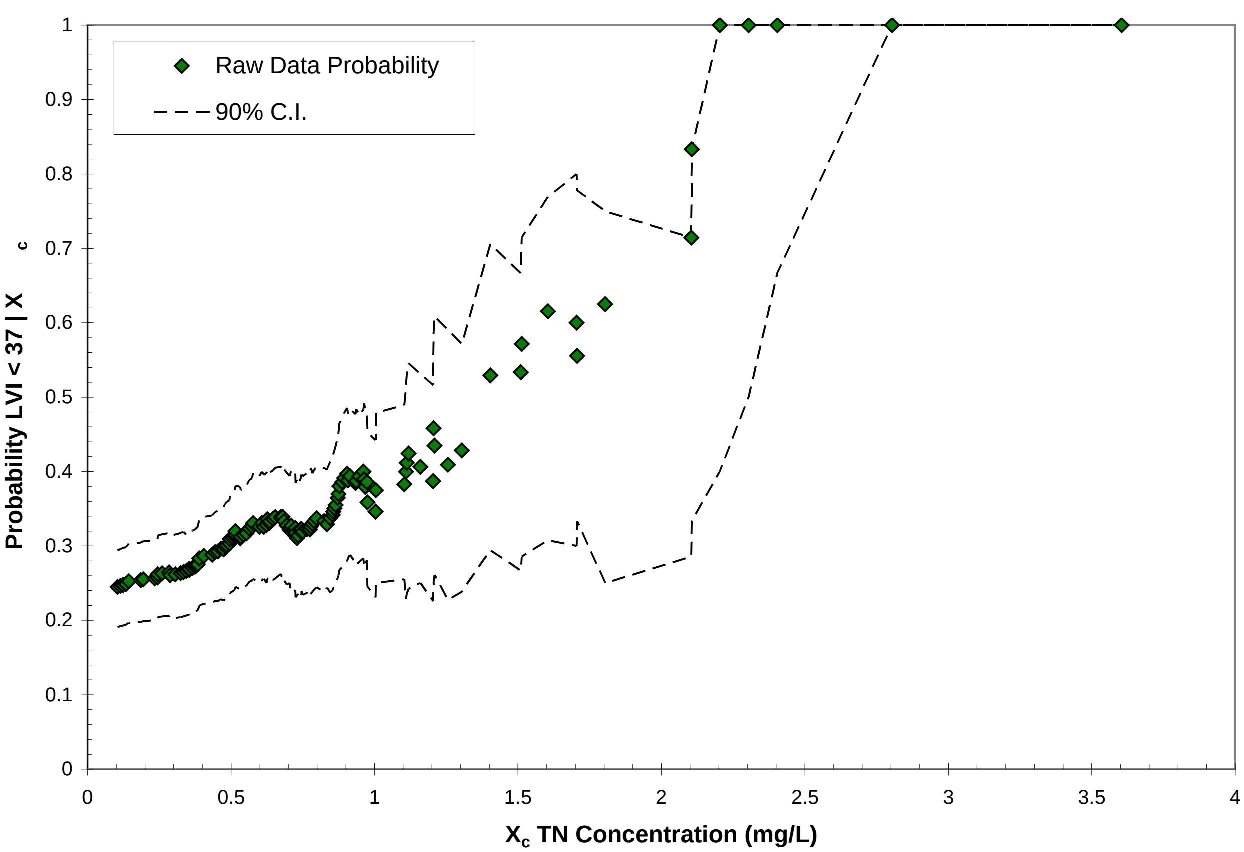
3.11 Application of Benchmark Distributional Approach to Lakes

The majority of FDEP's nutrient criteria efforts to date have focused on streams; however, much of the data and information necessary to apply the benchmark distributional approach to lakes currently exists within the state's extensive database. If needed, FDEP will have the option of applying an approach to lakes using a process similar to that developed for streams. The approach will include the same multi-step validation process incorporating land use evaluations (*e.g.,* LDI, recent aerial photographs, and field reconnaissance) coupled with confirmations of healthy biological communities using the LVI.

Because of the successful calibration of the LVI, FDEP is close to developing response-based nutrient criteria for lakes. Therefore, the benchmark distributional approach will only be pursued as a secondary line of evidence and will be used only to derive criteria if the recreational-based and algal and macrophyte response evaluations fail to identify significant relationships with nutrient enrichment.

Figure 10. Probability of observing LVI value less than 37 in Florida lakes if specified TN concentration is exceeded

Dashed lines are 90% confidence intervals from bootstrap estimation.



3.12 Approach for Estuaries

Florida estuaries tend to be dynamic, many with widely varying water residence times and highly fluctuating salinities, and some with transparency regimes dominated by riverine color inputs. Since a direct comparison between any two specific estuaries is difficult, the "EPA reference waters" approach appears to be less practical than the "dose-response" approach in estuaries. In the approach to estuarine nutrient criteria development, FDEP is seeking to establish empirical and other scientific relationships between nitrogen and phosphorus loads and response variables that represent a quality of water that supports a particular use. In doing so, those estuaries that are currently minimally disturbed will be protected from future adverse impacts associated with nitrogen and phosphorus enrichment. Furthermore, criteria for both causal and response variables will provide a basis for improving water quality in those estuaries currently impacted by excessive nitrogen and/or phosphorus loads.

FDEP currently intends to utilize its existing TAC—coordinated with the Florida Oceans and Coastal Council and the Gulf of Mexico Alliance (GOMA)—and EPA to help develop nutrient criteria for estuaries and coastal waters. FDEP is still evaluating whether to augment the TAC with additional members or to convene a smaller working group with expertise in estuarine and coastal systems. FDEP initiated the development of estuarine nutrient criteria at the beginning of 2008 and began a public process on June 5 and 6, 2008, with an estuarine nutrient criteria development workshop (http://www.dep.state.fl.us/water/wqssp/nutrients/tac_archive.htm). The objective of this meeting was to discuss the state of nutrient science, research, and monitoring for Florida's coastal waters, as well as potential numeric criteria derivation methods. FDEP invited scientists who had performed research on selected Florida estuaries and asked that they do the following:

- *Describe the system, including the hydrodynamics and sources and fates of nutrients;*
- *Describe the type, quality, community structure, areal extent, etc., of valued ecological attributes (biological communities), emphasizing those shown to respond to anthropogenic nutrient enrichment;*
- *Provide scientific evidence quantifying the relationship between anthropogenic nutrient inputs and adverse effects on biological communities; and*
- *Propose numeric targets needed for system protection or restoration, as well as demonstrate the bases for the nutrient targets.*

Of the ten estuary studies presented, half focused on the relationship between nutrient loading (mostly nitrogen) causing excess algal growth (as measured by chlorophyll *a* production), which resulted in decreased transparency and, consequently, light limitation/stress to SAV. In some estuaries, this complex relationship was established; in others, there was a relationship between nutrient loading directly on SAV (no chlorophyll issues); while in others, no relationship between nutrients and biological attributes could be quantified. In one instance, inorganic nutrients were elevated enough to foster harmful algal blooms (HABs) and concomitant declines in animal food webs, even though chlorophyll was low.

From the workshop, it appears that Florida estuaries generally fall into one of three groups, as follows:

(1) *Systems where nutrient dose-response relationships are sufficiently understood to warrant proposing criteria (e.g., Tampa Bay, Perdido Bay, North Indian River*

Lagoon (IRL), Lower St. Johns River, and potentially Sarasota Bay). These systems have historically demonstrated nutrient issues, and many are recovering due to restoration efforts. Note that in many of these systems, the strongest relationship between nutrients and SAV response was based on loadings, not concentrations. Time series data from these estuaries would be valuable in helping model dose-response relationships.

(2) Systems where factors other than nutrients appear to be more influential in defining biological community structure, making it currently difficult to propose scientifically defensible nutrient criteria (Caloosahatchee, South IRL, Pensacola Bay, parts of Florida Bay, and Charlotte Harbor). For these estuaries, some sort of reasonable assurance (e.g., from a model) that a particular nutrient regime protects the designated use would be needed.

(3) Systems that currently appear to be healthy and well-functioning and a "maintain the status quo" approach for nutrients may be appropriate (e.g., Apalachicola, Apalachee, St. Andrews, Nassau/Amelia/St. Marys, Tolomato, Guana, Matanzas, Ten Thousand Islands).

FDEP is particularly interested in an approach used by the St. Johns River Water Management District (SJRWMD) for the North IRL in which:

- *SAV was related to a watershed loading regression model;*
- *Transparency depth targets to protect SAV photosynthesis in the IRL ranged from 1.2 to 1.8 m; and*
- *Turbidity, chlorophyll a, and color targets were based on preventing a transparency reduction of greater than 10%.*

Using a model by Valiela and Cole (2002), total allowable nitrogen load limits for each segment could be calculated, and it was estimated that the loading needed to be below 20 kilograms of nitrogen per hectare per year (kg N/ha/yr) (based on water area) to protect SAV. A critical component is water residence time.

The EPA National Nutrient Criteria Technical Guidance Manual for estuarine and coastal marine waters recommended that appropriate response variables include chlorophyll, water clarity and other variables recognized in the scientific literature as responsive to nutrient inputs, including dissolved oxygen, seagrass or other biological components of the estuarine ecosystem. FDEP expressed the desire to target nutrient criteria development to protect seagrass habitats, a valued estuarine resource throughout the State that supports particular uses. The scientific literature recognizes that the effects of nutrients on seagrass are well-known, but also that these effects are largely indirect. To a first approximation, elevated nutrient loads enhance both phytoplankton production and growth of epiphytic algae on seagrass leaves. Together with colored dissolved organic matter and suspended particulates, these factors reduce water clarity and light availability for seagrass growth.

FDEP is currently working with EPA to gather the information necessary to develop a Florida-specific estuarine nutrient cause/effect relationship, potentially similar to the Valiela and Cole (2002) model, but tested against, and potentially adapted to, Florida estuaries. The following elements describe, in general, several critical information and data needs, computations and evaluations that will be undertaken by EPA's Gulf Ecology Division (GED) and/or EPA contractors include the following:

- Estuary Delineation. EPA and FDEP will establish a common approach to delineating the boundaries of estuaries and their watersheds in the State, and to identifying the resulting estuaries for which nutrient criteria will be developed.

- Nutrient Load Estimation. EPA and FDEP, with assistance from USGS, will develop a common approach to estimating monthly and annual nitrogen and phosphorus loads to each Florida estuary for a suitable period of record, including loads from atmospheric deposition, point and non-point sources, and, if possible, from ground water and oceanic sources. In addition to loads, estimates of freshwater discharge and source water nutrient concentrations will be needed.

- Water Quality Database. EPA and FDEP will evaluate the suitability and representativeness of water quality variables within existing FDEP databases. Priority variables include: salinity, temperature, nutrients (TN, TP, NOx, etc), dissolved organic matter, total suspended solids, Secchi depth, color, and chlorophyll a. Available data on historical seagrass coverage across Florida will also be compiled.

- Empirical Analysis. EPA and FDEP will analyze and evaluate empirical relationships between causal and response variables for each estuary using appropriate computational/statistical methods. The evaluation will include analysis of cause-effect relationships for all Florida estuaries combined, or some subset of estuaries based upon a defined criteria or categorization approach. For example, some Florida estuaries are naturally turbid due to a natural background of colored dissolved organic matter, whereas others lack significant natural turbidity. Moreover, some Florida estuaries naturally lack appreciable seagrass coverage. Efforts to identify and evaluate appropriate response variables that represent desired water quality and support designated uses will ensure that the proposed criteria are protective of all estuarine waters.

FDEP also plans to adopt regional response variable nutrient criteria based on site-specific thresholds developed for many of the larger coastal systems in the state (*e.g.*, Tampa Bay, IRL, Caloosahatchee, St. Lucie) and subsequently deriving causal variable criteria based on statistical relationships between these response variables and the causal variables. However, it should be noted that in many cases such relationships may not exist, as was the case in Sarasota Bay. Under this scenario, FDEP may only propose response variable–based criteria until the relationships are determined on a site-specific basis.

As a result of the state's 1987 Surface Water Improvement and Management (SWIM) Act and the National Estuary Program (NEP), efforts to develop nutrient-related thresholds for many of the state's largest estuaries and coastal waters are well under way and are briefly described below.

Tampa Bay

Tampa Bay NEP has established chlorophyll *a* targets for the different segments of the bay based on a goal of restoring seagrass beds to 38,000 acres within the bay. The bay now supports 28,299 acres of seagrass. The Tampa Bay chlorophyll *a* targets were established based on the effects of chlorophyll on light attenuation and ultimately on the depth of seagrass occurrence. TN loadings were in turn related to chlorophyll *a* concentrations, using a three-month lag time during the analysis. Ambient nitrogen concentration was not shown to directly affect light attenuation or seagrass condition.

IRL and Banana River

The IRL/Banana River Lagoon PLRG study set maximum loading targets for TN, TP, and TSS as a function of seagrass depth limits in the lagoon. The PLRG study found strong, negative correlations between watershed loadings of nutrients and TSS and the depth limit of seagrass. EPA proposed a TMDL in April 2007 based on the IRL/Banana River Lagoon PLRG, and FDEP proposed a state TMDL for the main stem of the Indian River and Banana River in fall 2008.

Caloosahatchee and St. Lucie Estuaries

The Northern Everglades and Estuaries Protection Program expanded the Lake Okeechobee Protection Plan (LOPP) requirements to the Caloosahatchee and St. Lucie River watersheds. This legislation created the Caloosahatchee and St. Lucie River Watershed Protection Program, which includes the development of Watershed Protection Plans for both rivers. Each Watershed Protection Plan must include a watershed construction project, a watershed pollutant control program, and a watershed research and water quality monitoring program. Under this legislation, the South Florida Water Management District (SFWMD), in collaboration with coordinating agencies, was directed to develop River Watershed Protection Plans for the Caloosahatchee and St. Lucie watersheds by January 1, 2009.

A primary objective of the program to address the Caloosahatchee and St. Lucie Estuaries is to develop “pollutant load reductions based upon adopted total maximum daily loads established in accordance with s. 403.067” (Senate Bill 392, 2007). After the TMDLs are completed, Basin Management Action Plans (BMAPs) will be developed. The TMDL for the St. Lucie estuary was proposed for final agency action on December 31, 2008. A notice of change to correct a minor typographical error in the rule will be published in the Friday, January 23, 2009 issue of the *Florida Administrative Weekly*. As of January 14, 2009, a draft TMDL for tidal portions of the Caloosahatchee River and Estuary is near completion, and it is anticipated that it will be completed, reviewed, and made publicly available by early February 2009.

In addition to the site-specific efforts previously mentioned, FDEP is actively involved in GOMA. It is working with the other Gulf states to develop broader-based strategies for developing nutrient criteria and control programs within the shared waters of the Gulf of Mexico. FDEP has assigned two staff members to directly participate in GOMA. Nutrient criteria–related activities are being coordinated between these staff and FDEP’s Water Quality Standards Program. An example of these ongoing activities includes a comprehensive session on water quality sampling and quality assurance (QA) that was provided to GOMA staff by the Standards and Assessment Section during the summer of 2008.

FDEP recognizes that inland water criteria must protect downstream uses, and since estuarine condition is affected by the nutrient loads delivered from upstream, there will be effort made to synchronize these two criteria development efforts.

3.13 Microcystin Round Robin

In an effort to initiate the development of a useful response threshold to HABs, FDEP has begun a series of QA “round robin” studies to evaluate the precision and accuracy of laboratory analytical results for microcystins. Because of the moderately large interlaboratory variability associated with these analytical results, further work to achieve consistency between labs is needed to further develop reliable indicators of HABs.

4. Relation to State Use Classifications

The CWA requires that the surface waters of each state be classified according to designated uses. Florida has five classes with associated designated uses, which are arranged in order of the degree of protection required: **Class I** (potable water supplies); **Class II** (shellfish propagation or harvesting); **Class III** (recreation, propagation of fish and wildlife); **Class IV** (agricultural water supplies); and **Class V** (navigation, utility, and industrial use). Under the current classification system, the majority of the state's waterbodies (*i.e.,* lakes, streams, estuaries, and wetlands) are Class III and are held to the same water quality criteria, with some differences between predominately fresh and marine waters

5. Relation to Biogeographic Classification

FDEP initially used Level IV ecological subregions, separately defined for streams (Griffith *et al.,* 1994) and lakes (Griffith *et al.,* 1997) in Florida's biocriteria development program, as a starting point for regionalization efforts necessary to establish nutrient criteria. FDEP has analyzed stream reference site macroinvertebrate community patterns in all nine ecological subregions north of Lake Okeechobee (Barbour *et al.,* 1996). The data indicated the presence of the following four distinct bioregions, within which there were similar biological community composition and structure (**Figure 4**): the panhandle (Regions 65f, 65g, and 65h, and the majority of 75a), the northeast (Regions 75e and 75f), the peninsula (Regions 75b, 75c, and 75d, and a small part of 75a), and the Everglades (Regions 76a, 76b, 76c, and 76d).

Similar patterns of relatively homogeneous groupings in the peninsula versus the panhandle have been observed in wetlands macrophyte, algae, and invertebrate data (Lane *et al.,* 2003). Lake macrophyte (for percent invasive species) and invertebrate (based on ecoregion, pH, and color) indices also utilize a similar bioregion scheme, with the three peninsular ecoregions being collapsed into a single peninsular bioregion (Fore, 2005; Gerrittsen *et al.,* 2000). FDEP is currently evaluating the potential of using ecological subregions collapsed into biological regions as the basis for future nutrient criteria groupings, although the issue is still a matter of continued discussion with the TAC (Weaver, 2006b, 2006c; Weaver and Frydenborg, 2006).

Based on the observed biological community resemblance within a bioregion, it is logical that these biologically similar regions will have analogously comparable responses to nutrient concentrations. If additional data indicate an alternate spatial classification scheme is more appropriate, the current system may be revised; however, current biological data suggest that bioregions are the most defensible approach to establish the appropriate protection of biota.

The current bioregions were derived based on macroinvertebrate assemblage patterns, which may not be entirely indicative of homogeneous response to nutrients. FDEP and its consultants are currently evaluating bioregions based on stream periphyton assemblages. If these evaluations reveal significantly different biological regions, the nutrient spatial classifications will be adjusted accordingly.

FDEP and the TAC are also evaluating scientifically defensible bases for the subregionalization of known naturally high-phosphate areas in the central peninsula and north-central Florida (Weaver, 2006c). Currently, in the peninsula bioregion pilot study, FDEP used an outlier analysis to exclude these naturally high-phosphate areas. It intends to evaluate other methods to explicitly subregionalize these areas.

6. Data Sources

6.1 Inventory of Existing Data

Florida has invested significantly in the acquisition and storage of scientifically defensible water quality and biological data. The state water quality database currently houses over 19 million data records, including over 890,000 phosphorus, 1 million nitrogen, and 450,000 chlorophyll *a* measurements. Additionally, FDEP has collected 3,867 SCI samples to assess stream health, 534 vegetation samples to assess lake health, 7,265 periphyton samples, and 7,897 phytoplankton samples. These biological samples allow FDEP to make connections between water chemistry and aquatic health to assist with determining protective values in a complex environment.

Under FDEP's watershed approach, the identification of data sources and development of tools to facilitate data entry and upload to the **STO**rage and **RET**rieval (STORET) Database have become high priorities for the agency. Florida's IWR (Chapter 62-303, F.A.C.) designates STORET (and its successor database) as the primary data source to be used by FDEP to assess water quality under the watershed approach. Efforts to upload new and additional data of known and defensible quality, under FDEP's Quality Assurance Rule (Chapter 62-160, F.A.C.) are ongoing and supported by a dedicated STORET group within FDEP. This group provides support to other state agencies, local governments, and various organizations in the transfer of data to Florida STORET.

6.2 FDEP's Ambient Monitoring Program

In 1996, FDEP redesigned its water resource monitoring programs to create an efficient, multi-resource, comprehensive monitoring network. While the revised network, called the Integrated Water Resource Monitoring (IWRM) Network, was designed to fulfill many different monitoring needs, it includes two statewide monitoring programs (described below) that provide data that have proven invaluable in FDEP's efforts to develop numeric nutrient criteria. It is anticipated that additional IWRM data will continue to be relied upon heavily for future nutrient evaluations.

The first IWRM program is a fixed-site statewide Trend Monitoring network. The objective of the Trend Monitoring program is to measure and estimate changes in the condition of water resources over time. FDEP's Watershed Monitoring Section samples 75 rivers and streams monthly for chemical and field analytes. In addition, benthic community and habitat assessments are conducted annually.

The second IWRM program, the Status Monitoring network, uses a stratified random sampling (probabilistic) design. The objective of the network is to broadly characterize the proportion of state water resources that meet or do not meet water quality standards. This statistical design was selected because sampling all water resources throughout the state would be cost and resource prohibitive. The Watershed Monitoring Section generates lists of representative surface and ground water sites, submits them to EPA for random selection, and samples 30 sites per resource, by basin. As part of the design, the section samples 6 different resources, as follows: 4 surface water types (rivers, streams, small lakes of 4 to less than10 hectares, and large lakes of more than 10 hectares), and 2 ground water aquifer types (confined and unconfined). Samplers collect a standard suite of chemical, physical, and biological parameters to estimate the condition of the state's water resources. Currently, the Watershed Monitoring Section collects 180 samples per resource in the state, or a total of 1,080 samples/year.

Starting in 2009, the Watershed Monitoring Section will continue to collect Status Monitoring network samples from all 6 resource types, but the numbers collected and the sampling frequency will change. Sixty samples of each of the surface water types will be collected, with a repeat visit resulting in a total of 120 samples/surface water resource/year. The repeat visits are scheduled at opposite seasons and rainfall patterns during the calendar year, thus capturing potential differences in water quality. However, the 2 ground water resources will be sampled once per year, resulting in 120 samples of each type. The fixed-site, statewide Trend Monitoring network will remain the same.

FDEP's watershed approach includes a strategic monitoring phase to gather new data within watersheds to supplement existing data. This monitoring is used to further characterize basin conditions, to investigate areas with identified or potential water quality problems, to evaluate the effectiveness of management actions, and for TMDL development. These activities, addressed in strategic monitoring plans, are intended to identify data gaps at the watershed level, to prioritize areas of data collection by FDEP or other partners, to establish a process for data dissemination, and to specify quality assurance/quality control (QA/QC) requirements.

6.3 Requirements for New Data Collection

Although FDEP has invested significant resources in its efforts to assess the ecological health of the state's waters, the process of developing numeric nutrient criteria has proven daunting. Most of the data described above were not originally collected for this purpose and thus have proven of limited value to derive protective response–based criteria. One of the greatest challenges is the fact that biological and water chemistry monitoring have been conducted on different temporal and spatial scales, making it difficult to appropriately pair nutrient and biological response data in a manner that can be used to link biological impairment to nutrient thresholds across a bioregion or ecoregion. As discussed previously, FDEP is currently conducting or initiating additional studies specifically aimed at making the necessary linkages for both streams and lakes.

FDEP is committed to pursuing additional grants and other funding opportunities to support specific projects directed toward establishing numeric nutrient criteria, including the collection of additional data. As the TAC identifies key parameters for criteria development, new data gaps may arise; therefore, it is not possible, at this time, to know how much data collection will be needed to propose ecoregional nutrient criteria.

7. Coordination with Bordering States

Florida shares some waterbodies with Alabama, Georgia, the Miccosukee Tribe, and the Seminole Tribe. Therefore, efforts will be made to coordinate with those states and tribes on any nutrient criteria Florida is considering on shared lakes and streams, prior to submittal to the ERC for rule development. Additionally, FDEP will meet with other Gulf of Mexico states to discuss the adoption of nutrient criteria for Gulf estuaries.

8. Prioritization of Waters and Schedule for Development and Adoption

FDEP initially prioritized waters for the development and adoption of regional numeric nutrient criteria based on the availability of EPA guidance documents—*i.e.,* lake and river stream guidance were available first, followed by estuaries and coastal waters, and finally wetland guidance. However, the development of site-specific numeric nutrient targets has been driven by TMDL development schedules, including a number of nutrient TMDLs for specific waterbodies, to be completed in accordance with the consent decree between EPA Region 4 and EarthJustice. Furthermore, FDEP will continue to identify (and prioritize for TMDL development) other waterbodies identified as potentially impaired by nutrients under Chapter 62-303, F.A.C.

These site-specific TMDL efforts are highly integrated with regional nutrient criteria development because information and experience gained in each effort has been and will continue to be used to refine the other. Methods originally developed by the TAC and FDEP to derive regional nutrient criteria have been used by FDEP to develop recommended TMDL thresholds for specific waterbodies. Conversely, site-specific targets developed via the TMDL process will be evaluated for potential regional application or possible consideration as site-specific nutrient criteria for given waterbodies, particularly for estuaries and coastal waters.

FDEP has already made significant progress towards nutrient criteria development for streams and lakes, and anticipates continuing on a schedule consistent with EPA's expectations for substantial progress towards criteria adoption (Grubbs, 2001). FDEP's commitment to this nutrient criteria development process is demonstrated by the assignment of seven staff and a statistical consultant to work at least part-time on this project; FDEP's continued consultation with its nutrient criteria development TAC; and FDEP staff participation in numerous regional and national nutrient criteria–related meetings, workshops, and conferences (*e.g.*, Region 4 Regional Technical Assistance Group [RTAG], 2006 All States Meeting, GOMA).

As FDEP's schedule follows the availability of EPA guidance documents, the state schedule is affected by the availability of those guidance documents and approaches. Continued progress on this schedule is also contingent on continued funding through state and federal programs to assist in completing the necessary research, developing appropriate assessment tools, and verifying the criteria.

8.1 Lakes and Streams (1st Priority)

Florida identified lakes and streams as its first priority for the development and adoption of regional numeric nutrient criteria. FDEP has been meeting with the TAC and primarily discussing the development of nutrient criteria for these waters since January 2003. The TAC has held 16 meetings addressing various topics related to lake, stream, and canal nutrient criteria. Summaries of these meetings and meeting materials are provided on FDEP's website (http://www.dep.state.fl.us/water/wqssp/nutrients/tac_archive.htm). FDEP currently anticipates that the TAC process for lakes and streams will be concluded by December 2009, with numeric water quality criteria subsequently submitted to the ERC by 2011.

FDEP currently plans to develop benchmark distributional approach–based criteria for lakes only as a backup, because it believes it is currently close to developing response-based criteria for lakes. However, FDEP may revisit the benchmark distributional approach for lakes if response-based approaches fail to identify significant relationships with nutrient enrichment.

The schedule below provides additional detail on Florida's progress to date and anticipated future activities. It should be noted that the projected future milestones are based on the assumption that FDEP's current track and technical approaches are acceptable to EPA, and that there are no administrative challenges to adopting the criteria.

It should also be noted that, while the schedule for criteria development does not make a specific distinction for south Florida streams/canals, criteria development for these systems may be unique because there currently are very limited bioassessment methods applicable to streams in Ecoregion XIII (**Figure 1**). As part of developing the stream criteria, FDEP plans to evaluate the nutrient criteria developed for peninsular Florida streams to determine whether they are adequately protective of south Florida streams.

8.2 Estuaries (2nd Priority)

FDEP selected estuaries as the second priority because of the site-specific nature of nutrient response in estuaries and because there currently are very limited bioassessment tools available for estuaries. EPA's (2001) nutrient criteria guidance for estuarine and coastal marine waters recognized the site-specific nature of nutrient response in estuaries, noting that "estuaries and coastal marine ecosystems tend to be relatively individualistic in their sensitivity and response to nutrient over enrichment." The guidance further states that "the lack of physically similar waterbodies may severely limit grouping (classifying) waterbodies as recommended for lakes, reservoirs, rivers, and streams where frequency distributions are used to derive reference conditions." FDEP concurs with these findings and anticipates that numeric nutrient criteria for Florida's estuaries and coastal waters will rely on both site-specific efforts, including TMDL-related efforts, and the general approaches described below.

EPA is assisting FDEP in the development of numeric nutrient criteria through the involvement of the EPA Office of Research and Development, Gulf Ecology Division, Gulf Breeze Laboratory. EPA/GED plans to focus on nutrient criteria development for estuaries over the next 12 to 24 months. There is likely to be uncertainty surrounding the observation of a single, comprehensive, statistically significant relationship between nutrient concentrations (or loads) and observed biological responses for all of Florida's estuaries due to their geological and ecological variability. The state recognizes that a one-size-fits-all approach to its estuaries may yield limited results. However, if a strong enough relationship can be generated in some Florida estuaries, and realistically applied to the remaining estuaries, the protection provided would serve as a solid foundation as more is learned about each estuary.

8.3 Wetlands (3rd Priority)

Florida leads the nation in the development of protective nutrient criteria for wetlands, having adopted a numeric phosphorus criterion for the Everglades in 2004, well in advance of EPA's draft wetland guidance. In fact, this guidance includes an appendix summarizing much of the research used to establish the Everglades phosphorus criterion of 10 μg/L. Furthermore, the state leads the nation in innovative treatment and best management practice (BMP) technologies and research to achieve compliance with ultralow nutrient standards (*e.g.*, Burns and McDonnell, 2003; Piccone, 2007).

FDEP does not plan to initiate the development of regional wetland nutrient criteria until after the estuary nutrient criteria are into the rule development phase. EPA released draft wetland guidance for review in December 2006 (EPA, 2006), and specifically solicited information, data, and views on scientific issues pertaining to the information the agency used to develop the draft document. Under this request, FDEP submitted review comments on the draft wetland guidance on February 15, 2007. EPA finalized its guidance in September 2007. FDEP is currently revaluating its statewide wetland strategy with the expectation that Florida's next plan update will include more specific strategies for wetland nutrient criteria development, including time frames and milestones.

The lower priority assigned to wetlands is based on an acknowledgment that wetlands are biologically very different from other waterbody types, that the state of the science on wetland nutrient dynamics is still evolving, that biological and water quality monitoring efforts for wetlands generally lag behind those of other waterbody types, and that with a few notable exceptions, wetlands tend to have a higher nutrient assimilative capacity. The implementation of nutrient threshold research or benchmark condition evaluations will take some time, given the current state of wetland science.

9. Florida's Ongoing Investment in Nutrient Criteria Development

Table 5 lists the funding Florida has provided for nutrient criteria development during the past several years, and includes studies planned for the next year.

10. Past, Current, and Future Schedule for Nutrient Criteria Development for Florida's Waters

This section summarizes both previous efforts and planned activities for the development of numeric nutrient criteria for Florida's waters. Previous efforts were specifically included because it is important to recognize the previous investments (in time and money) that have laid the groundwork for the establishment of biocriteria and numeric nutrient criteria. As evidenced throughout this document, FDEP strongly believes that scientifically defensible numeric nutrient criteria should be based on biological responses to nutrients. As such, it has invested significant resources in the development of biological assessment tools. This very complex process has required extensive methods development, staff training, and QA oversight to ensure the defensibility of the resulting products. The elements of this development and assessment process to date include habitat assessment for streams and lakes, benthic invertebrate indices for streams and lakes, a vegetation index for lakes, and a periphyton index for streams.

Table 5. Recent and planned funding for nutrient criteria development in Florida

Project or Activity	Cost to Date
SCI/BioRecon Development	$3,737,500
LVI Development	$358,750
LCI Development	$1,180,000
SPI Development	$1,020,000
Biocriteria Meetings and QA Activities	$530,400
Stressor Identification Study	$374,500
Nutrient Gradient Study	$132,675
Stream Benchmark Site Determination	$91,350
Longitudinal Study	$38,400
Springs Nitrate Studies	$384,000
Staff Technical Analysis and Coordination Time	$292,000
Statistical Consultants	$175,000
Nutrient Criteria Meeting Travel	$33,200
Everglades TP Criterion Development	$11,250,000
Total Numeric Nutrient Criteria Development Costs	**$19,597,775**

FDEP also made major investments in the development of nutrient criteria for the Everglades, leading to the adoption of a phosphorus criterion. Although work on other wetlands has begun, additional validation and calibration of the wetland indices are needed prior to proceeding to nutrient criteria development for other wetlands. Because of their complexity and the confounding effects of salinity, FDEP currently has only limited bioassessment tools for estuaries and still needs to make significant progress in that area.

It should also be noted that this schedule and plan focus primarily on the scientific components of numeric nutrient criteria development. However, the successful adoption of numeric nutrient criteria also depends on the successful completion of the administrative rulemaking process, and it is very difficult to estimate the time frame for the rulemaking process, particularly given the potential for administrative challenges.

Past, current, and planned activities for the development of numeric nutrient criteria are as follows:

1992	To begin the phosphorus criterion development process in the Everglades, a research plan was developed to specifically determine the level of phosphorus necessary to prevent an imbalance in Everglades flora and fauna. This plan, the Everglades Nutrient Threshold Research Plan (Lean *et al.,* 1992), was intended to provide appropriate data in support of a numerical interpretation of the existing state of Florida narrative nutrient criterion.
June 1995	FDEP formed the Everglades Technical Advisory Committee (ETAC) to review and comment to FDEP on Everglades research and monitoring in support of the process of developing a numeric phosphorus criterion for the Everglades.
Sept. 1999–Oct. 2001	FDEP staff published and revised three technical support documents in support of a numeric phosphorus criterion for the Everglades Protection Area (Payne *et*

	al., 2000, 2001a, 2001b). These reports recommended a phosphorus criterion of 10 μg/L.
Dec. 2001	Based on the results of FDEP's extensive analyses, the agency filed a notice of rulemaking and recommended a protective Everglades TP criterion of 10 μg/L for approval by the ERC.
	FDEP conducted a statewide numeric nutrient criteria development "kickoff" meeting in Tallahassee.
March 2002	FDEP created a nutrient criteria website (accessible to the public at http://www.dep.state.fl.us/water/wqssp/nutrients/index.htm) to facilitate the dissemination of information about Florida's nutrient criteria development process. The site includes agendas, minutes, and presentations from the Nutrient Criteria TAC meetings, copies of reports from the studies sponsored by FDEP on nutrient-related topics, links to federal nutrient websites, and other pertinent information.
	FDEP established an electronic mail listserver to distribute information directly to interested parties.
April 2002	FDEP refined the first draft of Florida's Numeric Nutrient Criteria Development Plan.
	FDEP identified potential Nutrient Criteria TAC members.
	FDEP received a draft report from Tetra Tech, Inc. detailing efforts to date on the review of nutrient data and proposed potential nutrient criteria for Florida lakes.
	FDEP received a draft report from the University of Florida presenting paleolimnological characterization of predisturbance water quality conditions in Florida lake regions (Griffith *et al*., 1997).
	FDEP hired a designated staff person to coordinate FDEP's nutrient criteria development efforts.
May 2002	FDEP submitted the Draft Numeric Nutrient Criteria Development Plan to EPA Region 4 for review.
	An FDEP representative participated in the Region 4 RTAG and presented an overview of Florida's Numeric Nutrient Criteria Plan for comment by RTAG members.
	FDEP solicited the participation of identified potential Nutrient Criteria TAC members.
June/July 2002	FDEP staff participated in the National Nutrient Team and the national stakeholders' meetings in Washington, DC.
Dec. 2002	The University of Florida completed a contract to conduct paleolimnological Cyanobacteria pigment studies to determine if past changes in the abundance of Cyanobacteria coincide with fossil diatom analysis in Florida lakes.
Jan. 2003	FDEP convened first meeting of the Nutrient Criteria TAC.
March–July 2003	The nutrient criteria coordinator position became vacant; therefore, no TAC meetings were held.
July 2003	The ERC approved the 10 μg/L TP criterion for the Everglades Protection Area during a July 8, 2003 hearing. Subsequent to the approval by ERC, both environmental and agricultural interest groups filed administrative challenges to the phosphorus criterion rule. Following discussions with FDEP concerning the application of the rule, all parties except the Miccosukee Tribe of Indians and the Friends of the Everglades withdrew their challenges.

	FDEP contracted a position to work with the TAC, to plan and facilitate/coordinate TAC meetings.
Aug. 2003	FDEP held a second TAC meeting in Tallahassee; agenda items included Florida water quality standards overview, existing narrative criteria, potential nutrient criteria tools, and nutrient criteria development approaches.
Oct. 2003	The University of Florida paleolimnological project was completed and the final report received.
	The third TAC meeting was held in Orlando on Florida lake nutrient criteria and data availability.
Nov. 2003	FDEP representatives participated in the EPA Region 4 RTAG meeting in Atlanta.
Nov. 2003–Jan. 2004	An administrative hearing was held to resolve the remaining challenges to the Everglades phosphorus criterion rule.
Dec. 2003	FDEP submitted a revised FDEP Nutrient Criteria Development Plan to EPA.
Jan. 2004	FDEP held the fourth TAC meeting and started holding TAC meetings approximately every one and a half months.
	FDEP representatives participated in the EPA Region 4 RTAG meeting.
Feb. 2004	A designated FDEP staff position took over TAC facilitation/ coordination duties.
	The fifth TAC meeting was held in West Palm Beach. The meeting focused exclusively on canal nutrient criteria development.
April 2004	The sixth TAC meeting was held in Tallahassee.
	The seventh TAC meeting (two days) was held in Fort Myers.
May 2004	The eighth TAC meeting was held in West Palm Beach.
June 2004	The final order filed by the Administrative Law Judge on June 17, 2004, upheld all parts of the proposed Everglades phosphorus criterion rule, finding that the rule “is not an invalid exercise of delegated legislative authority” by FDEP.
July 2004	EPA and the state reached mutual agreement on a Numeric Nutrient Criteria Development Plan for Florida.
Aug. 2004	The ninth TAC meeting (two days) was held in Tampa.
Nov. 2004	The tenth TAC meeting was held in Tallahassee.
Jan. 2005	EPA approved all portions of the Everglades phosphorus criterion rule, except the use of the assessment methodology specified in Appendix B of the Settlement Agreement in the Federal Everglades lawsuit, Case No. 88-1886-CIV-Hoeveler, U.S., as modified by Omnibus Order entered in the case on April 27, 2001.
Feb. 2005	The eleventh TAC meeting was held in Gainesville.
March 2005	Florida initiated the Dissolved Oxygen/Nutrient Study, an intensive one-year DO and nutrient study. Nutrient and biological data were collected in streams, canals, and lakes across the entire state. These data, in addition to other ambient data available in STORET, will be used to establish numeric nutrient criteria. Additionally, data will be used to help establish new bioassessment methods (phytoplankton and periphyton indices).
April 2005	A revised Everglades phosphorus criterion rule was presented to the ERC and received unanimous approval on April 7, 2005.

June 2005	The Everglades phosphorus criterion rule was resubmitted to EPA for approval.
July 2005	The Everglades phosphorus criterion received final approval from EPA.
Aug. 2005	The twelfth TAC meeting (two days) was held in West Palm Beach.
Oct. 2005	FDEP representatives participated in the EPA Region 4 RTAG meeting in Atlanta and presented an overview of the status of Florida's numeric nutrient criteria development.
Feb. 2006	FDEP representatives participated in EPA's All States Numeric Nutrient Criteria Meeting in Dallas.
	The thirteenth TAC meeting was held at Wakulla Springs State Park, Wakulla.
May 2006	The fourteenth TAC meeting was held in Gainesville.
	DO and nutrient study data collection were completed.
Oct. 2006	The fifteenth TAC meeting was held in Ponte Vedra Beach.
Dec. 2006	The sixteenth TAC meeting was held in Tallahassee.
Jan. 2007	FDEP established and SFWMD began monitoring an ambient monitoring network in the Everglades Protection Area designed to assess the achievement of the Everglades phosphorus criterion rule.
	FDEP representatives participated in the GOMA Nutrient Criteria Conference in Gulf Breeze.
Feb. 2007	FDEP submitted a revised Numeric Nutrient Criteria Development Plan to EPA.
	FDEP submitted review comments on EPA's *Draft Nutrient Criteria Technical Guidance Manual for Wetlands* (EPA 823-F-05-015 – December 2006).
March 2007	FDEP representatives participated in the EPA Region 4 RTAG meeting in Decatur, GA.
May 2007	FDEP submitted to EPA Region 4 a pilot study application of its benchmark distributional approach as part of FDEP's comments on EPA's *Proposed Total Maximum Daily Load (TMDL) for Biochemical Oxygen Demand, Dissolved Oxygen, Nutrients, and Unionized Ammonia In the Lake Okeechobee Tributaries.*
Aug. 2007	All macroinvertebrate, periphyton, and phytoplankton data from the intensive one-year DO and nutrient study were marked complete and entered into Florida's biological database.
Feb. 2008	The seventeenth TAC meeting was held in Tallahassee. FDEP received positive feedback from EPA on the application of the benchmark distributional approach as utilized in FDEP's pilot study for peninsula bioregion streams.
March 2008	The Nutrient Gradient Study sampling was initiated.
June 2008	FDEP held the estuaries and coastal waters numeric nutrient criteria kickoff meeting with the existing TAC and other experts, and provided training to GOMA staff on water quality sampling and QA.
Aug. 2008	FDEP analyzed algal response to nitrate concentrations in spring systems and proposed a criterion of 0.35 mg/L during the triennial review process.
Summer 2008	FDEP created a strategy for developing estuarine criteria and wrote scope of work for EPA assistance.
June 2008–Dec. 2009	FDEP continues data synthesis and analysis (*e.g.*, biological indices, regionalization analyses) for lakes, streams, and canals, and meets with the TAC as needed.

	FDEP continues additional data collection as needed.
Summer/Fall 2008	FDEP gathered LVI readings from targeted lakes to be used to explore relationships with nutrient concentrations and conducted QA testing of all LVI teams to ensure data usability.
Sept. 2008	FDEP representatives participated in the planned EPA Region 4 RTAG meeting.
Nov. 2008	A contract to develop the stressor identification conceptual model was initiated and the contractor began reviewing data. An intensive kick-off meeting was conducted in January 2009.
Dec. 2008	FDEP completed fieldwork for the validation of peninsula, panhandle, and northeast bioregion benchmark streams.
Dec. 2008	FDEP staff met with EPA Headquarters and EPA GED staff to discuss the project to develop numeric nutrient criteria for estuaries.
Jan. 2009	FDEP to collect final data and information related to the Nutrient Gradient Study. Approximately 95% of these data were collected by December 2008. FDEP completed sampling for Longitudinal Study
Feb 2009	FDEP convened (with EPA support and participation) a panel of national experts to assist and advise FDEP in the calibration of a Stream Periphyton Index (SPI)
March–April 2009	FDEP plans to generate draft benchmark distributional approach–derived stream nitrogen and phosphorus thresholds as potential backup criteria.
March–April 2009	FDEP to analyze data and information collected during the Nutrient Gradient Study and analyze nutrient statistics related to the LVI.
May 2009	FDEP to generate draft response–based nutrient criteria for streams, lakes, and estuaries if the statistical rigor of the results is sufficient (see Table 3 for specific causal and response variables).. If results are not sufficient, a six- to eight-month delay may occur to collect and analyze additional data.
July 2009	FDEP plans to gather data appropriate for nutrient criteria development in Ecoregion XIII streams/canals.
Dec. 2009	Conclude TAC process for lakes and streams, and potentially estuaries (if GED efforts are successful). Anticipated products include the recommended numeric nutrient criteria for Florida lakes, streams, and Ecoregion XIII streams/canals, and estuaries, and draft rule language to be incorporated into state water quality standards (see Table 3 for specific causal and response variables)..
Jan. 2010–Dec. 2010	DEP conducts formal rulemaking to incorporate nutrient criteria into Florida's water quality standards (Chapters 62-302 and 62-303, F.A.C.). FDEP works to refine draft rule text, allowing time for draft rule review and public workshops on the proposed rule before the nutrient criteria rule language is submitted to the ERC. It is anticipated that the rulemaking process will take approximately 12 months.

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APPENDICES

Appendix A: FDEP's Review of EPA's Recommended Nutrient Criteria for Streams and Lakes

Prepared by the Florida Department of Environmental Protection, Bureau of Assessment and Restoration Support

Background

EPA's *Nutrient Criteria Technical Guidance Manual: Rivers and Streams* (Buck *et al.,* 2000) described three general approaches for the development of numeric nutrient criteria for streams. This appendix evaluates EPA's third and least preferred approach, which involves establishing criteria using a lower distribution (*e.g.,* 5th to 25th percentile) of a pool of sites of unknown ecological quality in a designated ecoregion. It is FDEP's position that this approach is not scientifically defensible, since there is no connection between the resulting thresholds and any environmental measure. A general population of data contains an unknown mix of reference and nonreference sites with varying levels of impairment (*i.e.,* unknown ecological quality), allowing no predetermined relationship between the nutrient concentrations in this "unknown" population and any valued ecological attribute. Since there is no predestined relationship between the 25th percentile nutrient concentration of a general population and any biological response variable, nothing can be predicted concerning the level of protection afforded by a criterion derived using this approach.

EPA's approach uses designated ecoregions (**Figure A-1**). Florida's ecoregions are IX, XII, and XIII. These ecoregions cover a large area, and waterbodies within each of these areas can experience vastly different environmental circumstances. Note that Ecoregion IX starts in Pennsylvania, comes down to Florida, heads north to Illinois, heads west to Nebraska, and ends in Texas and Louisiana. EPA's recommended nutrient criteria were derived based on data collected throughout this vast and heterogeneous region (**Figure A-2**) and therefore cannot be expected to accurately reflect conditions in any particular state, including Florida.

The 25th percentile concentration of the general population is purely dependent on the number of sites and their level of enrichment. This fact is acknowledged in EPA guidance (EPA, 2000a, 2000b, 2000c, 2000d, 2000e). If the general population of data were primarily composed of minimally disturbed "reference" sites, a 25th percentile criterion would result in these healthy sites being out of compliance. Even worse, if nutrients were actually reduced below those needed for the proper functioning of these reference systems, adverse harm would occur. On the other hand, if the general population were primarily composed of highly nutrient-enriched sites, a criterion derived in this way might be underprotective. It would be purely coincidence that a criterion developed in this manner would be appropriate.

Therefore, any criterion derived based on the 25th percentile of data collected at a pool of random sites with unknown ecological quality is scientifically indefensible and unlikely to be upheld if challenged, due to the fundamental technical flaws associated with this approach. However, EPA has taken this method and recommended criteria for streams (**Table A-1**) and lakes/impoundments (**Table A-2**).

Figure A-1. Aggregations of Level III ecoregions for national nutrient strategy

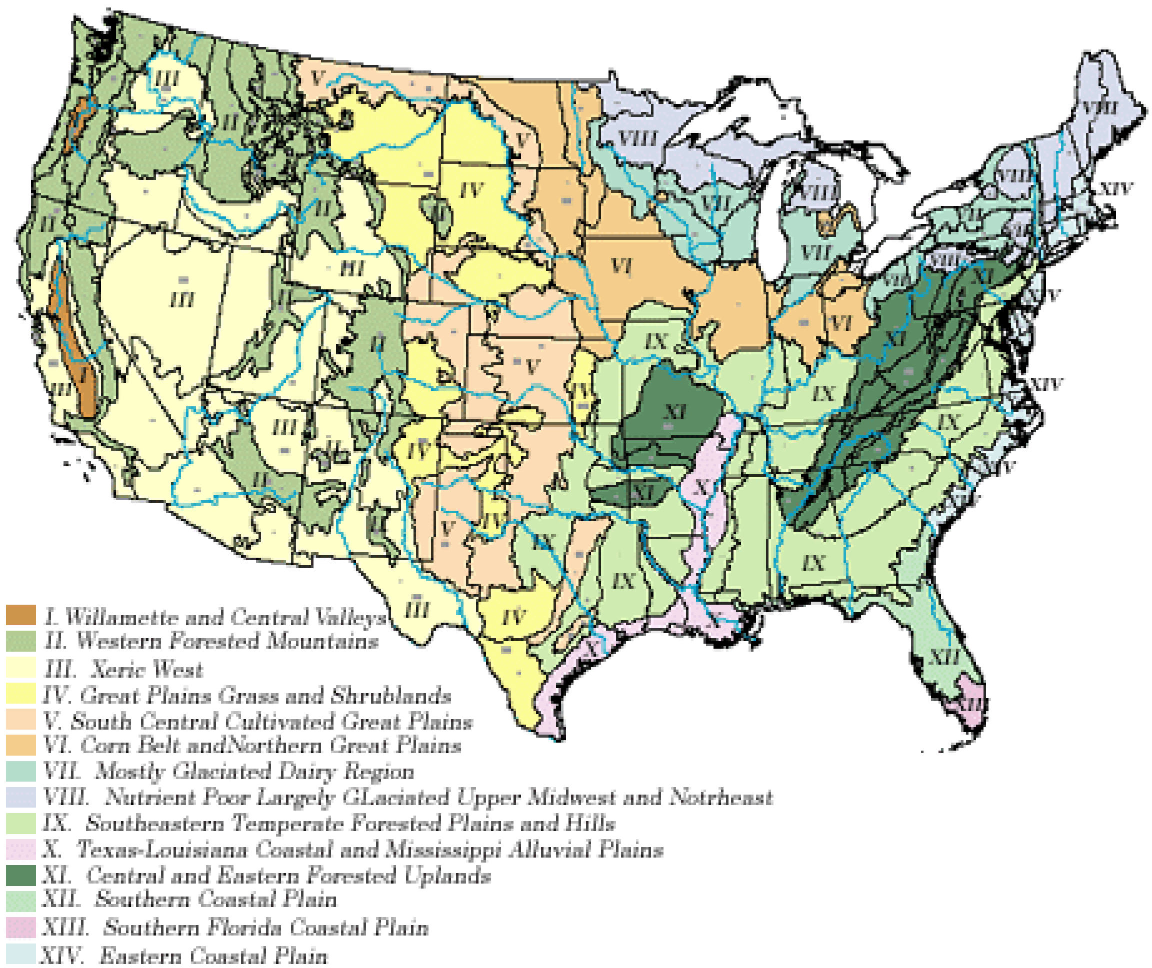


Figure A-2. Location of sampling stations used by EPA to derive Ecoregion IX recommended nutrient criteria for rivers and streams and lakes

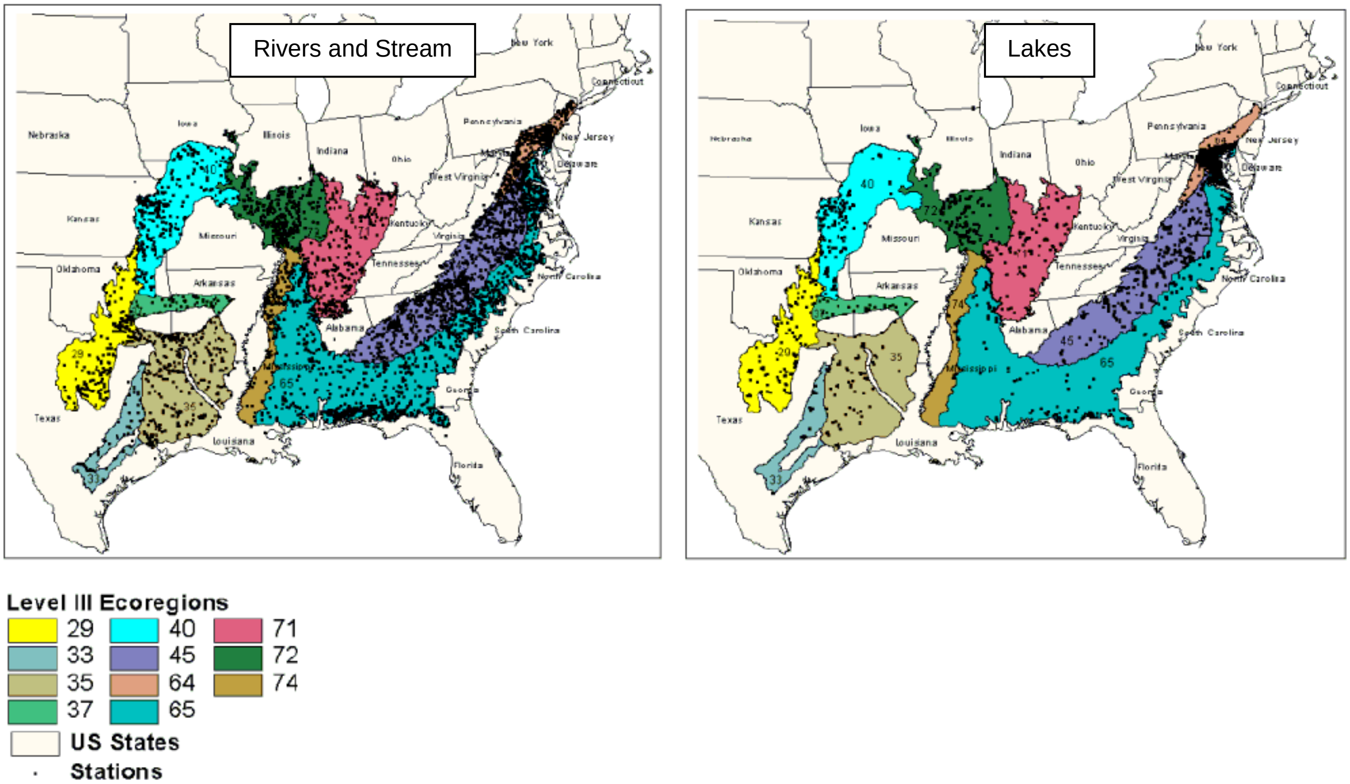


Table A-1. EPA recommendations for streams using the lower 25th percentile approach of a dataset of unknown site quality

	Region IX - Southeastern Temperate Forested Plains and Hills	Region XII - Southern Coastal Plain	Region XIII - Southern Florida Coastal Plain ++
TP (µg/L)	36.56	40.00	N/A **
TN (mg/L)	0.69	0.9	N/A **
Chlorophyll *a* (µg/L)	0.93	0.40	N/A **
Periphyton Chlorophyll *a* (mg/m^3)	20.35	N/A *	N/A **
Turbidity (NTU)	5.70	1.90	N/A **

N/A – Not available.
* Periphyton chlorophyll a (mg/m^3) criteria recommendations were not included in the EPA publication addressing ambient water quality criteria recommendations for rivers and streams in Region XII.
** EPA has not issued ambient water quality criteria recommendations for rivers and streams in Region XIII.

Table A-2. EPA recommendations for lakes/impoundments using the lower 25th percentile approach of a dataset of unknown site quality

	Region IX - Southeastern Temperate Forested Plains and Hills	Region XII - Southern Coastal Plain	Region XIII - Southern Florida Coastal Plain
TP (μg/L)	20.00	10.0	17.5
TN (mg/L)	0.36	0.52	1.27
Chlorophyll *a* (μg/L)	4.93	2.60	12.35
Secchi depth (m)	1.53	2.10	0.79

EPA notes in its national nutrient guidance documents that sampling protocols and analytical methods must demonstrate comparable data in order to compare data collected under different sampling programs or by different agencies, but EPA's contractor did not perform such a review when assembling the national nutrient database. The review focused on the following:

(1) Sample location verification;

(2) The deletion of duplicate samples;

(3) The deletion of samples downstream of effluent discharge points;

(4) The verification of station identification numbers, HUC codes, county, and ecoregions; and

(5) The verification of laboratory and sampling methods, where this information was available or in some cases when data generators responded to inquiries.

Several of the datasets (Legacy STORET, National Water Quality Assessment [NAWQA], and National Stream Quality Accounting Network [NASQAN]) received minimal review by the contractor on the assumption that the review had previously been conducted by a previous contractor, or on the assumption that the source agency, the USGS, had reviewed the data for QA/QC.

In short, the database lacks sufficient supporting information to indicate that acceptable measurement procedures were used and that the results are reliable. This is inconsistent with the manner in which both aquatic criteria and human health criteria are established. EPA has very specific guidelines regarding the documentation of test controls, endpoints, and data quality for both criteria types (Stephen *et al.,* 1985; EPA, 2000a, 2000b, 2000c, 2000d, 2000e). Equivalent scrutiny was not applied to the ecoregional numeric nutrient criteria recommendations.

EPA's handling of the national nutrient database also included a highly questionable data manipulation where values reported as less than the analytical detection limit were replaced with a value of zero. It is improbable if not impossible that the actual nutrient concentrations in the environment were zero. Additionally, values reported below the method quantitation limits were replaced with one-half the reported value. These decisions very likely caused EPA's recommended criteria to be biased low.

The method by which below detection and quantitation limit values are handled will bias low 25th percentiles and medians, when 25 and 50%, respectively, of the values are below these limits. However, it is impossible to determine the actual degree to which EPA's manipulations affected the final recommendations because (1) they do not document the percentage of altered values, and (2) the detection and quantitation limits used by the various data generators are not documented.

Method detection and quantitation vary among data generators depending on analytical procedures, which change over time, and organizational policies. However, the recommendations and data summaries can be compared with typical detection and quantitation limits used in Florida. For example, typical Florida chlorophyll *a* detection and quantitation limits are at or above 1 and 4 μg/L, respectively. The seasonal 25th percentile values used by EPA to derive the stream recommendations are all below the 1 μg/L detection limit, with one exception (**Tables A-3** and **A-4**). Furthermore, the seasonal 25th percentiles and median values are all between the detection and quantitation limits. This strongly suggests that EPA's data manipulations artificially biased its criteria recommendations. The recommendations reflect data manipulation artifacts rather than realistic or protective thresholds.

Table A-3. Summary of seasonal values chlorophyll *a* concentrations used by EPA to derive the recommended Ecoregion IX rivers and streams chlorophyll *a* criteria

The criterion was calculated as the median of seasonal 25th percentiles (P25).

Season	N	Mean	Minimum	Maximum	P5	P25	Median	P75
Fall	187	6.03	.000	78.60	0.25	0.9	2.85	7.50
Spring	206	6.54	.000	98.52	0.00	0.97	3.38	7.95
Summer	235	7.44	.000	79.20	0.00	1.03	3.48	9.00
Winter	178	3.13	.000	34.80	0.00	0.25	1.65	3.48

Table A-4. Summary of seasonal values chlorophyll *a* concentrations used by EPA to derive the recommended Ecoregion XII rivers and streams chlorophyll *a* criteria

The criterion was calculated as the median of seasonal 25th percentiles (P25).

Season	N	Mean	Minimum	Maximum	P5	P25	Median	P75
Fall	146	6.40	0.00	87.94	0.00	0.38	1.07	5.25
Spring	171	7.86	0.00	100.25	0.00	0.39	1.71	8.04
Summer	171	8.93	0.00	62.40	0.00	0.53	3.21	11.6
Winter	159	4.98	0.00	96.20	0.00	0.41	1.38	5.85

While these recommendations appear on the surface to represent water quality criteria that can be set for waterbodies, they are both incomplete and illogical. They are incomplete in that they only represent the magnitude of a criterion and do not provide duration and frequency. Duration is the averaging period that a criterion represents in order to be protective (*i.e.,* monthly average, annual average, instantaneous maximum, etc.). Frequency is the number of times the magnitude/duration expression can be violated and still protect the designated use (*i.e.,* no more than one exceedance per year, less than 10% exceedance over 5 years, etc.). Rarely does a single exceedance of a naturally occurring parameter impair the designated use.

While these values are incomplete, assuming they were established as an annual average not to be exceeded for the purposes of comparison with actual environmental data proves useful in trying to determine the logic of applying them to Florida waterbodies. Furthermore, the criteria recommendations are illogical from the perspective of protecting designated uses. As previously stated, there is no predestined relationship between the 25th percentile nutrient concentration of a general population and any valued ecological attribute linked to the designated uses. There is nothing that can be predicted concerning the level of protection afforded by a criterion derived using this approach.

Application of EPA Criteria Recommendations

STREAMS

This section tests the application of the criteria to determine if they meet the CWA test in Section 303(b)(2)(A), "Such standards shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this Act." The purposes of the CWA are defined in Section 101(a). The expectation of water quality standards to provide protection to waterbodies is further defined in federal regulation at 40 CFR Part 131.6 and Subpart B.

FDEP has identified a number of unimpacted reference streams in the central peninsula of the state, called the peninsula bioregion (**Figure A-3**). These streams represent conditions with minimal to no additional nutrient contribution from natural conditions. Therefore, one can conclude that the aquatic life in these waterbodies fully support the designated uses and are adapted to long-standing natural nutrient conditions. **Figure A-4** shows the distribution of nitrogen, phosphorus, chlorophyll *a*, and turbidity concentrations associated with these reference streams and the associated EPA criteria recommendation values.

The implementation of the criteria that EPA has recommended would result in the identification of many natural streams as impaired, and with a strict application of the CWA, would result in TMDLs requiring reductions in nutrient availability to the aquatic life dependent on the stream for habitat. This reduction in nutrient availability is no different than reducing the food supply for the organisms, and will alter the biological integrity of the waterbody and limit the aquatic life contained in the waterbody. This is inconsistent with the goals of the CWA and federal regulations. Furthermore, the application of EPA's recommendations would require the state to regulate and remediate nutrients below natural conditions in many streams throughout the state. This is illogical and would result in a waste of public and private resources that could otherwise be invested to address real societal problems, including valid nutrient impairments.

An additional complication is that monitoring the biological integrity of streams is an evolving science. EPA has recommended the use of chlorophyll *a* and turbidity (water clarity) as indicator tools for measuring biological response in streams. While chlorophyll *a* and turbidity are a way to measure algal mass buildup in waters, they are not the best tool for flowing waterbodies, where the excessive growth of algae due to elevated nutrients is often in the form of algae growth attached to physical objects in the stream (streambed, rocks, logs, etc.), not suspended and floating in the water column. EPA's chlorophyll *a* criteria recommendation is for suspended growth (floating algae). A better measure that is evolving involves an analysis of the attached plant community, known as periphyton. **Figures A-5** and **A-6** show the relationship between excess nutrients and periphyton growth in the Suwannee River in Florida (one waterbody in Florida with extensive periphyton data).

Figure A-3. Stream bioregions of Florida

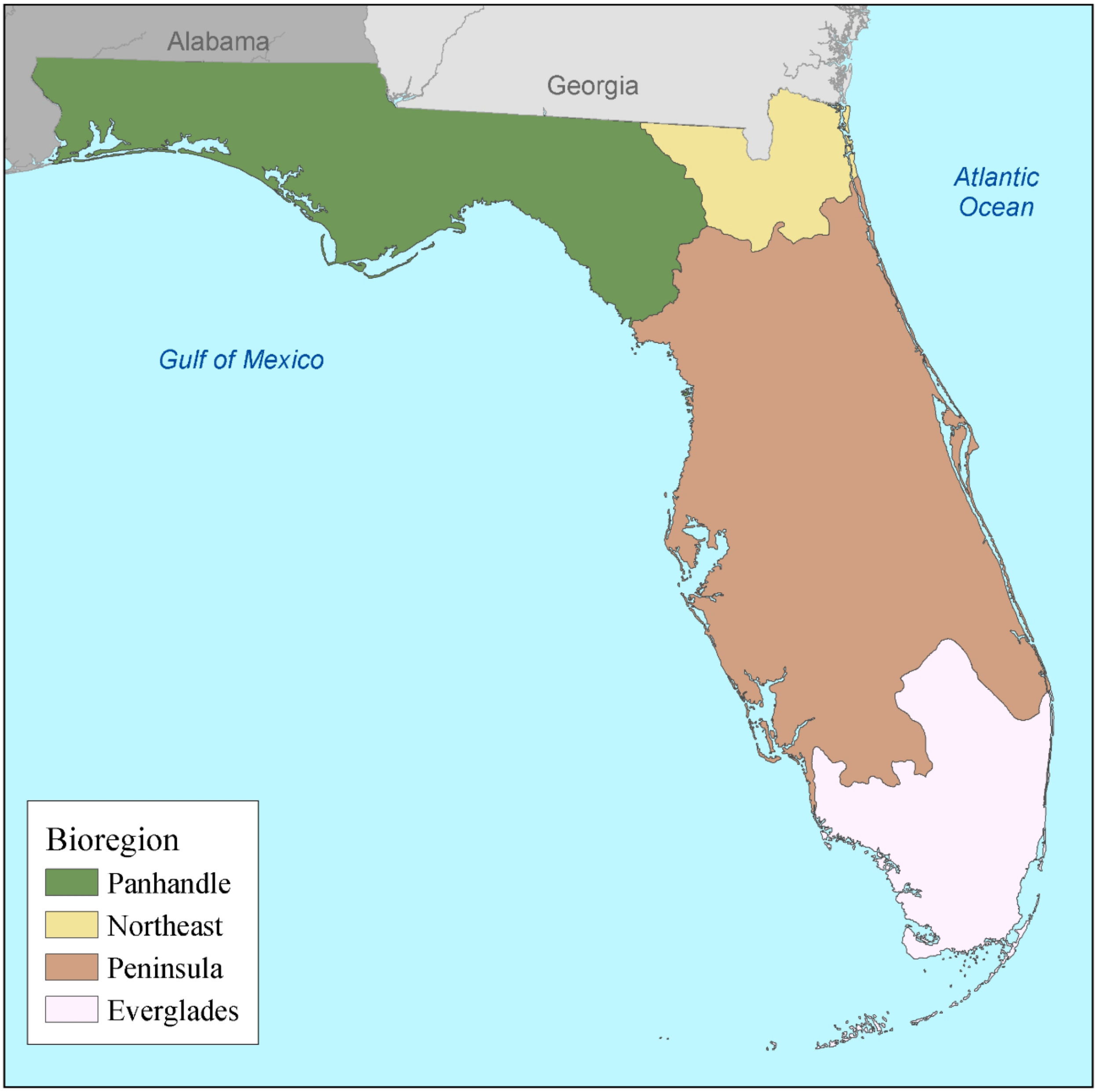


Figure A-4. Cumulative frequency distributions of (A) total phosphorus, (B) total nitrogen, (C) chlorophyll *a*, and (D) turbidity in confirmed peninsula bioregion reference streams

The vertical blue dash-dotted line indicates the EPA-recommended 25th percentile criterion for Ecoregion XII. The intersection between the curve and vertical lines demonstrates the percentage of biologically healthy streams (e.g., 80% for TP) that would be falsely identified as impaired if the EPA recommendations were adopted.

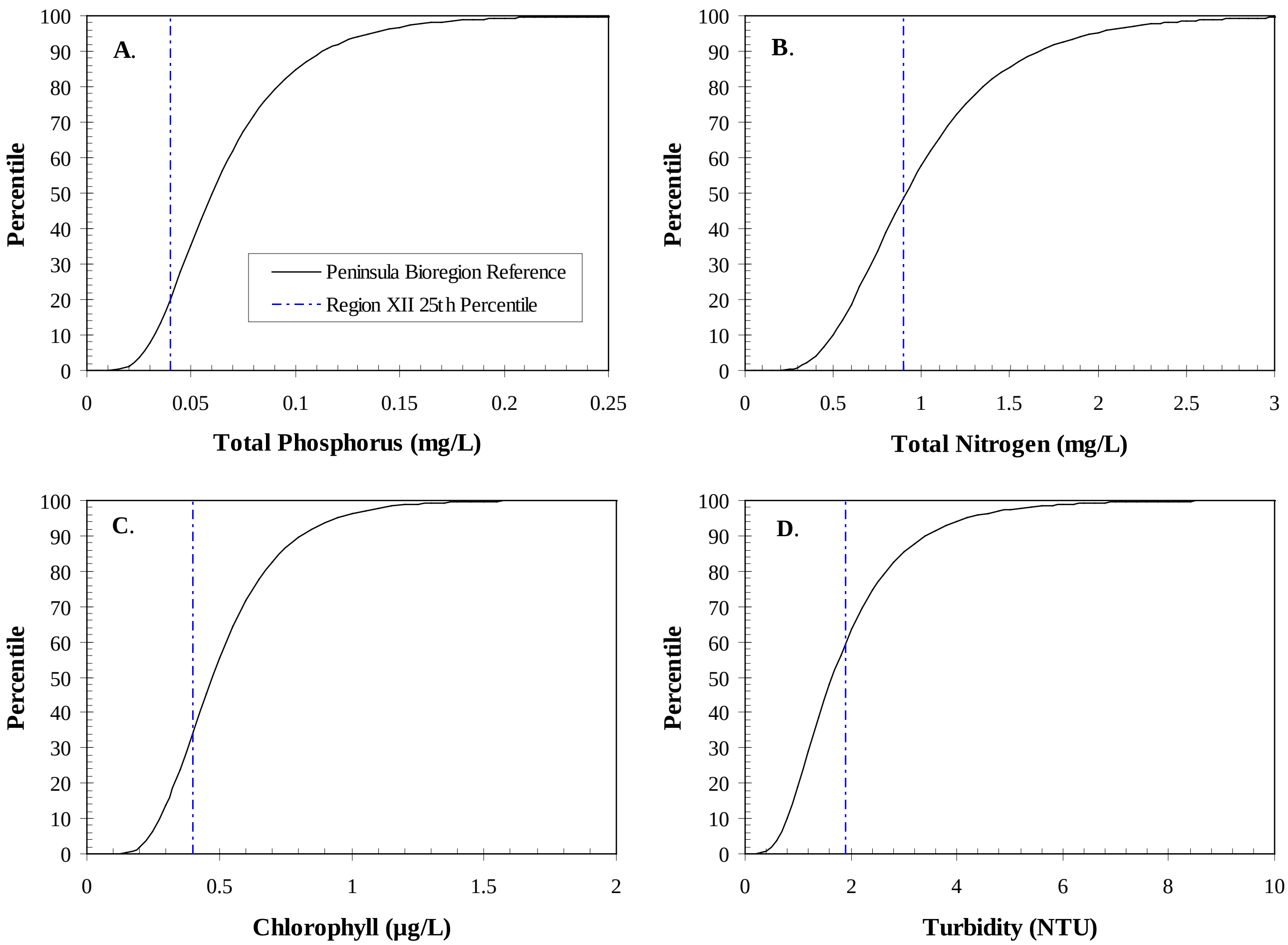


Figure A-5. Adverse biomass changes in Suwannee River periphyton related to anthropogenic nitrate-nitrate levels

Phytoplankton chlorophyll is typically very low.

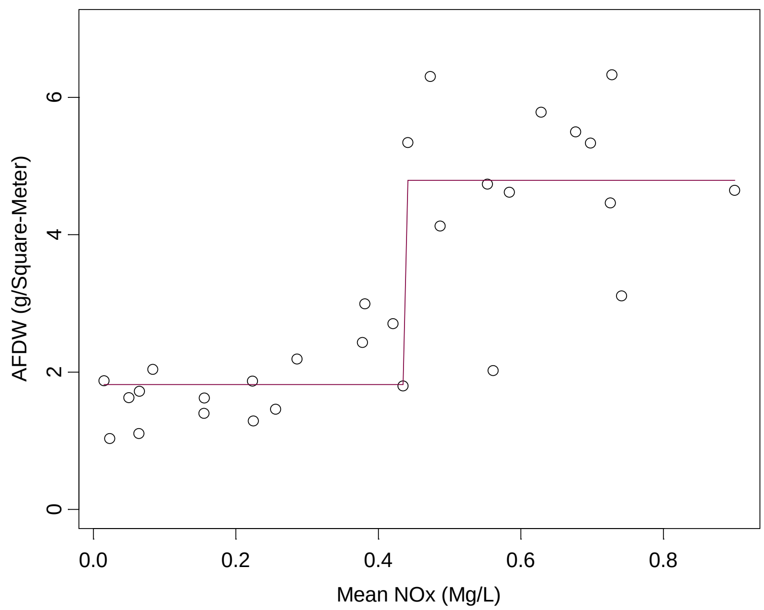
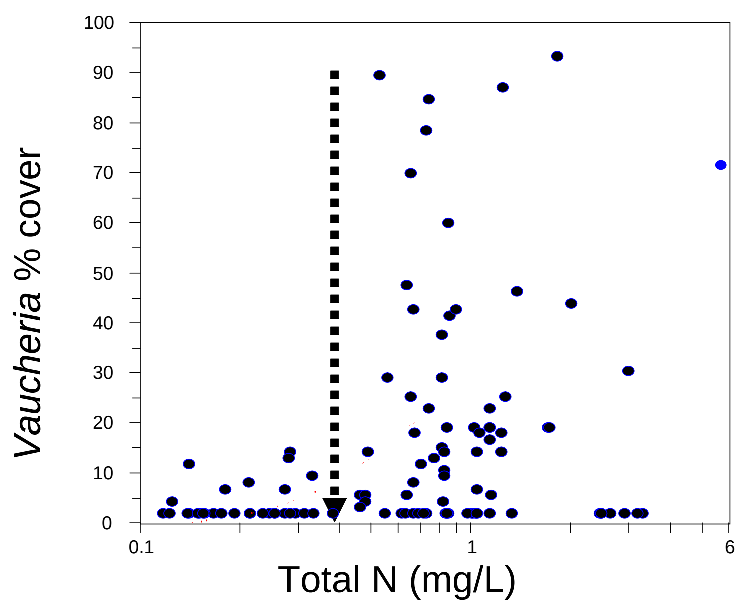


Figure A-6. Increases in *Vaucheria* sp. (nuisance algae) in Florida spring runs related to anthropogenic nitrate-nitrate levels (graph lists TN as axis, but this was predominantly nitrate-nitrate)

Phytoplankton chlorophyll in springs is typically very low.

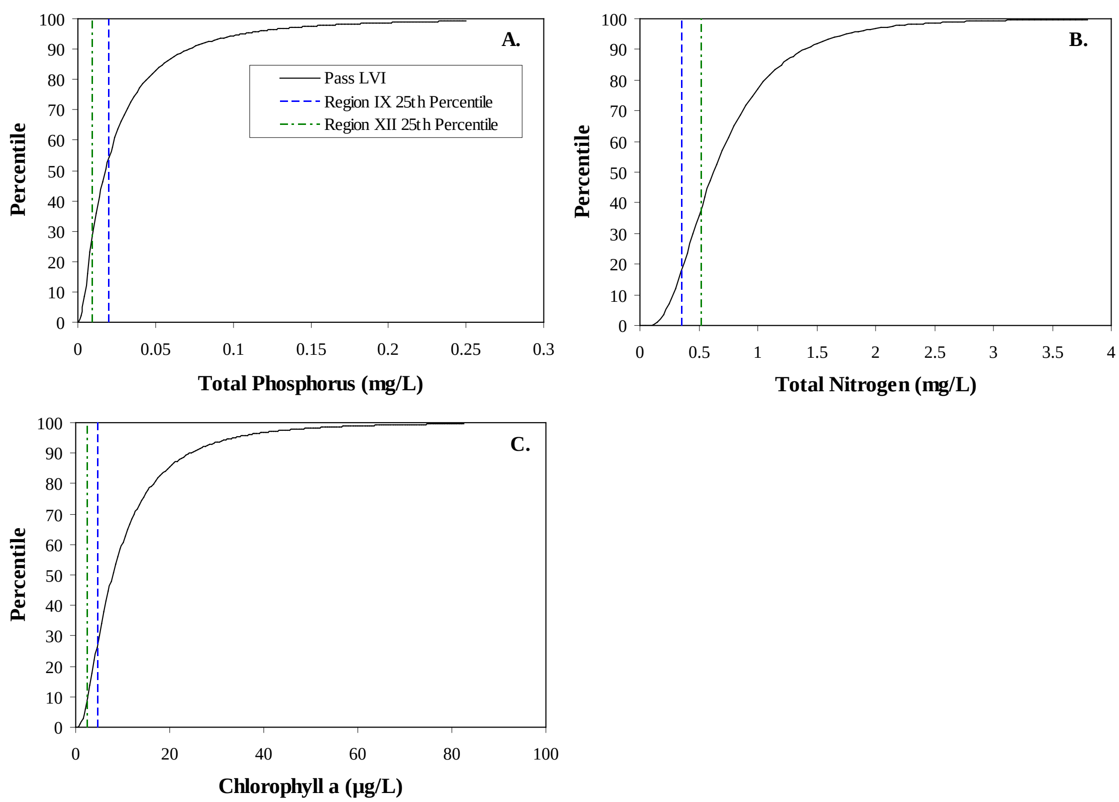


LAKES

FDEP has made very significant progress in the development of an LVI specifically designed to assess the health of aquatic biological communities in lakes. While FDEP intends to evaluate dose-effect relationships between the LVI and nutrients, the LVI may also be used to identify biologically healthy, reference lakes. Lakes with an LVI score of 37 or greater support healthy biological communities that fully support the designated uses and are adapted to long-standing natural nutrient conditions. **Figure A-7** shows the distribution of nitrogen, phosphorus, and chlorophyll *a* concentrations associated with these reference lakes and the associated EPA criteria recommendation values.

Figure A-7. Cumulative frequency distributions of (A) total phosphorus, (B) total nitrogen, and (C) chlorophyll *a* in Florida lakes with healthy aquatic plant communities (LVI ≥ 37)

The vertical green and blue dashed lines indicate the EPA-recommended 25th percentile criterion for Ecoregions XI and XII, respectively. The intersection between the curve and vertical lines demonstrates the percentage of biologically healthy lakes that would be falsely identified as impaired if the EPA recommendations were adopted.



The implementation of the criteria that EPA has recommended would result in the identification of many reference lakes (LVI $\geq$ 37) as impaired and, with a strict application of the CWA, would result in TMDLs requiring significant reductions in nutrient availability to aquatic life. As noted for streams, reducing nutrient availability is no different than reducing the food supply for the organisms. This will alter the biological integrity of the waterbody and limit its aquatic life, which is inconsistent with the goals of the CWA and federal regulations.

ESTUARIES

EPA published the document *Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters* in 2001. The guidance concluded that, because of differing geographic and climatic conditions among the East, Gulf, and West Coasts, uniform national criteria for estuarine and coastal waters are not appropriate, and that they should be developed at the state, regional, or individual waterbody levels. Therefore, EPA did not propose, nor is it currently in a position to propose, CWA Section 304(a) numeric nutrient criteria recommendations for estuaries. EPA currently has no basis upon which to promulgate nutrient criteria for Florida estuaries.

WETLANDS

EPA published a final document, *Nutrient Criteria Technical Guidance Manual: Wetlands,* in 2007. While the document provided technical guidance for developing numeric nutrient criteria for wetlands, EPA has not developed Section 304(a) recommendations upon which numeric nutrient criteria could be developed for Florida wetlands.

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Appendix B: Selection of Benchmark Sites (Characterized by Low Levels of Human Disturbance) Using the LDI Index

Prepared by the Florida Department of Environmental Protection, Water Quality Standards and Special Projects Program

Brown and Vivas (2003) have developed an LDI to estimate the intensity of human land use based on nonrenewable energy flow. The application of the LDI is based on the ecological principle that the intensity of human-dominated land uses in a landscape affect ecological processes of natural communities. The more intense the activity, the greater the effect on ecological processes. Natural landscapes with little or no agricultural or urban development will likely have intact ecological systems and processes. The intended use of the LDI was as an index of the HDG.

The LDI is a land use–based index of potential human disturbance calculated using coefficients corresponding to specific land use categories within drainage basins. The LDI coefficients were quantified using emergy[3] use per unit area per time (Brown and Vivas, 2003). Brown and colleagues collected energy consumption data from billing records and literature sources, for energies such as electricity, fuels, fertilizers, pesticides, and water (both public water supply and irrigation). Because the LDI was meant to be a measure of human disturbance, only nonrenewable energies were used in the calculation. Natural systems were assigned a nonrenewable empowerment density of 0 sej/ha·yr.[1] The LDI coefficients were calculated as the natural log of the empower densities normalized on a scale from 1 to 10. LDI coefficients for natural lands equal 1.0 and a LDI coefficient of 10.0 is associated with the highest intensity land uses (*e.g.,* central business district or power plant).

The LDI is calculated as the area-weighted value of the land uses within an area of influence. Using the land use coefficients and the percent area occupied by each land use as determined by GIS land use coverages, the LDI is calculated as follows:

$$LDI_{Total} = \Sigma \, (LDC_i * \%LU_i)$$

Where,

LDI_{Total} = LDI Index for the area of influence
$\%LU_i$ = percent of total area of influence in land use i
LDC_i = LDI coefficient for land use i

Brown and Vivas (2003) and Fore (2004) evaluated various methods for calculating the LDI, including distance weighting and the area of influence. Brown and Vivas (2003) evaluated the differences in LDIs calculated using 100, 200, and 500 m buffer differences around drainage basins for wetlands. They reported no significant difference between LDIs calculated using buffer distances of either 100 or 200 m; however, LDIs calculated using a 500 m buffer were different from those determined using either the 100 or 200 m distances in some cases. Additionally, they found that the LDIs determined using buffer distances of either 100 or 200 m were better able to predict the Wetland Biological Integrity (SFWMD's Wetland Rapid Assessment Procedure [WRAP]).

[3] "Emergy" is energy that has been corrected for different qualities. Its unit is expressed as the solar emergy joule (sej). The units for quantifying the intensity of human activity are therefore sej/ha•yr-1 (empower density).

Brown and Vivas (2003) also compared distance-weighted and area-weighted LDIs. They found no significant difference between the two methods and concluded that, since the time to calculate an area-weighted LDI was considerably less, the area-weighted method was the most efficient method to calculate an LDI. Fore (2004) evaluated the effect of upstream catchment distance on the LDI for streams, in order to determine which spatial scale was a better predictor of site condition. She compared a LDI calculated as 100 m buffers around the streams both 10 km upstream of sampling points and for the entire upstream catchment area (watershed). The LDIs calculated using the two distances were both highly correlated with each other and almost equally correlated with Florida's SCI of stream macroinvertebrate biological integrity.

EPA guidance (2000a, 2000b, 2000c, 2000d, and 2000e) states that reference reaches are relatively undisturbed stream segments that can serve as examples of the natural biological integrity of a region. Because reference reaches should be both minimally disturbed by anthropogenic influences and support valued ecological attributes (healthy populations of flora and fauna), the metrics used to select reference reaches need to be correlated with both the degree of human disturbance influencing the reach as well the biological or ecological health of the system. As discussed above, the LDI was developed as a direct and objective measure of human disturbance. It has also been shown to be a reliable predictor of pollutant loading (**Figure B-1**). Furthermore, the LDI has been demonstrated in multiple cases and across multiple waterbody types to be an effective predictor of biological health.

Brown and Reiss (2006) suggested an LDI breakpoint of less than or equal to 2.0 to identify minimally disturbed sites and an LDI of greater than 2.0 to designate areas with increasing levels of human disturbance based on an evaluation of diatom, macrophyte, and macroinvertebrate assemblages (*i.e.,* Florida Wetland Condition Index [FWCI]) in 193 depressional wetlands in Florida. The study divided wetlands into four groups for analysis (Group 1 – LDI = 1.0; Group 2 – 1.0 < LDI ≤ 2.0; Group 3 – 2.0 < LDI ≤ 3.0; and Group 4 – LDI > 3.0). Statistical comparisons (2-sample t-test and Fisher's one-way multiple comparison) showed that there were no significant differences in diatom, macrophyte, or macroinvertebrate FWCI scores for LDI Groups 1 and 2 (**Table B-1** and **Figure B-2**). Additionally, Groups 3 and 4 (LDI >2) were found to be significantly different from Groups 1 and 2 (LDI ≤ 2). Brown and Reiss (2006) concluded that an LDI of 2.0 represented a very conservative breakpoint between potentially disturbed sites and reference conditions.

The LDI has been also shown to be an effective predictor of stream macroinvertebrate biological integrity. Fore (2004) demonstrated a strong correlation (Spearman's r=-0.60, p<0.01) between the LDI and the SCI (**Figure B-3**). Furthermore, many of the 10 biological metrics that go into the SCI, particularly percent sensitive taxa, exhibit a strong correlation with the LDI (**Figure B-4**).

Niu (2004) provided another example of the relationship between LDI and biologic heath. He evaluated breakpoints in lake chlorophyll *a* concentrations relative to LDI in 547 Florida lakes using change point analysis and found statistically significant change points in median lake chlorophyll *a* concentrations at LDI values of 1.9 and 6.3 (**Figure B-5**).

As discussed above, the LDI was specially designed as a metric of human disturbance. LDI values of less than 2.0 are indicative of areas with very minimal levels of human disturbance. Although it would be ideal to incorporate direct measures of biological health into the selection of benchmark sites, this is not currently possible given the paucity of paired nutrient and biological data for the Lake Okeechobee Tributaries TMDL, determined based on the selected analysis method. Since it has been demonstrated that the LDI is highly correlated with multiple measures of biological health, the use of the LDI alone is deemed appropriate and adequate for the selection of benchmark sites. Further, across multiple waterbody types and multiple trophic levels, an LDI of 2.0 has been shown to be a biologically significant breakpoint that can be used to distinguish benchmark conditions from potentially disturbed areas. Therefore, an LDI of 2.0 or less is a conservative criterion that can appropriately and reliably be used to identify minimally disturbed benchmark sites.

Table B-1. Comparison of FWCI scores using Fisher's one-way multiple comparison test for three separate species assemblages (diatoms, macrophytes, and macroinvertebrates) for depressional palustrine wetlands

From Brown and Reiss (2006).

LDI Group	Diatom FWCI	Macrophyte FWCI	Macroinvertebrate FWCI
Group 1 LDI = 1.0	84.9 (15.2) a	85.1 (9.1) a	66.8 (17.1) a
Group 2 1.0 < LDI ≤ 2.0	80.4 (17.8) a	80.3 (13.4) a	65.9 (18.0) a
Group 3 2.0 < LDI ≤ 3.0	64.4 (18.9) b	56.8 (20.3) b	44.3 (22.1) b
Group 4 LDI > 3.0	35.5 (25.9) c	26.5 (21.7) c	34.0 (18.4) b

Notes:
Group values represent mean (standard deviation).
Means in the same column followed by the same letter are not significantly different at $\alpha = 0.05$ using Fisher's least significant difference (LSD) procedure.

Figure B-1. Area-weighted LDI Index versus phosphorus pollutant load in 64 hydrologic units (subwatersheds) of the St. Marks River watershed.

Re-created from Brown and Vivas (2003).

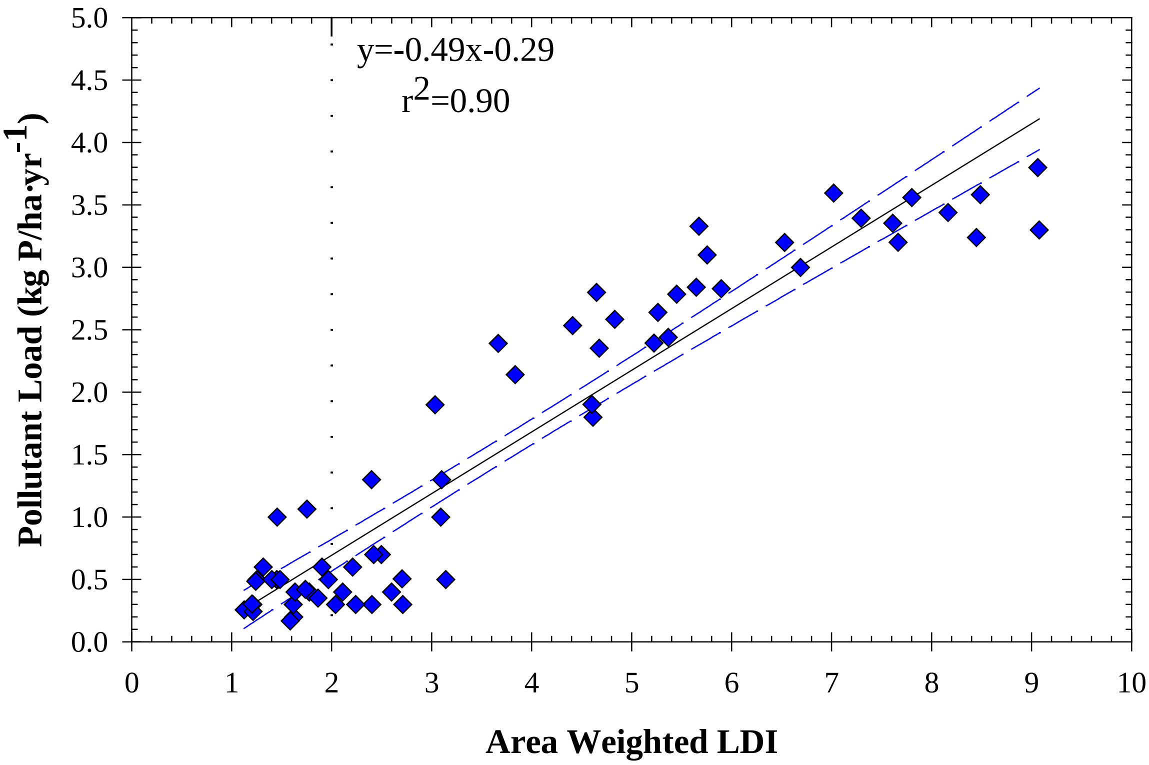


Figure B-2. Box plot comparison of macroinvertebrate FWCI scores among LDI groups, including Group 1 (LDI = 1.0), Group 2 (1.0 < LDI ≤ 2.0), Group 3 (2.0 < LDI ≤ 3.0), and Group 4 (LDI > 3.0).

Boxes represent the 25th to 75th quartile range, circles represent group mean values, and horizontal lines represent median values (from Brown and Reiss, 2006).

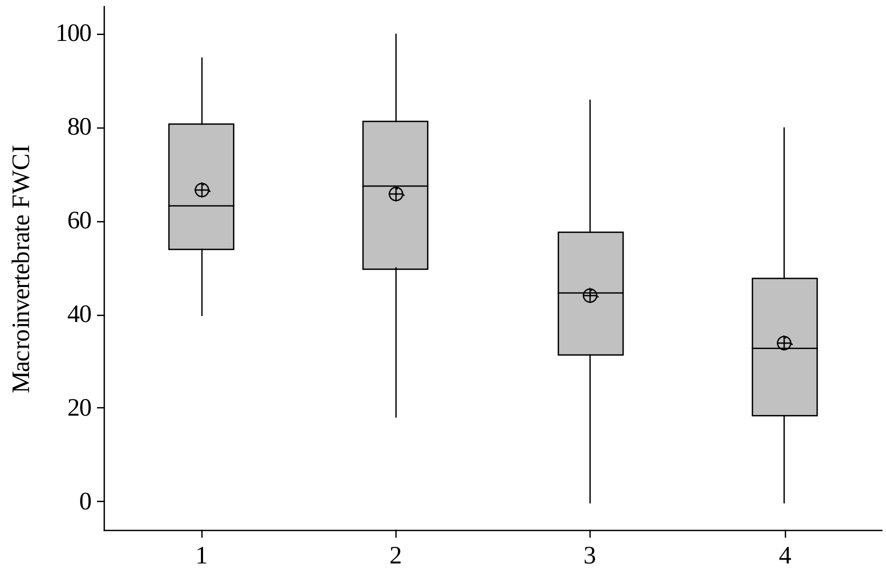


Figure B-3. Box plot comparison of SCI scores and LDI values calculated based on a 100 m buffer area extending 10 km upstream of the sample point

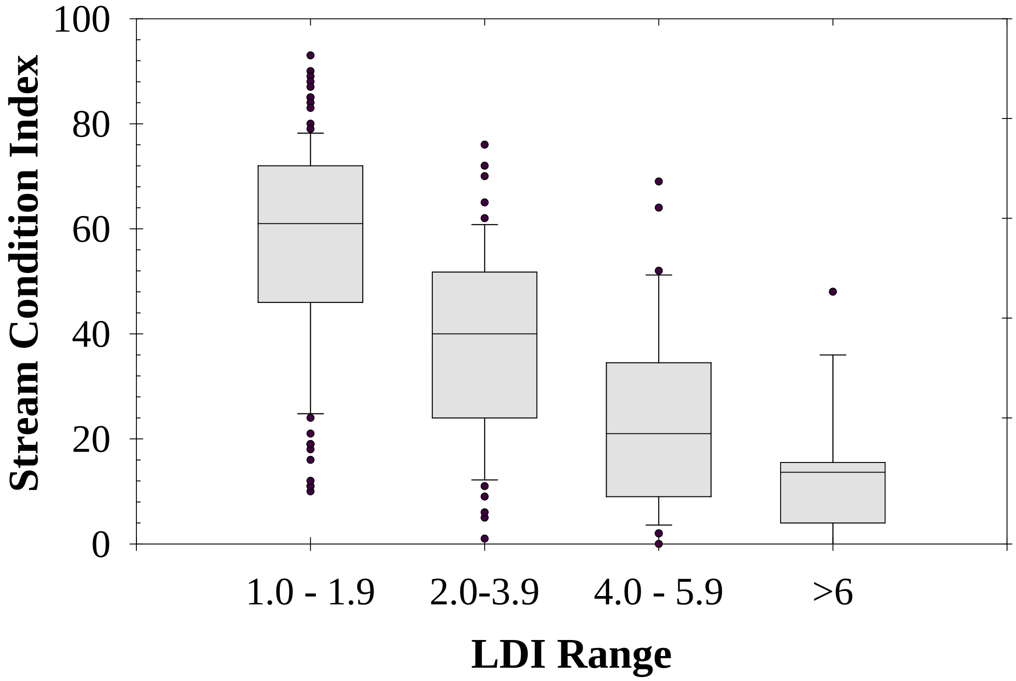


Figure B-4. Comparison of average number of sensitive stream macroinvertebrate taxa for sites within different LDI groups

The number of sensitive taxa from streams with LDIs < 2.0 was significantly greater than for streams with higher LDIs (Kruskall-Wallis p<0.0001).

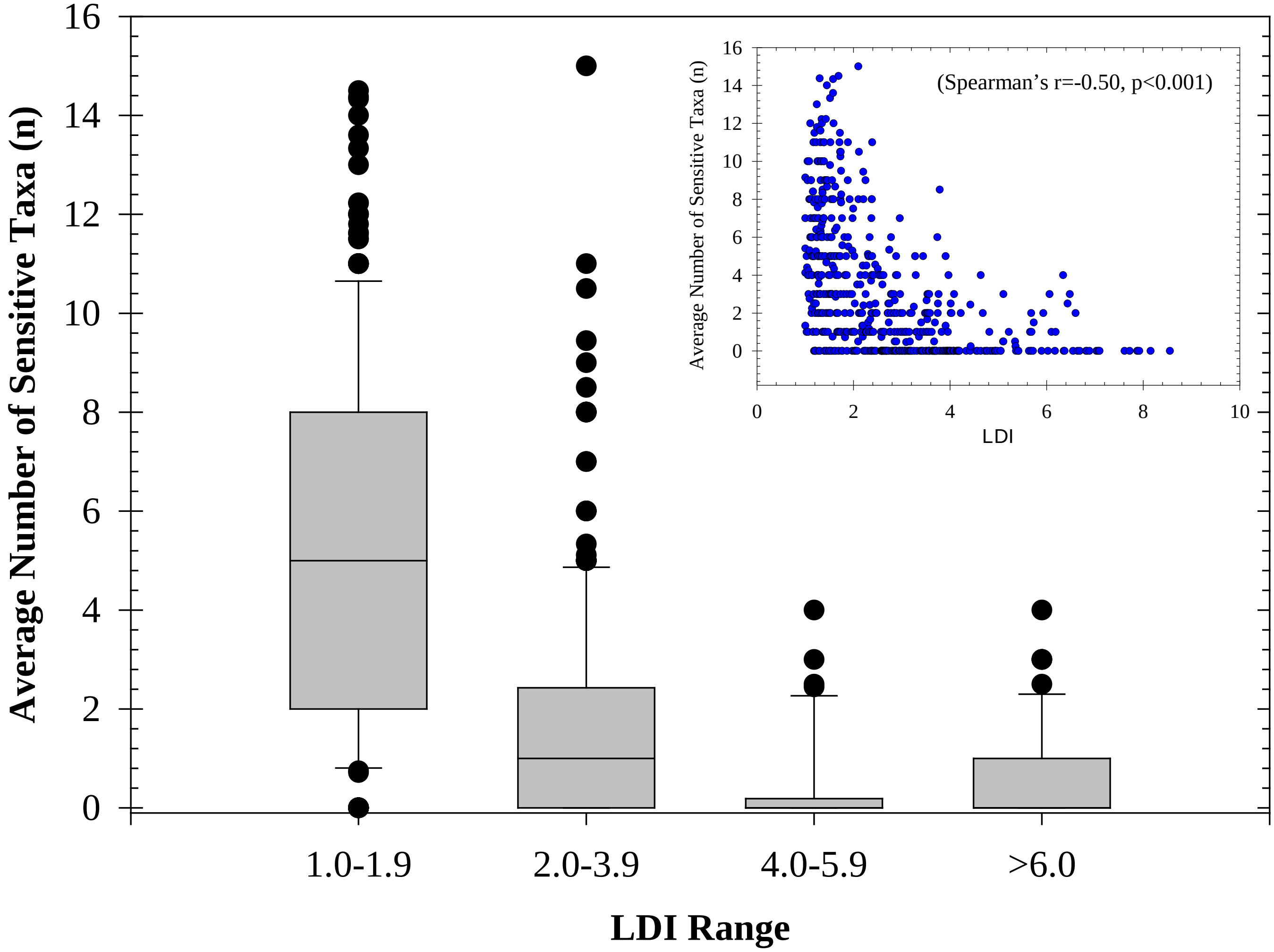
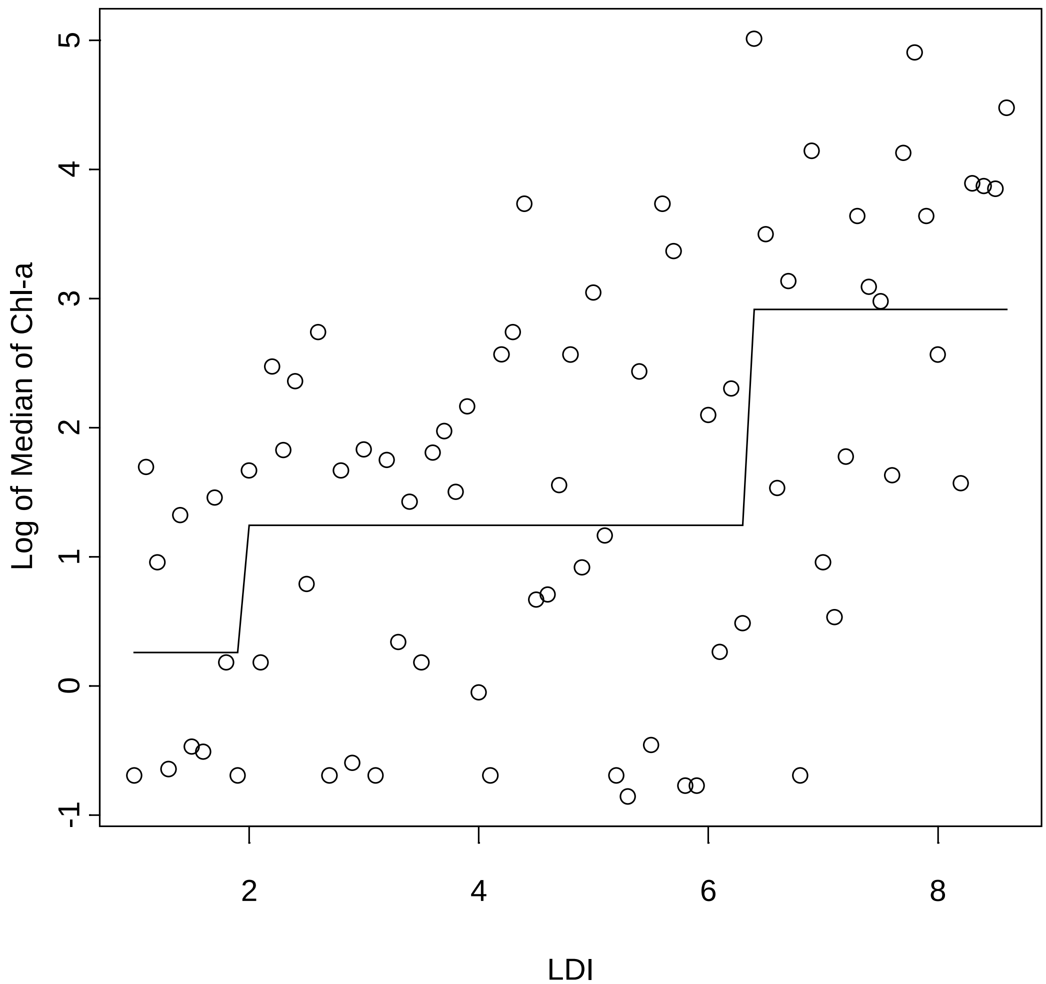


Figure B-5. Log of lake median chlorophyll *a* concentrations versus LDI

Two change points were detected. The first was detected at an LDI = 1.9 with about 80% confidence, and a second was detected at an LDI = 6.3 with about 95% confidence.



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Appendix C. Peninsular Nutrient Benchmark Summaries

Nutrient Benchmark Site Summary
Bee Branch
STORET Station 28020299FTM

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.64, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of citrus and field/pasture observed beyond the forested buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Bee Branch (Station 28020299FTM) showing watershed vicinity and land use. The headwaters drain an area dominated by pine flatwoods, prairie, and wetlands.

DOQQ 2004 aerial l photograph of Bee Branch (Station 28020299FTM) showing close-up of sampling site. An extensive forested riparian zone was evident of both sides of the system.

Photographs of Bee Branch (Station 28020299FTM).

<u>**Habitat, Biological and Water Quality Data**</u>

Parameter	Value
Habitat Assessment	147
Hydrologic Score	3
LDI Score	1.64
SCI Score	49 A
Total Phosphorus Geometric Mean (mg/L)	0.080
Total Nitrogen Geometric Mean (mg/L)	1.13

The habitat assessment scored in the “Optimal” range. The Stream Condition Index scored in the “Healthy” category, exhibiting a diverse assemblage of sensitive invertebrates and indicating the site is clearly meeting the Class III designated use.

<u>**Periphyton Community Composition**</u>

Algal Community Stricture	% Composition
% Bacillariophyta	91.33
% Chlorophycota	2.67
% Euglenophycota	0.67
% Cyanophycota	4.67
Number of Taxa	60

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 60 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal community) at Bee Branch. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Reference Site Summary
Blackwater Creek at State Road 44A
STORET Station ALT_BWC44 (20010455)

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.09, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Blackwater Creek at State Road 44A (Station BWC44 or 20010455) showing watershed vicinity and land use. The system originates in Lake Norris, an undeveloped lake surrounded by wetland.

DOQQ 2004 aerial photograph of Blackwater Creek at State Road 44A (Station BWC44 or 20010455) showing close-up of sampling site. An extensive forested riparian zone was evident on both sides of the system.

Photographs of Blackwater Creek at State Road 44A

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	125
Hydrologic Score	2
LDI Score	1.09
SCI Score	77 A
Total Phosphorus Geometric Mean (mg/L)	0.050
Total Nitrogen Geometric Mean (mg/L)	1.60

The habitat assessment scored in the "Optimal" range, and the Stream Condition Index scored in the "Exceptional" category, indicating an unusually diverse assemblage of sensitive invertebrates, definitively supporting the Class III designation.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	93.0
% Chlorophycota	0
% Cryptophycophyta	0
% Cyanophycota	7.0
Number of Taxa	45

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 45 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (hydrology, habitat assessment, local land use, algal and macroinvertebrate communities) at Blackwater Creek at State Road 44A. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
Blackwater Creek upstream of Carter Prop Bridge
STORET Station BWCCPB / 20010536

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.31, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Blackwater Creek upstream of Carter Prop Bridge (Station BWCCPB) showing watershed vicinity and land use. The system originates in Lake Norris, an undeveloped lake surrounding by wetland.

DOQQ aerial photograph of Blackwater Creek upstream of Carter Prop Bridge (Station BWCCPB) showing close-up of sampling site. An extensive forested riparian zone was evident of both sides of the system.

Photographs of Blackwater Creek upstream of Carter Prop Bridge

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	130
Hydrologic Score	2
LDI Score	1.31
Total Phosphorus Geometric Mean (mg/L)	0.054
Total Nitrogen Geometric Mean (mg/L)	1.28

The habitat assessment scored in the “Optimal” range. High water caused by recent rains made Stream Condition Index sampling inappropriate according to DEP standard operating procedures. Results from a Biorecon that was performed 2/7/2007 demonstrated that this site scored in the “healthy” range, indicating that the Class III designation is being fully supported.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	72.43
% Chlorophycota	15.28
% Cryptophycophyta	0.33
% Cyanophycota	7.31
% Euglenophycota	2.99
Number of Taxa	72

Very little periphyton was observed at the site, which would allow optimal substrate use by macroinvertebrates. No nuisance algal growth was found. Of the 72 algal taxa observed, the majority of the periphyton community was composed of diatoms.
.

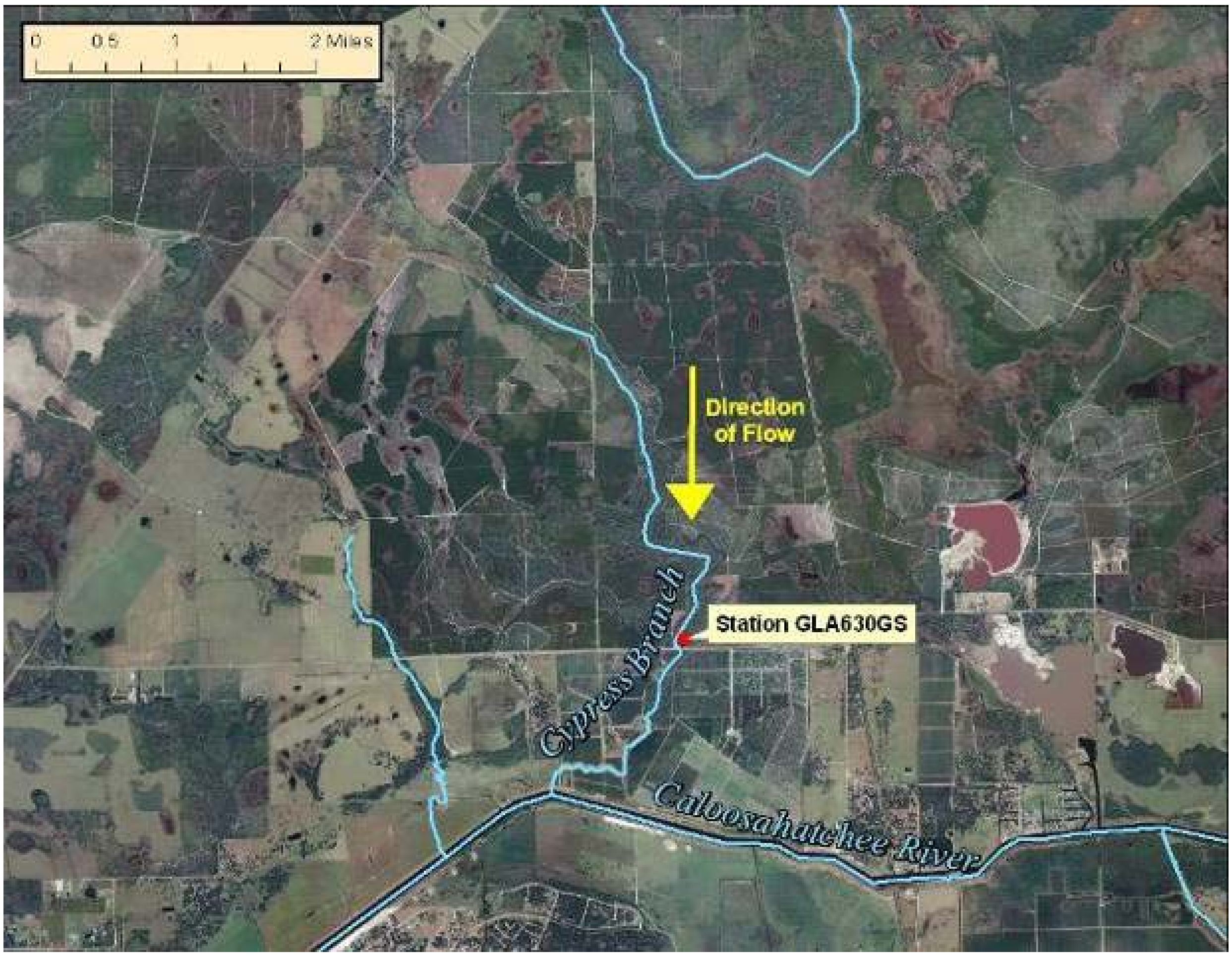
Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (hydrology, local land use, and algal communities) at Blackwater Creek, upstream of Carter Prop Bridge. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
Cypress Branch above 78
STORET Station GLA630GS

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.21 suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with areas of citrus and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.



DOQQ 2004 aerial photograph of Cypress Branch (Station GLA630GS) showing watershed vicinity and land use. The stream originates in an area of prairie, flatwoods, and swamp.

DOQQ 2004 aerial photograph of Cypress Branch (Station GLA630GS) showing close-up of sampling site. An extensive riparian forested zone is generally present on both sides of the system throughout the watershed, with a minimum of a 75-100 m buffer.

Photograph of Cypress Branch (Station GLA630GS).

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	134
Hydrologic Score	2
LDI Score	1.21
SCI Score	63 A
Total Phosphorus Geometric Mean (mg/L)	0.131
Total Nitrogen Geometric Mean (mg/L)	1.97

The habitat assessment scored in the “Optimal” range, and the Stream Condition Index scored in the “Healthy” category, indicating a diverse assemblage of sensitive invertebrates, and fully supporting the Class III designation.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	91.33
% Chlorophycota	0
% Cryptophycophyta	0
% Cyanophycota	8.67
Number of Taxa	48

Very little periphyton was observed at the site, which would allow optimal substrate use by macroinvertebrates. No nuisance algal growth was found. Of the 48 algal taxa observed, the majority of the periphyton community was composed of diatoms.

Overall Reference Site Conclusion:

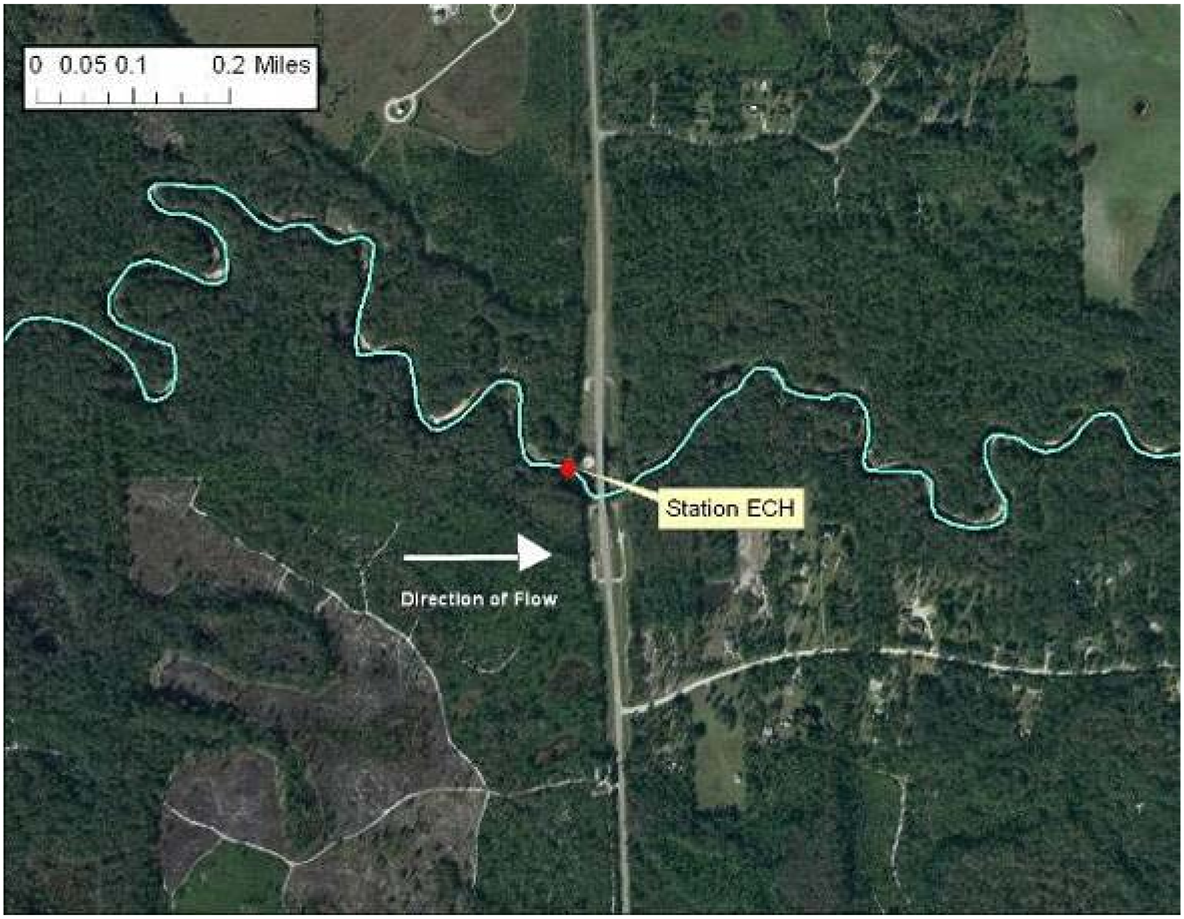
Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, and local land use) at Cypress Branch. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
Econlockhatchee River at Snowhill Road
STORET Station ECH

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.14, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond the forested buffer zone.

DOQQ 2004 aerial photograph of Econlockhatchee River at Snowhill Road (Station ECH) showing watershed vicinity and land use. The system originates in the Econlockhatchee River Swamp, an extensive wetland area.



DOQQ 2004 aerial photograph of Econlockhatchee River at Snowhill Road (Station ECH) showing close-up of sampling site. An extensive forested riparian zone was evident of both sides of the system.

Photographs of Econlockhatchee River at Snowhill Road

<u>Habitat, Biological and Water Quality Data</u>

Parameter	Value
Habitat Assessment	106
Hydrologic Score	2
LDI Score	1.14
SCI Score	52 A
Total Phosphorus Geometric Mean (mg/L)	0.098
Total Nitrogen Geometric Mean (mg/L)	0.93

The habitat assessment score of 106 placed this site in the high “Suboptimal” range. The Stream Condition Index score of 52 was in the “Healthy” category, exhibiting a diverse assemblage of sensitive invertebrates and indicating the site is clearly meeting the Class III designated use.

<u>Periphyton Community Composition</u>

Algal Community Structure	% Composition
% Bacillariophyta	90.31
% Chlorophycota	1.38
% Cryptophycophyta	0
% Cyanophycota	8.3
Number of Taxa	53

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 53 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

Overall Reference Site Conclusion:

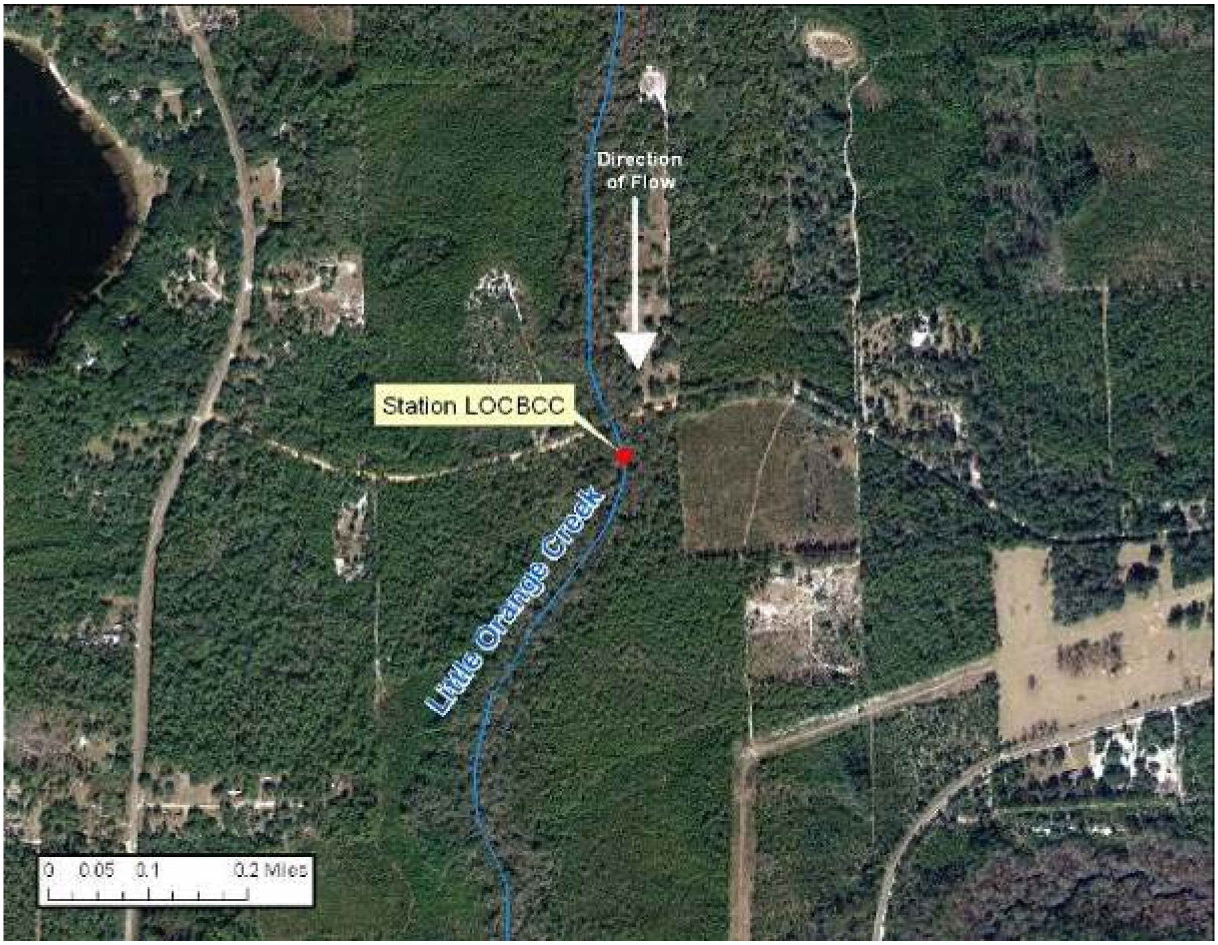
Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) at Econlockhatchee River at Snowhill Road. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
Little Orange Creek below Cabbage Creek
STORET Station LOCBCC

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.54, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Little Orange Creek below Cabbage Creek (Station LOCBCC) showing watershed vicinity and land use. Little Orange Creek originates from Little Orange Lake, a completely undeveloped system surrounded by forest, and associated wetlands.



DOQQ 2004 aerial photograph of Little Orange Creek below Cabbage Creek (Station LOCBCC) showing close-up of sampling site. An extensive riparian forested wetland buffer is present on both sides of the system.

Photographs of Little Orange Creek below Cabbage Creek

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	132
Hydrologic Score	2
LDI Score	1.54
SCI Score	89 A
Total Phosphorus Geometric Mean (mg/L)	0.067
Total Nitrogen Geometric Mean (mg/L)	0.70

The habitat assessment scored in the "Optimal" range, and the Stream Condition Index scored in the "Exceptional" category, indicating an unusually diverse assemblage of sensitive invertebrates, definitively supporting the Class III designation.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	84.52
% Chlorophycota	5.16
% Cryptophycophyta	0
% Cyanophycota	10.32
Number of Taxa	54

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 54 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) at Little Orange Creek below Cabbage Creek. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
Little Orange Creek
STORET Station PUT308GS

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 2.01, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Little Orange Creek (Station PUT308GS) showing watershed vicinity and land use. The stream originates from Little Orange Lake, an undeveloped system surrounded by forest and swamp.

DOQQ 2004 aerial photograph of Little Orange Creek (Station PUT308GS) showing close-up of sampling site. An extensive riparian forested buffer is generally present on both sides of the system throughout the watershed, with one small clear-cut area approaching within 75 m of the stream.

Photograph of Little Orange Creek

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	131
Hydrologic Score	2
LDI Score	2.01
SCI Score	75 A
Total Phosphorus Geometric Mean (mg/L)	0.201
Total Nitrogen Geometric Mean (mg/L)	1.13

The habitat assessment scored in the "Optimal" range, and the Stream Condition Index scored in the "Exceptional" category, indicating an unusually diverse assemblage of sensitive invertebrates, definitively supporting the Class III designated use. This is one of the few peninsular sites where Plecopterans (stoneflies, known to be extremely sensitive to stress) are routinely found.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	86.6
% Chlorophycota	5.7
% Cryptophycophyta	0
% Cyanophycota	7.4
Number of Taxa	48

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 48 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

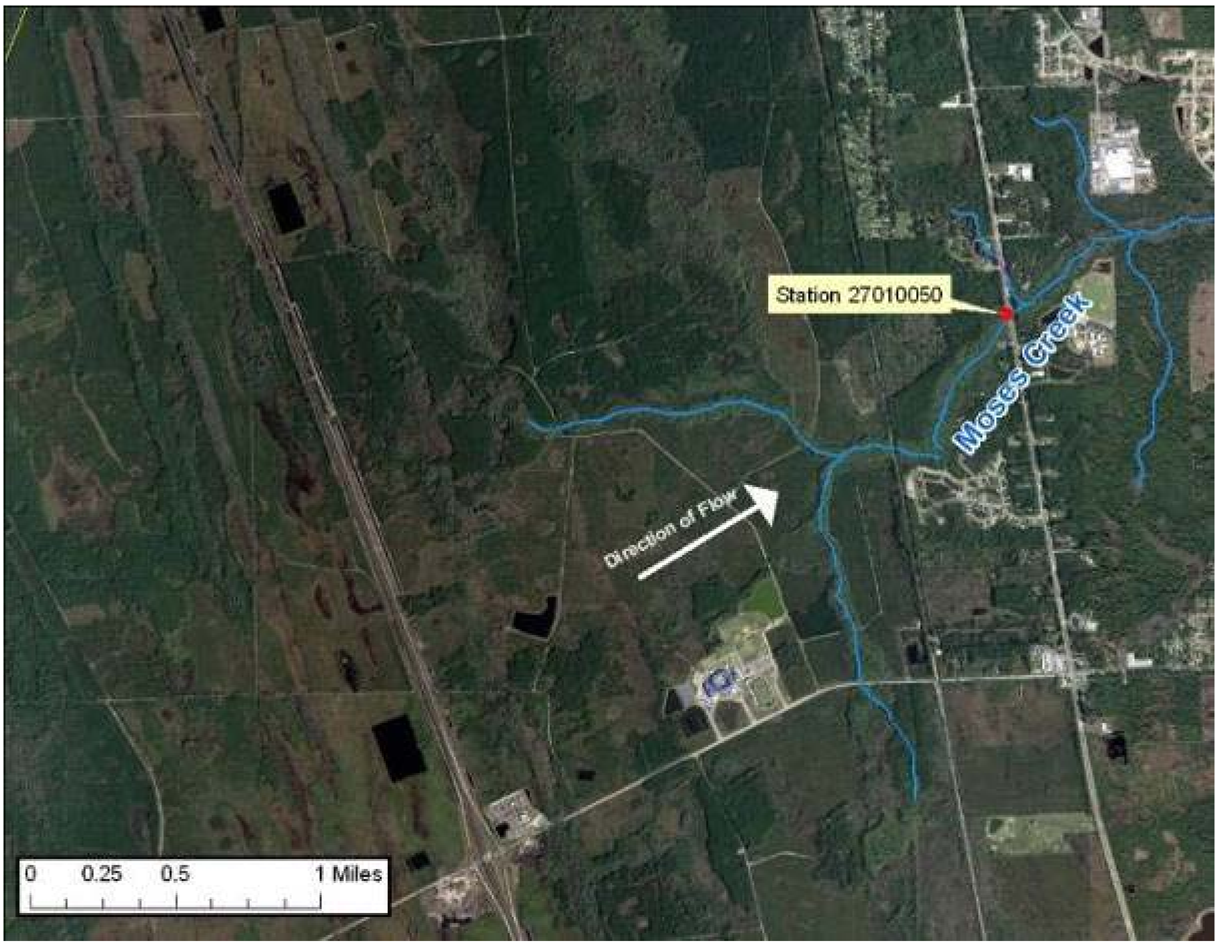
Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) at Little Orange Creek. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

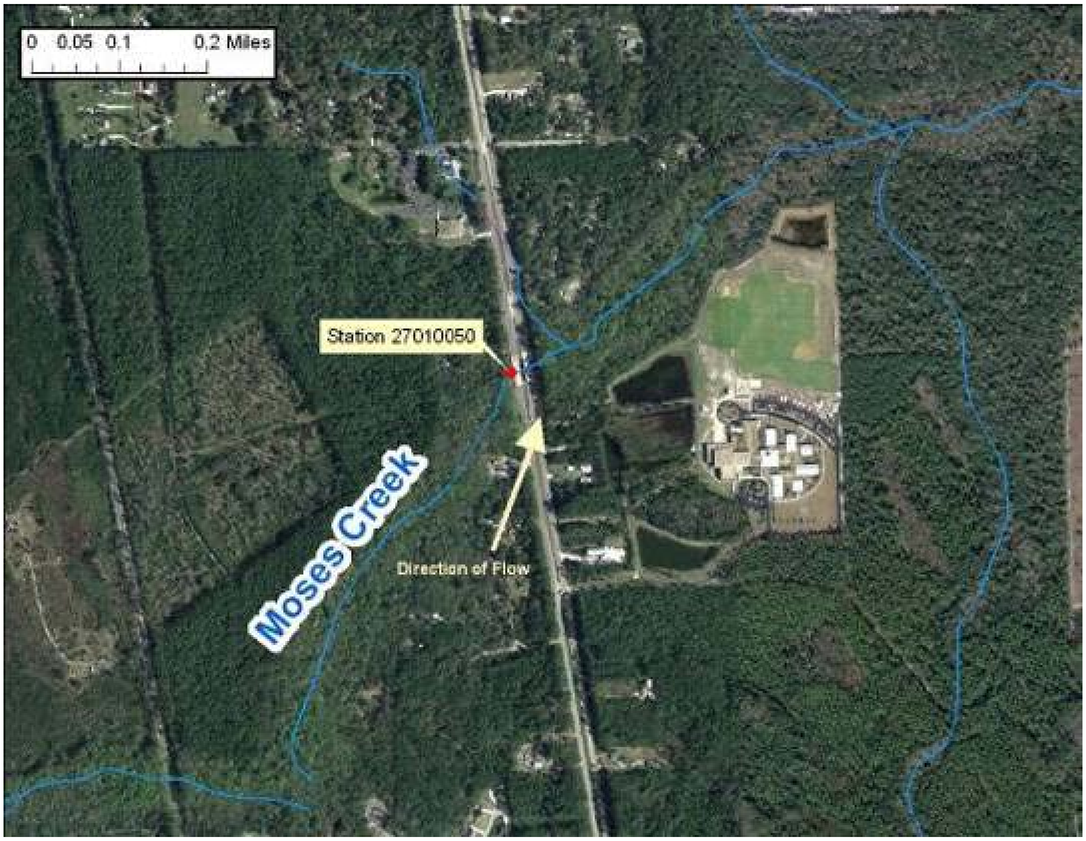
Nutrient Benchmark Site Summary
Moses Creek at US 1
STORET Station 27010050

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.24, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond the forested buffer zone. There are no point source discharges upstream of the site.



DOQQ 2004 aerial photograph of Moses Creek at US 1 (Station 27010050) showing watershed vicinity and land use.



DOQQ 2004 aerial photograph of Moses Creek at US 1 (Station 27010050) showing close-up of sampling site. Moses Creek originates in an area of pine flatwoods and swamp. An extensive riparian forested buffer is present on both sides of the system.

Photograph of Moses Creek at US 1

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	138
Hydrologic Score	1
LDI Score	1.24
SCI Score	60 A
Total Phosphorus Geometric Mean (mg/L)	0.081
Total Nitrogen Geometric Mean (mg/L)	1.03

The habitat assessment scored in the "Optimal" range. The Stream Condition Index score of 60 was in the "Healthy" category, exhibiting a diverse assemblage of sensitive invertebrates and indicating the site is meeting the Class III designated use.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	14.33
% Chlorophycota	1.33
% Euglenophycota	1.67
% Cyanophycota	81.67
Number of Taxa	71

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 71algal taxa observed, including 66 diatom taxa, the majority of the periphyton community was composed of blue-green algae. No problematic filamentous algal growth was found.

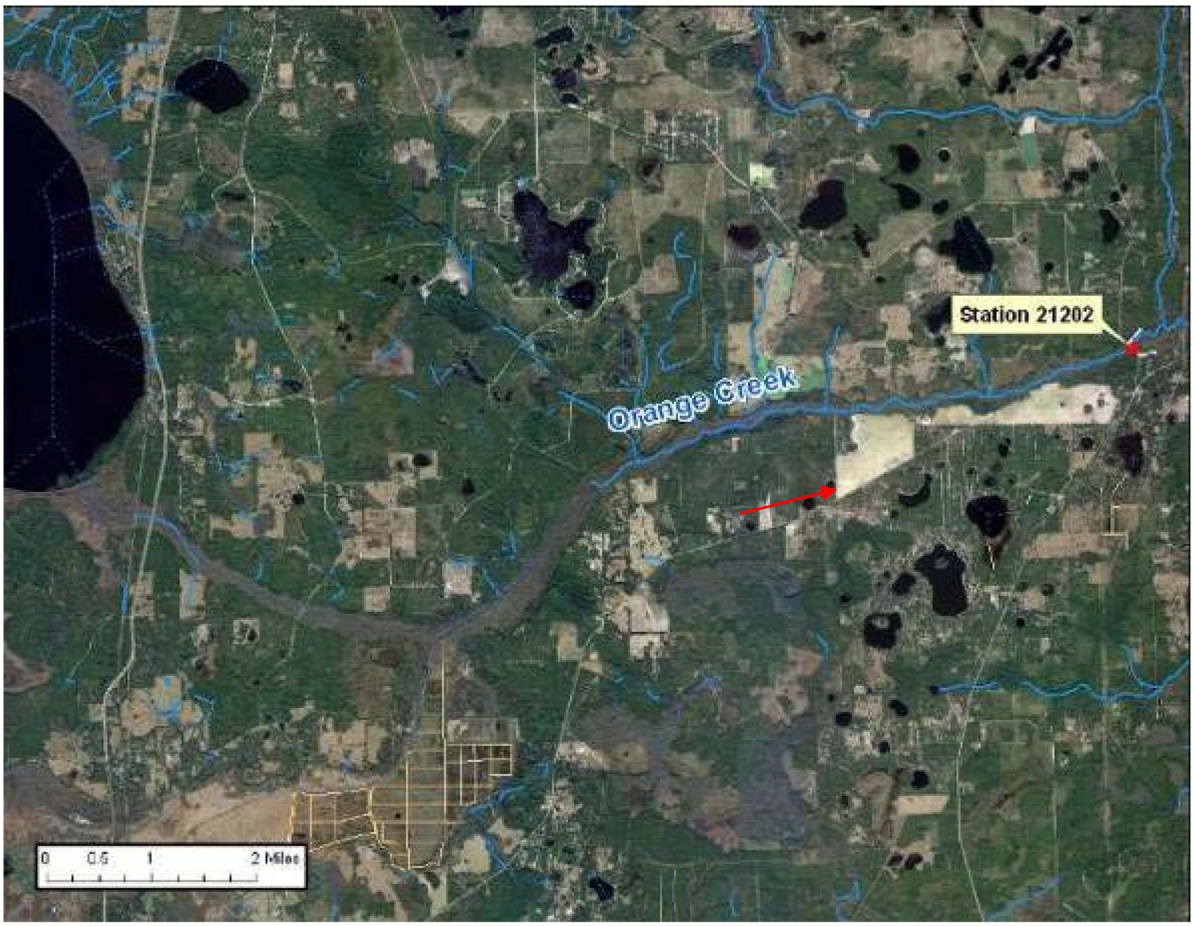
Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, and local land use) at Moses Creek at US 1. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

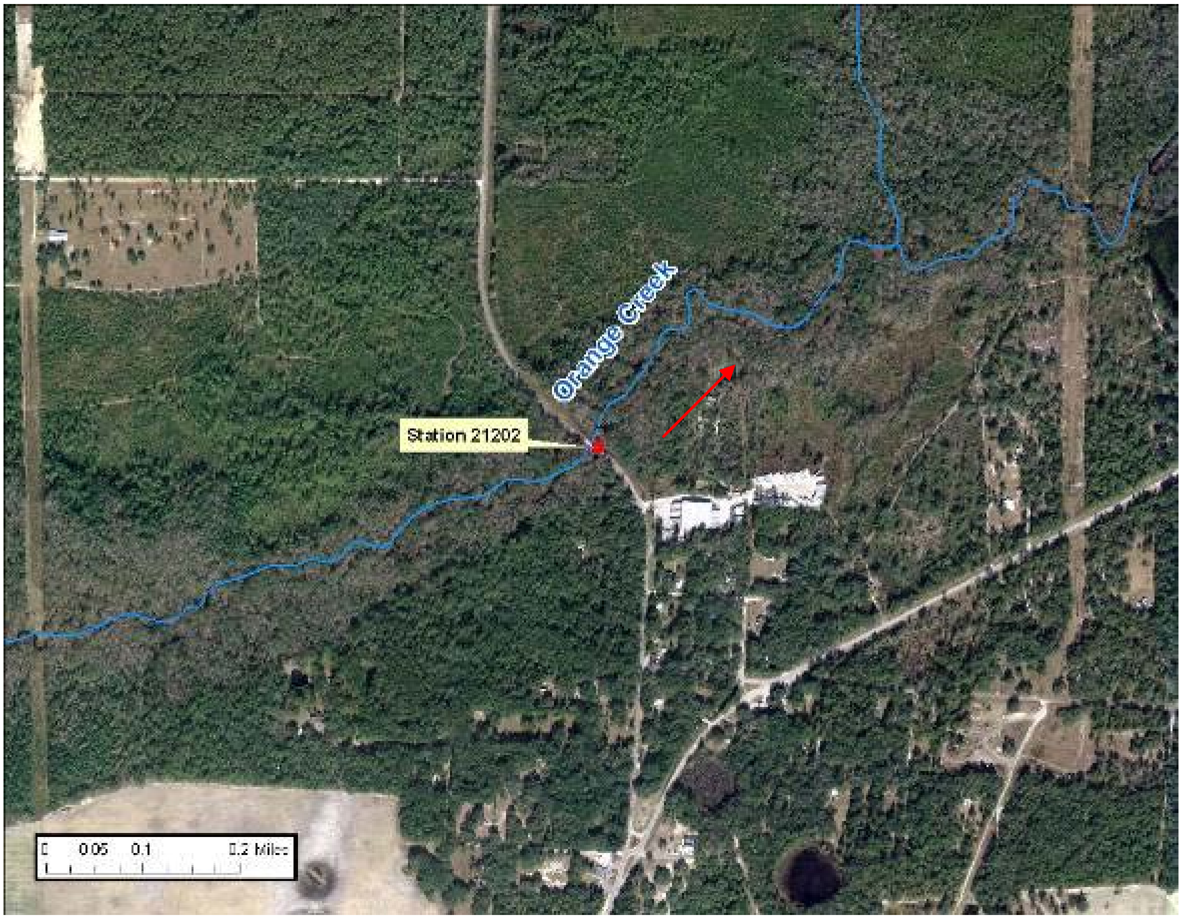
Nutrient Benchmark Site Summary
Orange Creek Upstream of Highway 21
STORET Station 21202

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.7, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture and field/pasture observed beyond a forested riparian buffer zone. There are no point source discharges upstream of the site.



DOQQ 2004 aerial photograph of Orange Creek upstream of Highway 21 (Station 21202) showing watershed vicinity and land use. The stream originates from Orange Lake, an Outstanding Florida Water.



DOQQ 2004 aerial photograph of Orange Creek upstream of HWY 21 (Station 21202) showing close-up of sampling site. An extensive riparian forested wetland buffer is present on both sides of the system.


Photograph of Orange Creek upstream of Highway 21

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	121
Hydrologic Score	3
LDI Score	1.74
SCI Score	74 A
Total Phosphorus Geometric Mean (mg/L)	0.125
Total Nitrogen Geometric Mean (mg/L)	1.43

The habitat assessment scored in the "Optimal" range, and the Stream Condition Index scored in the "Exceptional" category, indicating an unusually diverse assemblage of sensitive invertebrates. This is one of the few peninsular sites where Plecopterans (stoneflies, known to be extremely sensitive to stress) are routinely found.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	90.38
% Chlorophycota	1.37
% Cryptophycophyta	0
% Cyanophycota	8.25
Number of Taxa	51

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 51 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

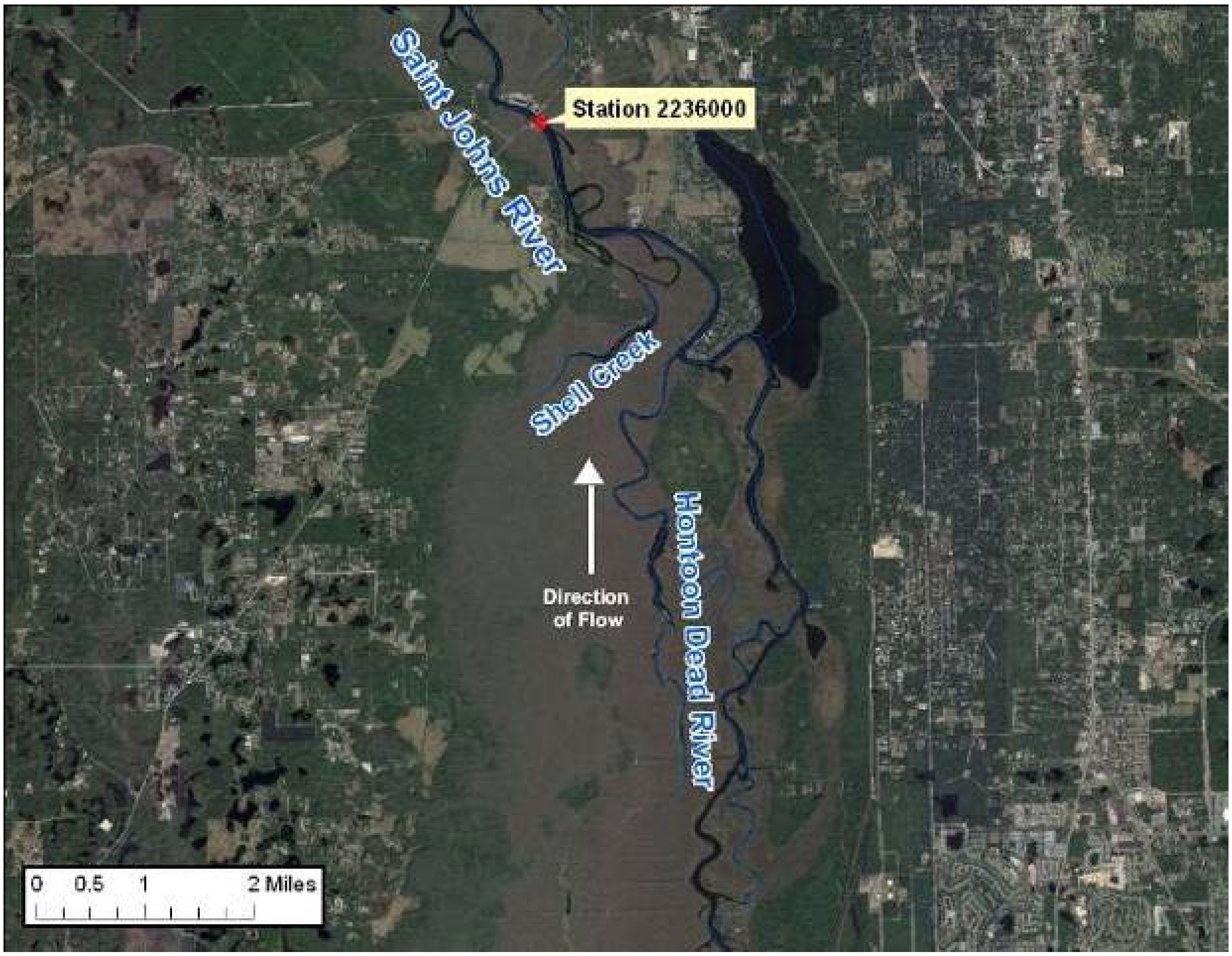
Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) at Orange Creek, upstream of Highway 21. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
St. Johns River Near DeLand
STORET Station 2236000

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.68, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond the forested buffer zone.



DOQQ 2004 aerial photograph of St. John's River near DeLand (Station 2236000) showing watershed vicinity and land use. The system originates from Blue Cypress Lake, a completely undeveloped system surrounding by forest and wetlands.

DOQQ 2004 aerial photograph of St. John's River near DeLand (Station 2236000) showing close-up of sampling site. An extensive riparian forested wetland buffer is present on both sides of the system.

Photographs of St. John's River near DeLand

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	128
Hydrologic Score	4
LDI Score	1.68
SCI Score	NA
Total Phosphorus Geometric Mean (mg/L)	0.078
Total Nitrogen Geometric Mean (mg/L)	1.39

The habitat assessment scored in the "Optimal" range. This system is characterized by very low flow, therefore Stream Condition Index sampling was inappropriate according to DEP standard operating procedures. Aquatic vegetation present was typical of sluggish, open systems and there were no nuisance plant issues.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	88.2
% Chlorophycota	2.4
% Cryptophycophyta	0
% Cyanophycota	9.5
Number of Taxa	53

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 53 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal communities) at the St. Johns River near Deland. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and based upon observations during the site visit, that no adverse algal or aquatic plant issues were present. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which suggest support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
Steven's Branch off CR 204
STORET Station 27010070

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.29, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Steven's Branch off CR 204 (Station 27010070) showing watershed vicinity and land use. Steven's Branch originates in an area of pine flatwoods, wetlands and prairie.

DOQQ 2004 aerial photograph of Steven's Branch off CR 204 (Station 27010070) showing close-up of sampling site. An extensive riparian forested buffer is present on both sides of the system.

Photographs of Steven's Branch off CR 204 (Station 27010070)

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	128
Hydrologic Score	3
LDI Score	1.29
SCI Score	76 A
Total Phosphorus Geometric Mean (mg/L)	0.120
Total Nitrogen Geometric Mean (mg/L)	1.09

The habitat assessment scored in the “Optimal” range, and the Stream Condition Index scored in the “Exceptional” category, indicating an unusually diverse assemblage of sensitive invertebrates, definitively supporting the Class III designation.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	75.14
% Chlorophycota	3.39
% Cryptophycophyta	0
% Cyanophycota	21.47
Number of Taxa	66

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 66 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

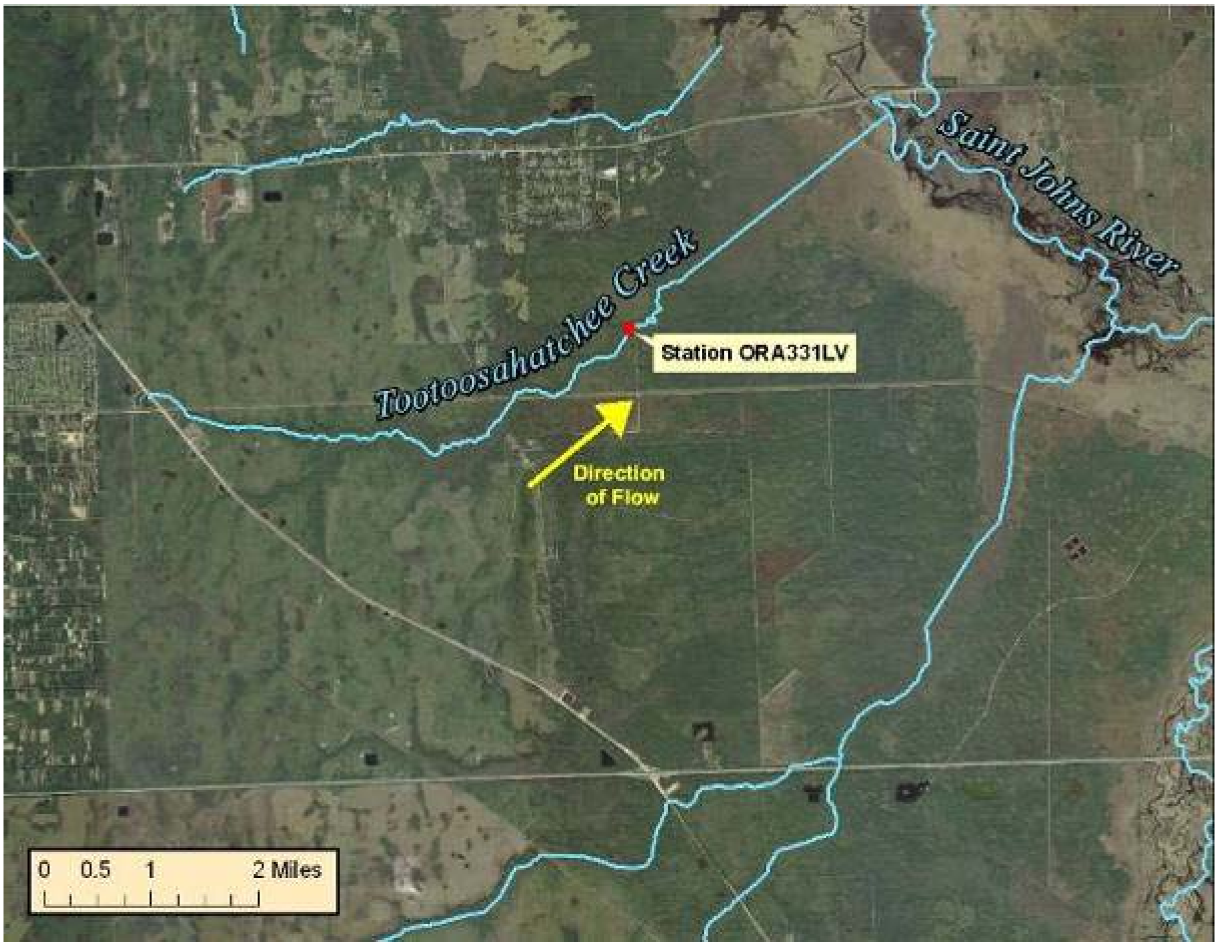
Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) at Steven’s Branch off CR 204. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which demonstrate full support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

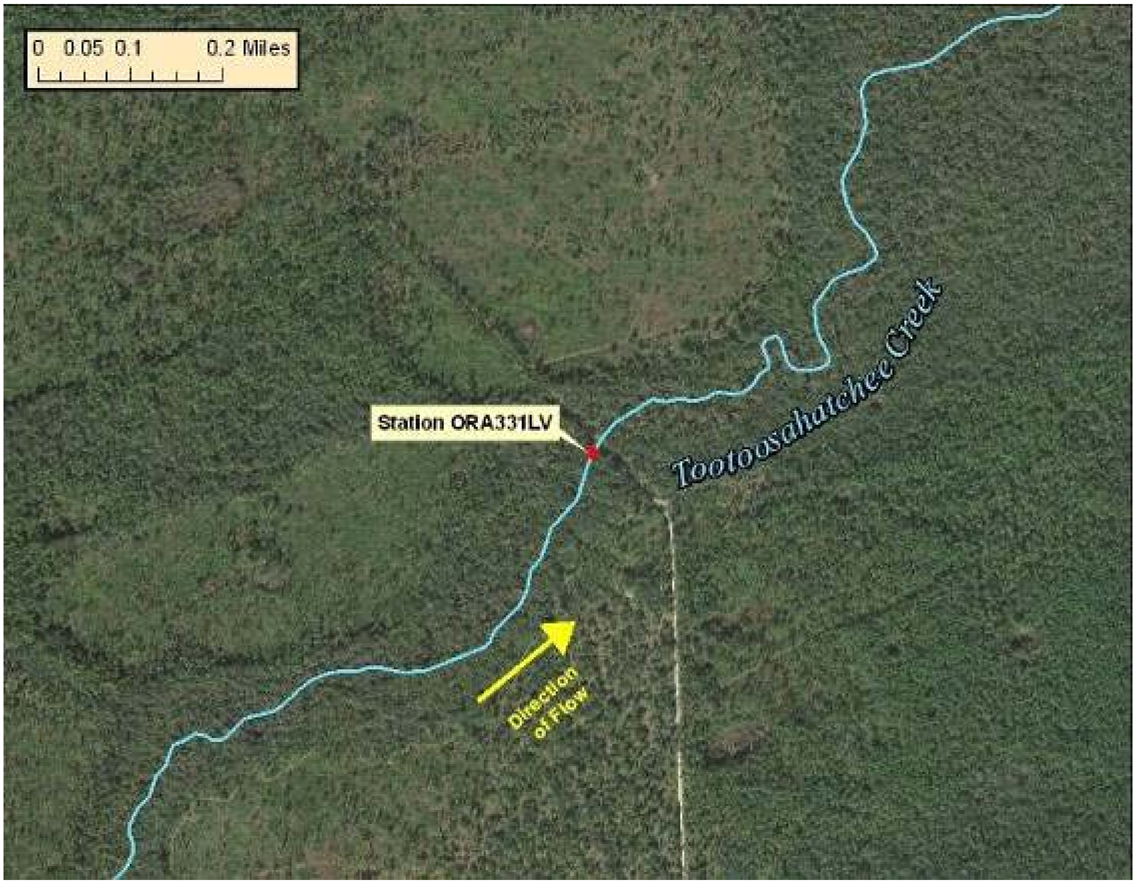
Nutrient Benchmark Site Summary
Tosohatchee Creek @ WMA
STORET Station ORA331LV

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.50, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.



DOQQ 2004 aerial photograph of Tosohatchee Creek (Station ORA331LV) showing watershed vicinity and land use. The stream originates in a swampy area adjacent to Tosohatchee Creek State Preserve.



DOQQ 2004 aerial photograph of Tosohatchee Creek (Station ORA331LV) showing close-up of sampling site. An extensive riparian forested wetland buffer is present on both sides of the system.

Photograph of Tosohatchee Creek (Station ORA331LV).

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	116
Hydrologic Score	1
LDI Score	1.50
SCI Score	NA
Total Phosphorus Geometric Mean (mg/L)	0.034
Total Nitrogen Geometric Mean (mg/L)	0.77

The habitat assessment scored in the high "Suboptimal" range, with water velocity being the lowest scoring parameter. The site was deemed inappropriate for SCI sampling due to the swamp-like nature of the system and lack of water flow. Vegetation present was typical of minimally disturbed swamp systems.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	89.00
% Chlorophycota	0.33
% Euglenophycota	0.33
% Cyanophycota	10.33
Number of Taxa	56

Of the 56 algal taxa identified, the majority of the periphyton community was composed of diatoms. No problematic filamentous algae were observed.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, algal community, and local land use) at Tosohatchee Creek. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that no adverse algal or aquatic plant issues were present. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which suggest support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

Nutrient Benchmark Site Summary
Waccasassa River above SR 24
STORET Station LEV502GS

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.23, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, and field/pasture observed beyond the forested riparian buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of the Waccasassa River (Station LEV502GS) showing watershed vicinity and land use. The Wacasassa River originates in an area of hardwood swamp known as Devils Hammock.

DOQQ 2004 aerial photograph of the Waccasassa River (Station LEV502GS) showing close-up of sampling site. Although there was some encroachment from a clear cut area near the site, extensive riparian forested wetland buffer is present on both sides for the majority of the system. Note that the forested buffer still exceeded approximately 75 m at minimum, and was generally several hundred m wide.

Photographs of the Waccasassa River

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	138
Hydrologic Score	1
LDI Score	1.23
SCI Score	69 A
Total Phosphorus Geometric Mean (mg/L)	0.065
Total Nitrogen Geometric Mean (mg/L)	0.63

The habitat assessment scored in the high "Optimal" range, and the Stream Condition Index scored in the "Exceptional" category, indicating an unusually diverse assemblage of sensitive invertebrates, definitively supporting the Class III designation.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	84.24
% Chlorophycota	0.32
% Cryptophycophyta	0
% Cyanophycota	15.43
Number of Taxa	46

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 46 algal taxa observed, the majority of the periphyton community was composed of diatoms. Although some filamentous algal growth was found in a few small areas, it did not affect habitat suitability, as evidenced by the very good SCI score.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) at the Waccasassa River. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota demonstrated to be fully supportive of the designated use (healthy, well balanced populations of aquatic organisms).

Nutrient Benchmark Site Summary
Withlacoochee River at Stokes Ferry
STORET Station 3513

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.82, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, field/pasture, and residential uses observed beyond a forested riparian buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Withlacoochee River at Stokes Ferry (Station 3513) showing watershed vicinity and land use. The Withlacoochee River originates in the Green Swamp, a very large wetland with considerable areas in public ownership.

DOQQ 2004 aerial photograph of Withlacoochee River at Stokes Ferry (Station 3513) showing close-up of sampling site. An extensive riparian forested wetland buffer is present on both sides of the system.

Photographs of the Withlacoochee River at Stokes Ferry

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	153
Hydrologic Score	4
LDI Score	1.82
SCI Score	68 A
Total Phosphorus Geometric Mean (mg/L)	0.043
Total Nitrogen Geometric Mean (mg/L)	0.86

The habitat assessment scored in the high “Optimal” range, and the Stream Condition Index scored in the “Exceptional” category, indicating an unusually diverse assemblage of sensitive invertebrates, definitively supporting the Class III designated use.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	90.24
% Chlorophycota	0.7
% Cryptophycophyta	0
% Cyanophycota	9.06
Number of Taxa	40

Moderate periphyton growth was observed at the site; however, substrate availability for benthic invertebrates was not problematic, as evidenced by the “exceptional” SCI score. Of the 40 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found, despite the relatively open, sunny conditions characteristic of the site.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) at Withlacoochee River at Stokes Ferry. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota demonstrated to be fully supportive of the designated use (healthy, well balanced populations of aquatic organisms).

Nutrient Benchmark Site Summary
Withlacoochee River at Trails End
STORET Station FL0052000087500

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.34, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture, field/pasture, and residential uses observed beyond the forested buffer zone. There are no point source discharges upstream of the site.

DOQQ 2004 aerial photograph of Withlacoochee River at Trails End (Station FL0052000087500) showing watershed vicinity and land use. The Withlacoochee River originates in the Green Swamp, a very large wetland with considerable areas in public ownership.

DOQQ 2004 aerial photograph of Withlacoochee River at Trails End (Station FL0052000087500) showing close-up of sampling site. An extensive riparian forested wetland buffer is present on both sides of the system.

Photographs of Withlacoochee River at Trails End

<u>Habitat, Biological and Water Quality Data</u>

Parameter	Value
Habitat Assessment	118
Hydrologic Score	2
LDI Score	1.34
SCI Score	NA
Total Phosphorus Geometric Mean (mg/L)	0.059
Total Nitrogen Geometric Mean (mg/L)	1.01

The habitat assessment scored in the high “Suboptimal” range. The SCI was not performed due to the morphology of the system in this area (lake-like), which when coupled with low water levels, resulted in the system having no perceptible water velocity. Typical aquatic plants observed at the site included *Taxodium distichum, Hydrocotyle* sp., *Panicum hemitomon*, *Myriophyllum heterophyllum,* and *Polygonum* sp., indicating healthy conditions.

Qualitative Periphyton Sampling was not performed at this site, however minimal periphyton growth was observed, which would allow for optimal substrate use by benthic invertebrate and fish communities. No problematic filamentous algal growth was found, despite the relatively open, sunny conditions characteristic of the site.

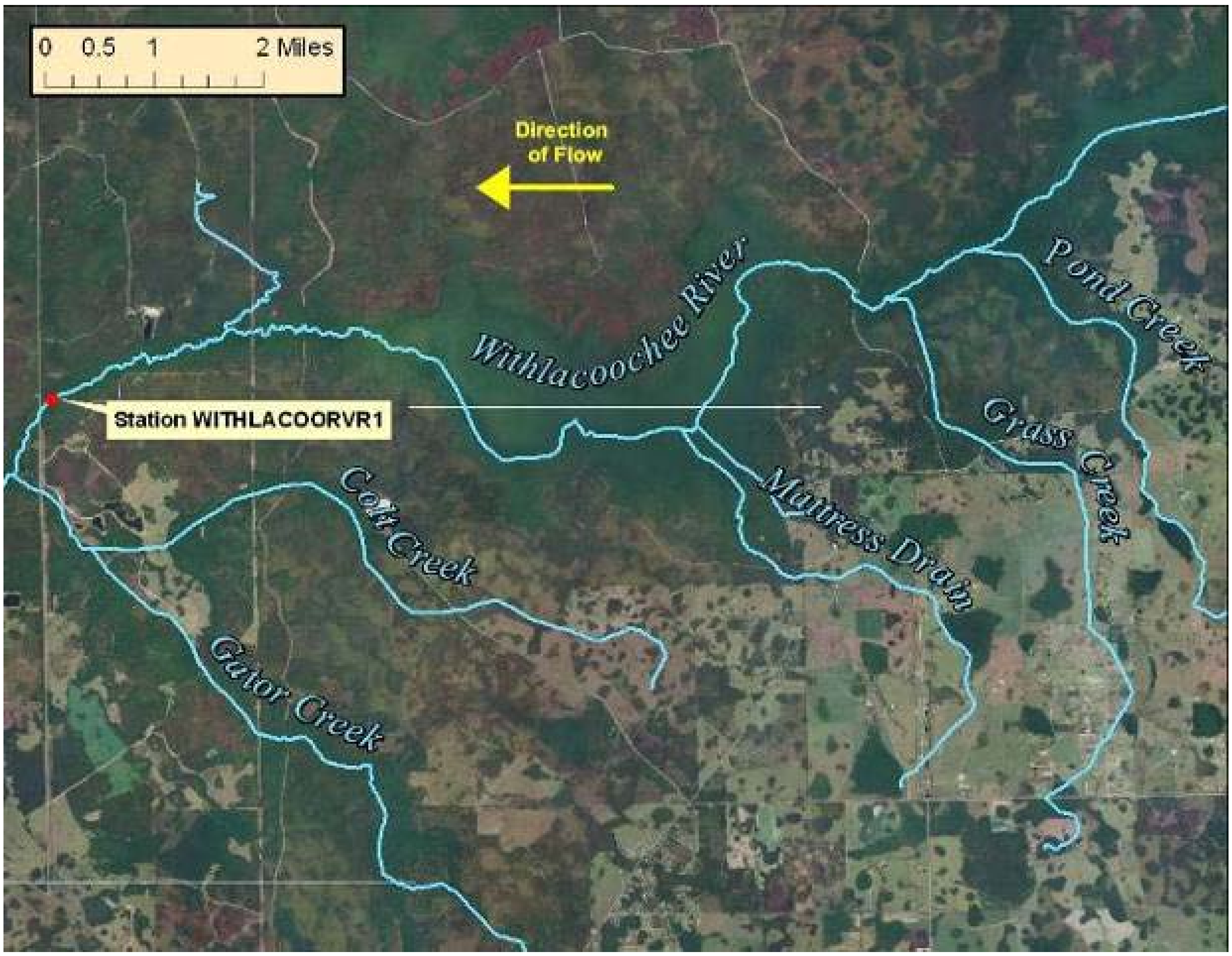
Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology and local land use) at Withlacoochee River at Trails End. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that no adverse algal or aquatic plant issues were present. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota which suggest support of the most sensitive designated use (propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

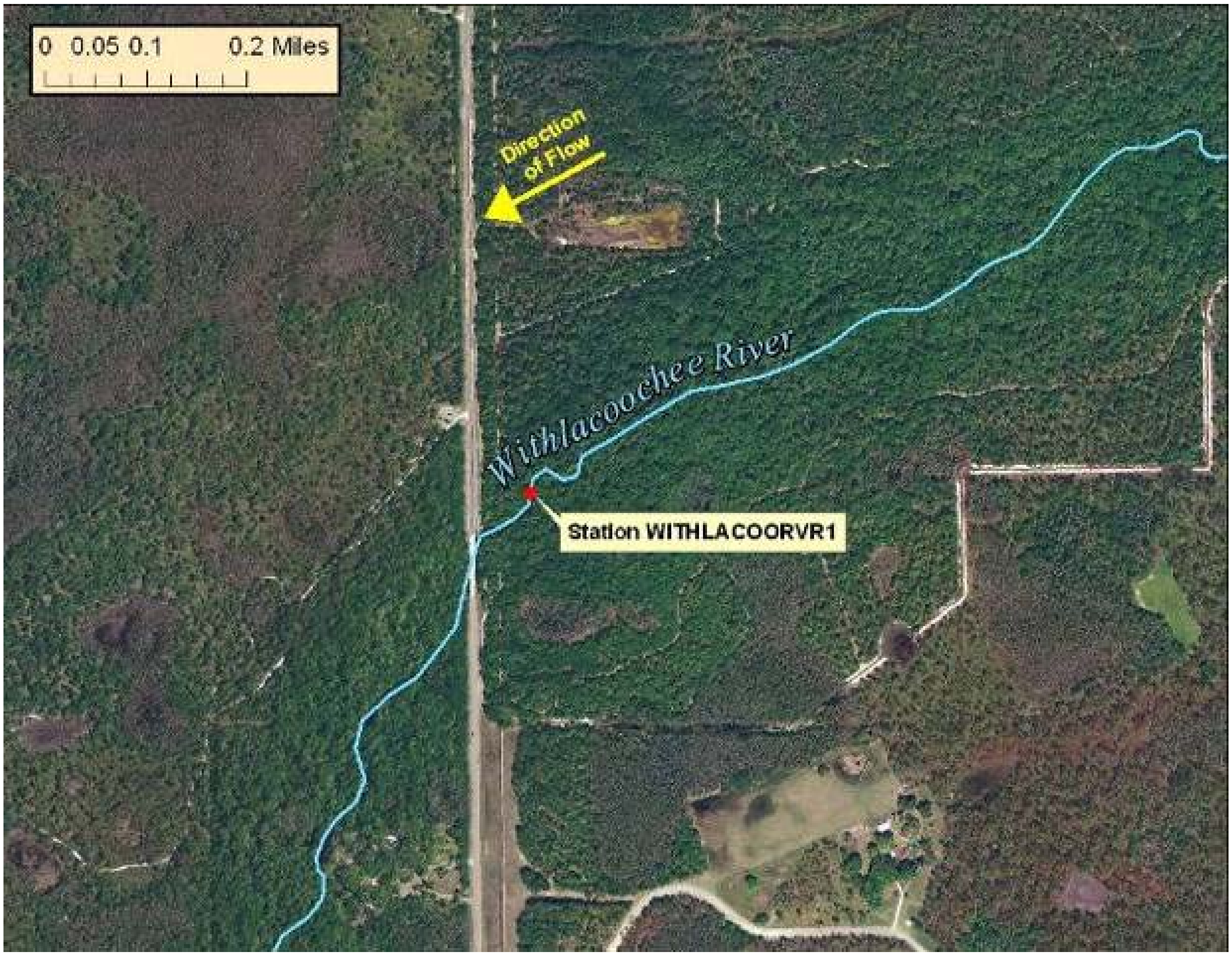
Nutrient Benchmark Site Summary
Withlacoochee River at SR 471
STORET Station WITHLACOORVR1

Land Use

This station was considered to be a candidate reference site based on the Landscape Development Intensity Index score of 1.45, suggesting benign human influences in the watershed. During the site visit, aerial photographs were examined and direct observations confirmed that the majority of the watershed land use was forest/natural, with small areas of silviculture and field/pasture observed beyond an extensive forested riparian buffer zone. There are no point source discharges upstream of the site.



Aerial photograph of Withlacoochee River at SR 471 (Station WITHLACOORVR1) showing watershed vicinity and landuse. The Withlacoochee River originates in the Green Swamp, an extensive wetland with considerable areas in public ownership.



Aerial photograph of Withlacoochee River at SR 471 (Station WITHLACOORVR1) showing close-up of sampling site. An extensive riparian forested wetland buffer is present on both sides of the system.


Photograph of Withlacoochee River at SR 471 (Station WITHLACOORVR1).

Habitat, Biological and Water Quality Data

Parameter	Value
Habitat Assessment	119
Hydrologic Score	2
LDI Score	1.45
SCI Score	46 A
Total Phosphorus Geometric Mean (mg/L)	0.080
Total Nitrogen Geometric Mean (mg/L)	1.68

The habitat assessment scored in the high "suboptimal" range due to no water velocity. The Stream Condition Index was not performed during this site visit due to low water levels and minimal stream velocity. However, sites both upstream (station 33449) and downstream (station 34401) of the sampling location and within the same WBID received "healthy" SCI designations in 2007, (51 A and 40 A, respectively) indicating that the water quality is fully supporting the Class III designated use. These scores were averaged for the above table.

Periphyton Community Composition

Algal Community Stricture	% Composition
% Bacillariophyta	85.95
% Chlorophycota	1.3
% Cryptophycophyta	0
% Cyanophycota	12.1
% Euglenophycota	0.7
Number of Taxa	61

Minimal periphyton growth was observed at the site, which would allow for optimal substrate use by benthic invertebrate and fish communities. Of the 61 algal taxa observed, the majority of the periphyton community was composed of diatoms. No problematic filamentous algal growth was found.

Overall Reference Site Conclusion:

Experienced FDEP scientists conducted a series of observations and measurements (habitat assessment, hydrology, local land use, and algal and macroinvertebrate communities) Withlacoochee River at SR 471. Based on our analyses, the Department concluded that the site was influenced only by very low levels of anthropogenic stressors and that it clearly maintained healthy biological assemblages. Thus, not only are the nutrient concentrations reflective of minimally disturbed conditions, they are associated with biota demonstrated to be fully supportive of the designated use (healthy, well balanced populations of aquatic organisms).