

Physical, Chemical and Biological Assessments of

Selected Lakes in Clay and Putnam Counties

Sampled October 1998

February 2000

Environmental Assessment Section

Division of Resource Assessment and Management

Comprehensive Quality Assurance Plan No's:

Laboratories- 870346G & 870688G

Field- 980028

Executive Summary

FDEP's Bureau of Laboratories was requested to assess the condition of five lakes and one impoundment in Clay and Putnam counties by conducting habitat, water quality and biological monitoring of the waterbodies. A study of the waterbodies was conducted in October 1998, forming the basis for this report.

Moderate nutrient enrichment in the form of nitrate-nitrite was observed at Rodman Reservoir in concentrations above those observed in 70% of other Florida lakes. All other nutrient concentrations at Rodman Reservoir were below the 50th percentile concentrations for other lakes. Moreover, the concentrations of most nutrients in the other lakes from this study were below the lower 5th percentile concentrations for other Florida Lakes. Water column TOC concentrations for Rodman Reservoir (16-19 mg/L) were elevated and sediment organic matter percentages were high (48.1 to 53.75%).

Exceedance of the State of Florida Class III surface water quality criterion for D.O. (5.0 mg/L) occurred at the Rodman Reservoir West site (3.8 mg/L). D.O. concentrations for all other sites from this study were good, ranging from 6.5 to 8.1 mg/L.

Water column TOC concentrations for Rodman Reservoir (16-19 mg/L) were elevated and sediment organic matter percentages were high (48.1 to 53.75%). TOC and sediment organic content were low for all other sites from this study.

Habitat assessment scores were in the "suboptimal" range for all sites except Cowpen Lake, which was in the "optimal" range. Contributors to lowered habitat quality ("suboptimal" ratings) at the other sites included a "poor" score at Rodman Reservoir and a "marginal" score at Kingsley Lake for bottom substrate diversity, "marginal" scores for submerged and floating vegetation quality at Rodman Reservoir and Lake Johnson, and a "marginal" score for Secchi depth at Rodman Reservoir.

Based on the results of this assessment, Rodman Reservoir should be considered for placement on the 303(d) and particularly should be reassessed once algal or macrophyte biological indices are available to determine if it should be added to the 303(d) list. All other lake sites monitored for this report showed overall good water quality.

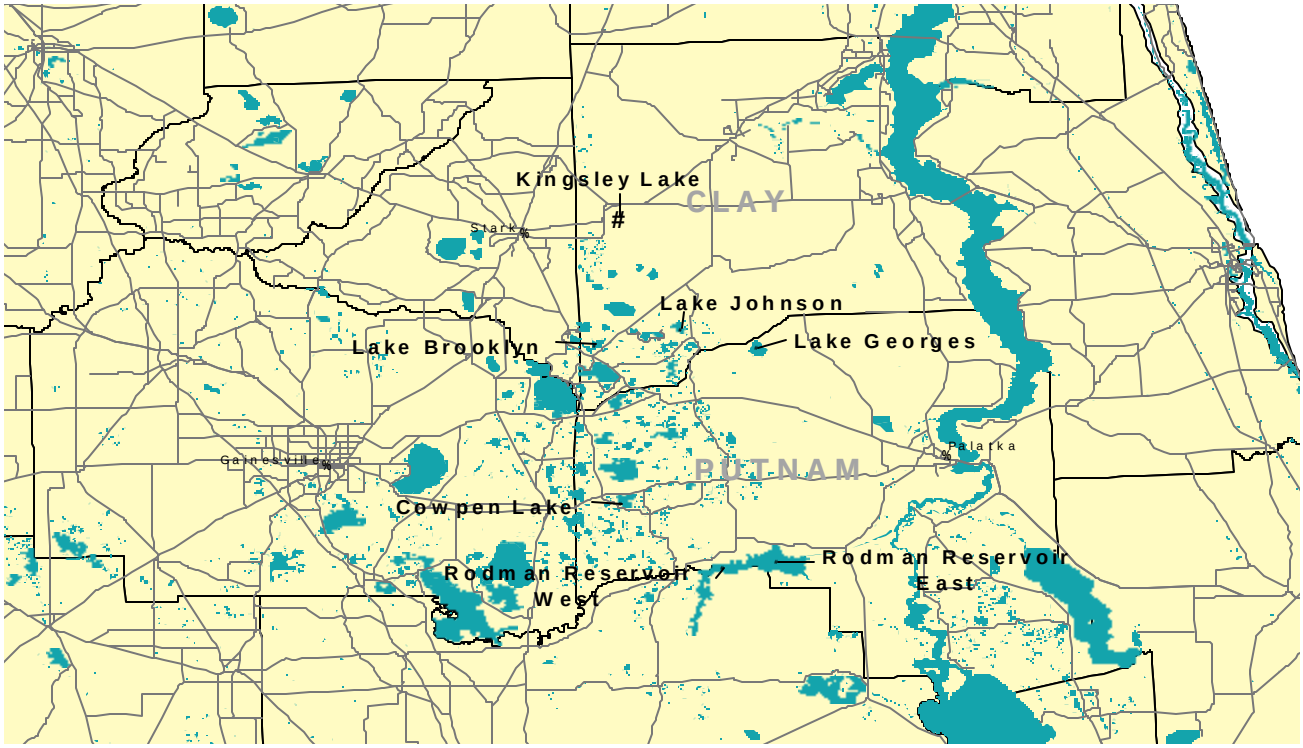


Figure 1: Overview Map

Introduction

For the past several years, FDEP staff have been sampling lakes throughout the state for the purpose of collecting data to be used in the development of indices of lake biological condition. Such indices, once developed, should be very good assessment tools when used in conjunction with assessment of the physical and chemical data. During the process of sampling lakes throughout the state, FDEP's Environmental Assessment Section (EAS) was requested to assess the condition of five lakes and one impoundment in Clay and Putnam counties. Data from earlier sampling of two of the five lakes had been used as reference data for development of macroinvertebrate indices of lake condition. The remaining three lakes also were thought to represent reference conditions, and sampling was requested to investigate their condition. EAS staff also were requested to assess the condition of an impoundment in that same area. The designated use of each of the five lakes and the impoundment is for recreation and the maintenance of a healthy, well-balanced aquatic community.

The five lakes for this study (Lakes Brooklyn, Georges and Johnson, and Cowpen and Kingsley Lakes) lie within the Trail Ridge lake region of Clay or Putnam counties. This region is described as having lakes that are mostly small, acid, clear and oligotrophic (Griffin et al., 1997). According to Griffin et al. (1997), "Atmospheric deposition may be contributing to the some acidification of lakes in this region". Kingsley Lake is one of the largest lakes in this region and is one of the deeper lakes in the state. It is described as having a higher pH and alkalinity and a different cation/anion mix than most other lakes in the region as a result of groundwater inputs to the lake (Griffin et al., 1997). The impoundment included in this study, Rodman Reservoir, lies within the Central Valley area of Putnam County. Figure 1 shows the location of the six water bodies.

Methods

The focus of this investigation was to determine if human activities were affecting the water quality or health of receiving water biota in Lakes Brooklyn, Georges and Johnson, Kingsley (2 sites) and Cowpen Lakes and Rodman Reservoir (2 sites). Sampling of these water bodies was conducted on October 26 and 27, 1998.

A habitat assessment (FDEP, 1997a, Biology Section Standard Operating Procedure, BA-18) and physical/chemical characterization (FDEP 1997b, Biology Section Standard Operating Procedure, BA-17) were conducted at each site. Field measurements were conducted by FDEP Central Laboratory staff at each site for surface water dissolved oxygen (D.O.), pH and conductivity, with bottom, mid and surface depth horizons being measured for most sites. Water quality data in this report are from the mid-depth horizon, unless otherwise indicated. Surface water samples were collected from the center of each site and analyzed in the FDEP Central Laboratory for nitrite-nitrate, total Kjeldahl nitrogen (TKN), total ammonia, total phosphorus (TP), total organic carbon (TOC), turbidity, total suspended solids (TSS), chlorophyll a, biochemical oxygen demand (BOD), algal growth potential (AGP), and color. Measurements also were conducted on each sample for fecal and total coliforms. Sediment collection and analysis were conducted to characterize sediment grain size and percent organic content.

Each of the eight sites also was sampled to determine the biological health of the systems. Benthic macroinvertebrate samples were collected at each site using a Petite PONAR sampler. For these samples, the 2-4m sublittoral zone of each site basin was divided into 12 equal segments, a grab was collected in each segment with the Petite PONAR sampler and combined into a single composite sample for each site, as described in FDEP, 1996. Each composite sample was randomly subsampled in the laboratory to a count of at least 100 organisms, which were identified to the lowest practical taxonomic level using a dissecting microscope.

Additionally phytoplankton grab samples were collected at each site using a water bottle (FDEP, 1993, Biology Section Standard Operating Procedure, BA-4), with sample handling and taxonomic analysis being conducted per FDEP, 1997c, and FDEP 1997d, respectively.

Explanation of Measurements of Community Health

Selected measurements of community health were applied to assess each lake site. These measurements are briefly described here:

Habitat Assessment: Five attributes known to have potential effects on the lake biota were evaluated and scored at the site, with 20 points possible for each factor. The five attributes are: Submerged and Floating Vegetation Quality; Bottom Substrate Diversity; Riparian Zone Alterations; and Visible Upland Land Use. Overall habitat quality is assigned to one of four categories based on the sum of individual scores for those five attributes: Optimal (76-100 Points); Suboptimal (51-75 points), Marginal (26-50 points); and Poor (0-25 points).

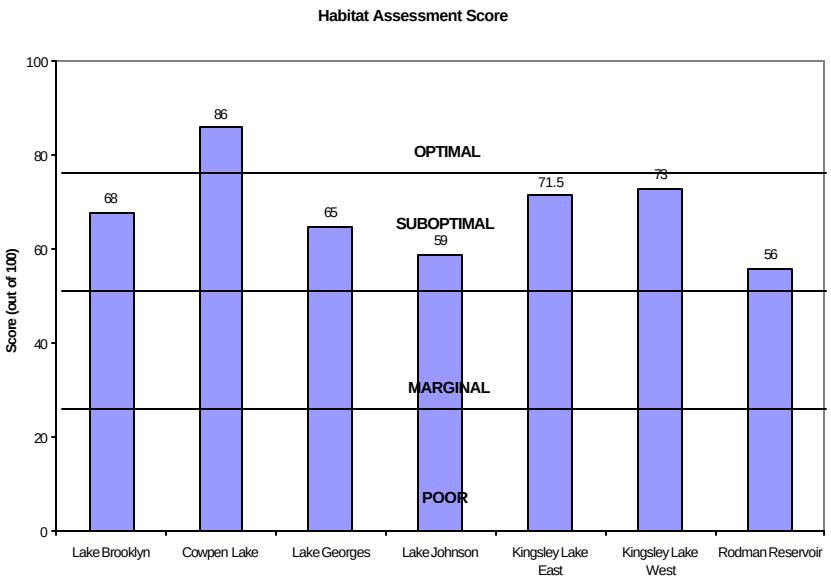


Figure 2: Habitat Assessment Score

Taxa Richness: This measurement is based on the total number of macroinvertebrate taxa or phytoplankton taxa found at a site. Stress tends to reduce the number of different types of macroinvertebrate organisms present in a system. However, moderate nutrient enrichment may sometimes be correlated with increased algal taxa richness, thus rendering phytoplankton taxa richness questionable as a measure of waterbody disturbance.

Numbers of pollution sensitive taxa: Some organisms become rare or absent as the intensity or duration of disturbance increases. The Hulbert Index assigns points to lake-dwelling macroinvertebrate taxa (0, 1 or 2) based on their sensitivity to pollution (Hulbert, 1990). A high score for the Hulbert Index typically is considered an indicator of good health for a waterbody.

Community structure: A system generally is considered degraded if a substantial shift in the proportions of the major taxonomic groups is observed. For macroinvertebrates, increases in the percentage of dipteran organisms in a sample are indicative of poorer health of the system.

Ephemeroptera/Trichoptera/ Odonata (ETO) Index: This index is expressed in two ways: as the sum of the number of ETO taxa present; and as the percentage of ETO organisms in the sample. This index is analogous to the Ephemeroptera/Plecoptera/Trichoptera Index used in stream systems. Higher numbers of ETO taxa and higher percentages of ETO organisms typically are associated with healthier systems.

Shannon-Weaver Diversity Index: This index is specified in the Florida Administrative Code as a measure of biological integrity. Low diversity values are undesirable, in that they represent conditions where only a few organisms are abundant, to the exclusion of other taxa. Such values may be associated with organic/nutrient enrichment and decreased dissolved oxygen. In this study, the Shannon-Weaver Diversity Index was calculated for both benthic macroinvertebrate samples and for phytoplankton samples. Again, however, since this index is a measure of diversity, it may be of limited utility for the assessment of phytoplankton data as algal diversity may increase with moderate nutrient enrichment.

Algal Biomass: The density of algal cells and the chlorophyll *a* concentration of phytoplankton typically are used as estimators of biomass. A lake traditionally has been considered stressed when biomass exceeds problem threshold levels (e.g., approximately 20 mg/L of chlorophyll *a*), although far smaller increases in chlorophyll *a* may be among the first signs of trouble in a system. In this study, algal biomass estimates were based on the chlorophyll *a* concentration of phytoplankton as well as on phytoplankton densities (number of individuals/mL).

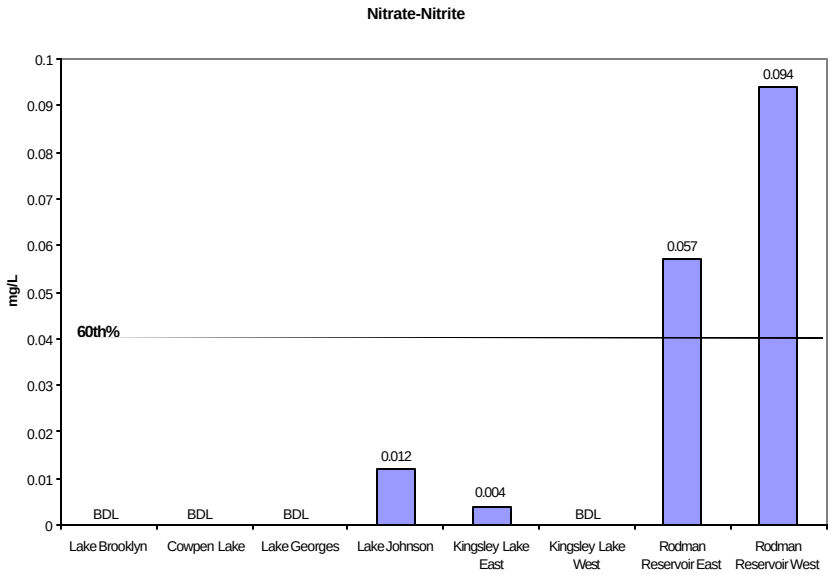


Figure 3: Nitrate-Nitrite

Descriptions of Study Sites

Lake Brooklyn covers an area of approximately 650 acres in southwestern Clay County. Lake Brooklyn and several other lakes of it's size and larger are contained in the Lake Brooklyn Outlet basin. According to 1988 land use information for the St. John's River Water Management District (SJRWMD), land use in that basin is a mixture of residential and upland forest with smaller agricultural and open urban areas, and with approximately 1/3 of the basin (northeast) being institutional use. SJRWMD land use information depicts the area directly surrounding Lake Brooklyn as predominantly residential, with some upland forest at the north perimeter and a small commercial area abutting the southwest edge of the lake.

Cowpen Lake covers an area of approximately 500 acres within southwestern Putnam County. SJRWMD 1988 land use information for the Lake Cowpen Outlet basin shows water bodies accounting for approximately 25% of the basin, with 30-40% residential areas, approximately 20% upland forest, 10% urban forest and a small amount of agricultural land use. 1988 land use directly surrounding the lake is described as predominantly residential.

Lake Georges covers an area of approximately 800 acres in north central Putnam County. SJRWMD 1988 land use information indicated that the basin containing Lake Georges was predominantly upland forest (~70%), with the lake accounting for ~20% of the basin, and residential areas covering some 10% of the basin with smaller areas of open urban, rangeland and agricultural use. Immediately surrounding the lake, land use was mostly residential (~75%) with some upland forest and open urban areas.

Lake Johnson covers an area of approximately 330 acres in southwestern Clay County. The basin in which it resides is described in 1988 SJRWMD land use information as being predominantly upland forest (~65%) with some agricultural (~15%), residential (~10%) and upland forest (~10%) areas. Immediately surrounding Lake Johnson, land use was depicted as upland forest with ~20-25% residential areas and a small area of agriculture.

Kingsley Lake covers an area of approximately 1,400 acres in western Clay County. Lakes greater than 1,000 acres are divided for study purposes into two or more basins (FDEP, 1996). Thus, for sampling purposes, Kingsley Lake was divided into two sites (Kingsley Lake East and Kingsley Lake West). According to SJRWMD 1998 land use maps, land use in the basin is mainly institutional (~85% Army facility), including most of the eastern half of the lake. The western perimeter of the lake is depicted as being a residential area, with a recreational area along the northnortheast margin of the lake and a small amount of upland forest in the basin, as well.

Rodman Reservoir covers an area of approximately 6,200 acres spanning Putnam and Marion Counties. Because of it's size, the artificial impoundment of Rodman Reservoir was divided into two sites for sampling (East and West), both of which are located in Putnam County. According to SJRWMD 1988 land use information, the primary land use in the basin which includes Rodman Reservoir is upland forest, with wetlands and institutional use areas each comprising another <20% of the area, with <10% residential and <5% commercial areas. Immediately surrounding the reservoir, land use is depicted as wetland and upland forest ar-

Table 1: Macroinvertebrate Parameters of the Bio-Recon

Site	Lake Brooklyn	Cowpen Lake	Lake Georges	Lake Johnson	Kingsley Lake East	Kingsley Lake West	Rodman Reservoir East
Storet Number	NONSTORET294	NONSTORET290	20030417	20030438	NONSTORET021	20030278	NONSTORET295
Sampling Date	10/27/98	10/26/98	10/27/98	10/27/98	10/27/98	10/26/98	10/26/98
MACROINVERTEBRATE DATA:							
# Total Taxa	33	26	25	23	25	22	11
Hulbert Index	15	13	18	5	10	14	1
%Diptera	75.8	85.6	27.2	27.5	53.9	63.2	86.4
#ETO Taxa	4	4	4	3	2	1	0
%ETO	4.7	4.8	32.6	5.9	11.5	2.2	0.0
Shannon-Weaver Index	4.4	3.3	3.9	3.6	3.8	3.6	2.0
WATER QUALITY DATA:							
DO (mg/L)	7.8	8.1	8.12	6.5	7.2	7.3	6.9
pH (SU)	5.3 [a]	4.5 [a]	4.3	4.1	6.6	6.3	7.5
Cond (umhos/cm ^{2})	15	58	26	17	49	50	440
Color (PCU)	30 A	5 Q	30	40	10 Q	10 Q	150 Q
BOD5 (mg/L)	1.4	0.4 IQ	0.8 I	0.4 I	1.1 Q	0.8 IQ	1.4 Q
Turbidity (NTU)	7.6	2.5 Q	5.7 Q	4.5	2.3 Q	3.8 Q	2.6 Q
TSS (mg/L)	4 U	4 U	4 U	4 U	4 U	4 U	4 U
NO_2NO_3(mg/L)	0.004 U	0.004 U	0.004 U	0.012	0.004 I	0.004 U	0.057
Ammonia (mg/L)	0.01 U	0.01 U	0.01 U	0.014 I	0.01 U	0.01 U	0.028
TKN	0.28	0.13 I	0.16 I	0.18 I	0.26	0.27	0.78
TP (mg/L)	0.015 U	0.041	0.04 U	0.015 U	0.016 I	0.015 U	0.065
TOC (mg/L)	3.1 I	1.9 I	2.3 I	2.1 I	4.9 I	4.8 I	19
Fecal Coliforms (#/100 mL)	1 KQ	1 KQ	1 KQ	1 KQ	1 KQ	1 KQ	1 KQ
Total Coliforms (#/100 mL)	1 KQ	1 KQ	10 Q	1 KQ	1 KQ	1 KQ	10 Q
AGP (mg dry wt/L)	0.052 U	0.05 U	0.449 Q	0.248 IQ	0.105 I	0.114 I	0.134 I

A Indicates value reported is the mean of two or more determinations.
I Indicates value reported is between the method detection limit (MDL) and the practical quantitation limit (PQL).
K Indicates the actual value is known to be less than the value reported (actual value is off-scale low).
ND No data.
Q Indicates the sample was analyzed outside the holding time.
U Indicates parameter was not detected at or above this method detection limit.

eas with small areas of residential use along the south perimeter.

Results and Discussion

Summary of Results by Site

Lake Brooklyn: The habitat assessment for Lake Brooklyn indicated overall "suboptimal" quality (68 points out of 100), with "suboptimal" scores for bottom substrate diversity, riparian zone alterations and visible upland land use. Littoral zone emergent vegetation was dominated by macrophytes. No local watershed erosion was noted at the time of sampling, but the potential for local watershed non point source (NPS) pollution was noted to be moderate. At the time of sampling, the lake was observed to be very clear and uncolored.

D.O. in Lake Brooklyn was good at 7.8 mg/L, and BOD was low (1.4 mg/L). In keeping with the description of lakes typical to this region, the lake was acidic (pH of 5.1 SU) with low conductivity (15 mmhos/cm^2) and relatively low color (30 PCU). Nutrient concentrations were very low, with undetected nitrate-nitrite, total ammonia and TP, and a TKN concentration (0.28 mg/L) that places it in the lower 5% of all other lakes in Florida (Table 1; refer to Appendix B, *Typical Values for Selected Parameters in Florida Waters*). Chlorophyll *a* and AGP also were undetected. TSS was below the limit of detection (<4 mg/L), however, turbidity was relatively high at 7.6 NTU. TOC was low at 3.1 mg/L. Both fecal and total coliform counts were low, at 1 colony/100 mL for both. It should be noted that the 6-hour holding time for bacteriological analyses were exceeded for samples from all eight sites in this study.

Sediment particle size in Lake Brooklyn was a mix of sand to gravel (65%) and very fine sand (32%), with the silt/clay fraction making up only 2%. Organic content of the sediment was very low (0.2%).

Macroinvertebrate taxa richness (# of taxa) was 33 for Lake Brooklyn, the Hulbert Index value for the lake was 15 and the macroinvertebrate Shannon-Weaver diversity Index was 4.4. The percent contribution of dipteran organisms was high, at 76% of the total number of organisms counted. The number

of ETO taxa was 4, with numbers of ETO organisms accounting for 4.7% of the sample. These metric values compare favorably to reference conditions for lakes in this ecoregion with similar pH and color characteristics, suggesting good community health. However, recent information based on the development of a Florida Lake Condition Index indicates that macroinvertebrates are not useful indicators of biological condition in peninsular Florida lakes. More information on this finding in relation to the macroinvertebrate parameter values for the six waterbodies assessed in this report is provided at the end of this section.

Phytoplankton taxa richness (# of taxa) was 15 for Lake Brooklyn, with phytoplankton density (1,877 organisms/mL). While this is the highest phytoplankton density value for any of the sites from this study, this value is low, indicating that algae were sparse. Chlorophyll *a* was undetectable (<1 mg/L) in this sample, corroborating the assessment of a very low overall algal biomass in the lake. Of those phytoplankton that were present, the % contribution of the dominant phytoplankton taxon high (73.4%). Green algae dominated the sample (88.5%), with only a 5% contribution by diatoms and 0% contribution by blue-greens. Phytoplankton Shannon-Weaver Diversity was 1.7 for the site sample. Currently, there are no lake phytoplankton reference values for comparison with these measurements, but an algal sensitivity index is under development.

Cowpen Lake: The Cowpen Lake habitat assessment indicated overall "optimal" quality (86 points out of 100), with the lowest scores being in the upper "suboptimal" range for riparian zone alterations and visible upland land use. At the sampling site, littoral zone emergent vegetation was dominated by shrubs. Slight local watershed erosion was noted at the time of sampling, and local watershed NPS pollution was noted to be slight. Cowpen Lake was observed to be very clear and uncolored.

Cowpen Lake exhibited good D.O. (8.1 mg/L), and BOD was very low (0.4 mg/L). Cowpen Lake was acidic (pH of 4.5 SU) with low conductivity (58 mmhos/cm^2) and low color (5 PCU). Nutrient concentrations were very low, with undetected nitrate-nitrite and total ammonia, with TP (0.041 mg/L) and TKN concentrations (0.13 mg/L) below the lower 5th percentile concentrations for those nutrients for other lakes in Florida (Table 1). Chlorophyll *a* and AGP also were undetected. TSS was below the limit of detection (<4 mg/L), and turbidity was low at 2.5 NTU. TOC also was low at 1.9 mg/L. Both fecal and total coliform counts were very low, at 1 colony/100 mL for both.

Sediment particle size in Cowpen Lake was predominantly sand to gravel (69%) with a very fine sand fraction of 17% and a silt/clay fraction of 14%. Organic content of the sediment was low (2.85%).

Macroinvertebrate taxa richness (# of taxa) was 26 for Cowpen Lake, and the Hulbert Index value for the lake was 13. The contribution of dipteran organisms to the sample was high (86%). Macroinvertebrate Shannon-Weaver Diversity for Cowpen Lake was 3.3. The number of ETO taxa was 4, with numbers of ETO organisms accounting for 4.8% of the sample.

The Cowpen Lake phytoplankton sample exhibited a taxa richness of 8, a density of 63 organisms/mL and an undetectable chlorophyll *a* content, indicating very low algal biomass in the lake. For those phytoplankton that were present, the contribution of the dominant taxa was 47.6%, with contributions of 28.6% from green algae, 4.8% from

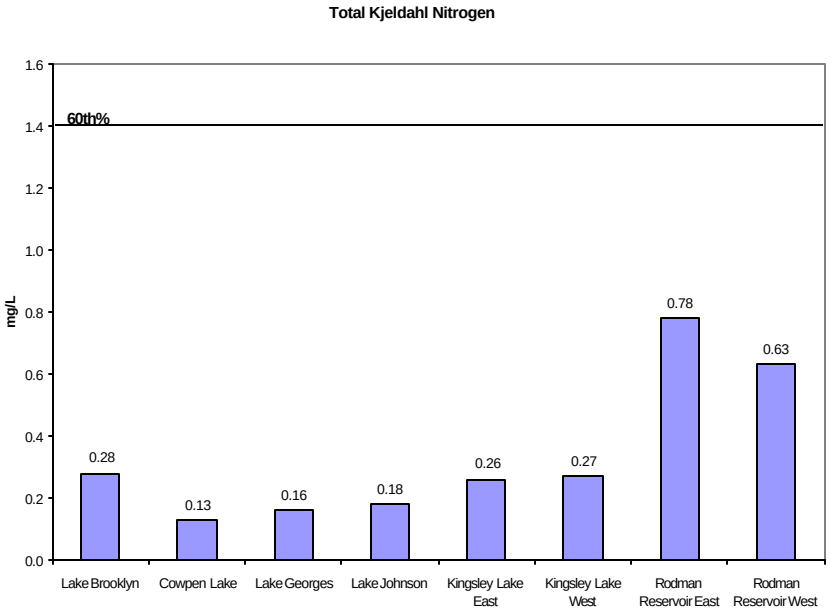


Figure 4: Total Kjeldahl Nitrogen

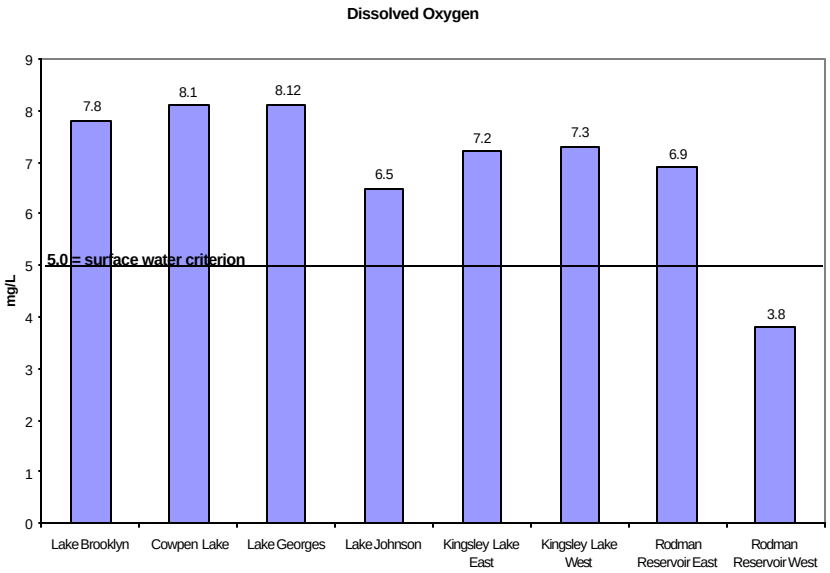


Figure 5: Dissolved Oxygen

diatoms and 4.8% from blue-green phytoplankton. The phytoplankton Shannon-Weaver Diversity Index for the Cowpen Lake sample was 2.3.

Lake Georges: The habitat assessment for Lake Georges indicated overall "suboptimal" quality (65 points), based primarily on "marginal" bottom substrate diversity and "suboptimal" Secchi depth. Littoral zone emergent vegetation at the sampling site was dominated by macrophytes. Additionally, Lake Georges was noted as having clear water that was somewhat tannin stained.

Dissolved oxygen at Lake Georges was good (8.1 mg/L), and BOD was very low (0.8 mg/L). The lake was acidic (pH of 4.3 SU) with low conductivity (26 mmhos/cm^2) and relatively low color (30 PCU). Nutrient concentrations in Lake Georges were very low, with undetected nitrate-nitrite, total ammonia and TP, and a TKN concentration (0.16 mg/L) below the lower 5th percentile concentration for TKN in other lakes in Florida. Chlorophyll *a* was undetected and AGP was low at 0.449 mg dry wt/L. It should be noted that, based on sample preparation problems with an initial analysis, the reported AGP result for Lake Georges is from a re-analysis conducted approximately 3 weeks beyond the acceptable 14-day holding time. TSS was below the limit of detection (<4 mg/L), while turbidity was 5.7 NTU. TOC also was low at 2.3 mg/L. Both fecal (1 colony/100 mL) and total coliform counts (10 colonies/100 mL) were very low.

Sediment particle size in Lake Georges was a mix of sand to gravel (56%) and very fine sand (38%), with a silt/clay fraction of 9%. Organic content of the sediment was low (4.66%).

The Lake Georges macroinvertebrate sample yielded a taxa count of 25 and a Hulbert Index value of 18. The contribution of dipteran organisms to the sample was low (27%). Macroinvertebrate Shannon-Weaver Diversity for Lake Georges was 3.9. The Lake Georges sample contained 4 ETO taxa, with numbers of ETO organisms accounting for 32.6% of the sample.

The number of phytoplankton taxa from the Lake Georges sample was 9, algal density was 168 organisms/mL and chlorophyll *a* was undetected, indicating very low algal biomass in the lake. The dominant taxa of those phytoplankton present accounted for 36.7% of the number of organisms in the samples. Diatoms comprised 50% of the organisms in the sample, with 43.3% green algae and 1.7% blue-green phytoplankton. The phytoplankton Shannon-Weaver Diversity Index for Lake Georges was 2.3.

Lake Johnson: Lake Johnson habitat quality was rated overall as "suboptimal", based on a "marginal" score for the quality of observed submerged and floating vegetation, and "suboptimal" scores for riparian zone alterations, Secchi depth and bottom substrate diversity. Observed littoral zone emergent vegetation was dominated by macrophytes. Lake Johnson was noted as having clear water that was somewhat tannin stained.

D.O. in Lake Johnson (6.5 mg/L) was above the State of Florida Class III criterion, and BOD was very low (0.4 mg/L). Lake Johnson was acidic (pH of 4.1 SU) with low conductivity (17 mmhos/cm^2) and color of 40 PCU. Nutrient concentrations in Lake Georges were low, with concentrations of TKN (0.18 mg/L) and TP (undetected) below the lower 5th percentile concentration for those parameters in other lakes in Florida, a nitrate-nitrite concentration (0.012 mg/L) less than the concentrations in 50% of other Florida lakes, and total ammonia (0.014 mg/L) less than the concentrations found in the lowest 10% of

other Florida lakes. Chlorophyll *a* was undetected and AGP was very low at 0.25 mg/L. It should be noted that, based on sample preparation problems with an initial analysis, the reported AGP result for Lake Johnson is from a re-analysis conducted approximately 3 weeks beyond the acceptable 14-day holding time. TSS was below the limit of detection (<4 mg/L), while turbidity was 4.5 NTU. TOC also was low at 2.1 mg/L. Both fecal and total coliform counts in Lake Johnson were very low (1 colony/100 mL).

Sediment particle size in Lake Johnson was a mix of sand to gravel (76%) and very fine sand (23%), with a low silt/clay fraction of 1%. Organic content of the sediment was low at 1.48%.

Lake Johnson exhibited a macroinvertebrate taxa richness of 23 and a Hulbert Index value of 5. The contribution of dipteran organisms to the sample was low (27%), and the macroinvertebrate Shannon-Weaver Diversity for Lake Johnson was 3.6. The Lake Johnson sample contained 3 ETO taxa, with numbers of ETO organisms accounting for only 5.9% of the sample.

There were 5 phytoplankton taxa in the Lake Johnson sample, with an algal density of 87 organisms/mL and chlorophyll *a* content that was undetected (<1 mg/L), once again indicating low algal biomass for lakes from this study Of those organisms present, the diatom *Asterionella* was dominant, accounting for 77.8% of the sample and all of the diatoms in the sample. No green or blue-green phytoplankton were encountered in the sample. Phytoplankton Shannon-Weaver Diversity for the Lake Johnson sample was low, at 1.2.

Kingsley Lake: The habitat quality of Kingsley Lake was rated in the high "suboptimal" category for both east (71.5 points) and west (73 points) sampling sites, primarily as a result of receiving top scores (20 points) for Secchi depth at both sites. Bottom substrate diversity received a "marginal" score, at both sites. With the exception of visible upland land use for the west site ("optimal"), the remaining habitat parameters for both sites were in the "suboptimal" range. Kingsley Lake littoral zone vegetation at both east and west sites was dominated by macrophytes. No local watershed erosion was noted at the time of sampling, but the local watershed NPS pollution was noted to be slight for Lake Kingsley East and of moderate potential for Lake Kingsley West. Kingsley Lake East was observed to be very clear and uncolored, while Kingsley Lake West was noted to be clear with the presence of green algae.

Kingsley Lake exhibited good D.O. concentrations at both east and west sites (7.2 mg/L and 7.3 mg/L, respectively), and BOD was very low at both sites (1.1 mg/L and 0.8 mg/L, respectively). The lake was less acidic than others in this region, with pH ranging from 6.3 to 6.6 SU between the sites. Conductivity was low (49 to 50 mmhos/cm^2) as was color (10 PCU at both sites). Kingsley Lake was oligotrophic, with nitrate-nitrite and ammonia being undetected at both sites, TP being undetected at the west site, and TP at the east site (0.016 mg/L) and TKN at both sites (0.26 to 0.27 mg/L) being lower than the concentrations found in the lowest 5% of other Florida lakes. Consistent with the other lakes in this study, chlorophyll *a* was undetected. AGP was very low at 0.11 mg/L for both sites. TSS at both sites was below the limit of detection (<4 mg/L), while turbidity ranged from 2.3 NTU (east site) to 3.8 NTU (west site). TOC also was ranged from 4.8 to 4.9 mg/L between the sites. Both fecal and total coliform counts in Kingsley Lake were very low (1 colony/100 mL for both parameters at both sites).

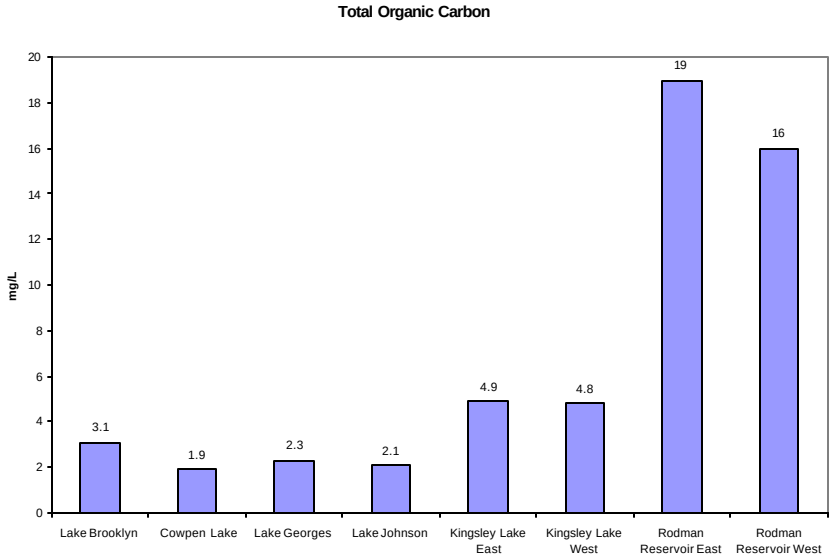


Figure 6: Total Organic Carbon

Sediment particle size in Kingsley Lake (east site sample only) was a mix of sand to gravel (69%) and very fine sand (31%), with a low silt/clay fraction of 1%. Organic content of the sediment was low at 0.36%.

Macroinvertebrate taxa richness values for Kingsley Lake East and West were 25 taxa and 22 taxa, respectively. The Hulbert Index values for the two sites (east and west) were 10 and 14, respectively. Dipteran organisms contributed 54% and 63% of the total number of organisms present at the east and west sites, respectively. Macroinvertebrate Shannon-Weaver Diversity for Kingsley Lake East was 3.8 and West was 3.6. The Kingsley Lake samples contained few ETO taxa (2 and 1 taxa, respectively for east and west sites) with percentages of ETO organisms in the samples of 11.5% and 2.2% for the east and west sites, respectively.

Kingsley Lake East and West exhibited similar phytoplankton populations in most of the observed metrics. The numbers of taxa were 17 and 22 for the east and west sites, respectively, with algal densities of 590 and 716 organisms/mL, respectively. Chlorophyll *a* content of the phytoplankton samples once again was undetectable (<1 mg/L). The percent contribution of the dominant taxon (*Cosmarium* for both sites) ranged from 51.8 to 54.9%. Diatoms contributed between 6.2% and 8.8% of the two samples, and green algae contributed 67.2% to 68.9%. The one notable difference between the two site samples was a 0% contribution of blue-green phytoplankton at Kingsley Lake East compared with a 20.2% contribution at Kingsley Lake West. Phytoplankton Shannon-Weaver Diversity range from 2.5 to 2.7 for the two sites.

Rodman Reservoir: The habitat assessment for Rodman Reservoir (east site only) indicated overall "suboptimal" quality (56 points, lower end of the range), resulting from a "poor" score on bottom substrate diversity and "marginal" scores on submerged and floating vegetation and Secchi depth. Rodman Reservoir littoral zone emergent vegetation was dominated by trees. Water was observed to be clear and tannic at both sites.

Rodman Reservoir exhibited a good D.O. concentration at the east site (6.9 mg/L). However, D.O. at the west site (3.9 mg/L) exceeded the State of Florida Class III criterion of 5.0 mg/L. BOD at both sites was low (1.2 to 1.4 mg/L). Conductivity ranged from 415 to 440 mmhos/cm^2 between the two sites, pH ranged from 7.1 to 7.5 SU and color was high at 150 PCU for both sites. Nitrate-nitrite concentrations in Rodman Reservoir exceeded the concentrations found in 70% of other lakes in Florida, with east and west site concentrations of 0.057 mg/L and 0.094 mg/L, respectively. Total ammonia concentrations between the two sites (0.028 to 0.031 mg/L) were comparable with concentrations found in the lower 30th percentile of other lakes, while TKN concentrations (0.78 mg/L east and 0.63 mg/L west) were lower than concentrations found in 30% and 20%, respectively, of other Florida lakes. TP concentrations at the two sites (0.063 to 0.065 mg/L) were between the 40th and 50th percentile concentrations for other Florida lakes. As for all other lakes in this study, chlorophyll *a* was undetected. AGP was very low (0.13 mg/L for the east site and undetected at the west site). TSS at both sites was below the limit of detection (<4 mg/L), while turbidity ranged from 2.6 to 3.0 NTU. While being lower than the State of Florida Class III criterion, TOC at Rodman Reservoir was elevated, ranging from 16 to 19 mg/L between the sites. Fecal coliform counts ranged from 1 to 54 colonies/100 mL at the two sites, while total coliform counts ranged from 10 to 120 colonies/100 mL, both parameters

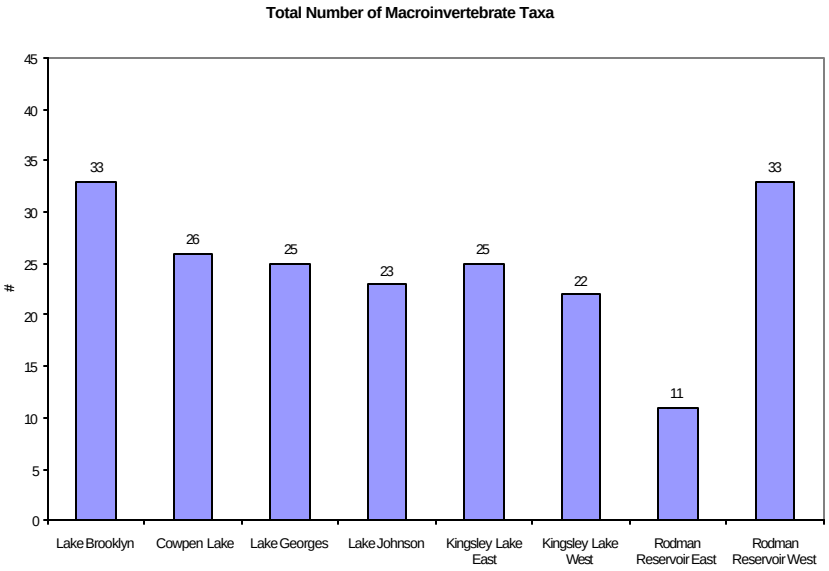


Figure 7: Total Number of Macroinvertebrate Taxa

being much lower than the State of Florida Class III criteria for coliforms.

Sediment particle size at Rodman Reservoir East was approximately an equal mix of sand to gravel (32%), very fine sand (31%), and silt/clay (36%). Organic content of the sediment was high at 53.75%. At Rodman Reservoir West, contributions were 24% sand to gravel, 31% very fine sand and 45% silt/clay fraction, with an organic content of 48.1%.

Macroinvertebrate metric values for Rodman Reservoir East and West differed between the two sites, with Rodman Reservoir East consistently exhibiting lower metrics values. Taxa richness values for Rodman Reservoir East and West were 11 taxa and 33 taxa, respectively. The Hulbert Index values for the two sites were a low 1 for the east site and 7 for the west site. Dipteran organisms contributed 86% and 36% of the total number of organisms present at the east and west sites, respectively. Macroinvertebrate Shannon-Weaver Diversity for Rodman Reservoir East was 2.0 compared to a value of 4.4 for Rodman Reservoir West. The Rodman Reservoir samples contained few ETO taxa (0 and 2 taxa, respectively for east and west sites) with percentages of ETO organisms of 0% for Rodman Reservoir East and 5.4% for the west site.

Rodman Reservoir East and West exhibited similar phytoplankton populations, with both sites exhibiting low algal biomass. The numbers of taxa were 20 and 16 for the east and west sites, respectively, with algal densities of 306 and 108 organisms/mL, respectively. Chlorophyll *a* content of both phytoplankton samples was undetectable (<1 mg/L). Of those phytoplankton that were present, the percent contribution of the dominant taxa (*Melosira* for the east site and *Nitzschia* for the west site) were 27.3% to 32.4%. Diatoms contributed between 62.3% and 63.3% of the two samples, and green algae contributed 15% to 18% of the two samples. Blue-green phytoplankton accounted for only between 0% to 1.9% of the samples. Phytoplankton Shannon-Weaver Diversity range from 3.3 to 3.4 for the two sites.

Macroinvertebrate metrics values appear to be moderate to good for most sites of the six waterbodies studied. However, recent information based on development of a composite Lake Condition Index (LCI), which ranks a lake based on its attainment of eco-regional expectations, indicates that lake macroinvertebrate metrics for the Florida peninsular ecoregion (75) will be inconclusive. Reference and non-reference lakes from the Florida peninsula did not show a clear distinction when compared using the six metrics described previously, namely: taxa richness; Hulbert Index, % Diptera; #ETO taxa; %ETO; and macroinvertebrate Shannon-Weaver diversity. The conclusion was made that macroinvertebrates aren't sensitive biological indicators in the highly colored, organic rich lakes of Ecoregion 75 and it was recommended that macroinvertebrates not be used as lake assessment tools for this ecoregion. All six waterbodies from this study are located in Ecoregion 75. Therefore, while the macroinvertebrate metric values are summarized in this report (refer to Table 1), no definitive conclusions regarding biological condition can be drawn from those data at this time.

Conclusions

Moderate nutrient enrichment in the form of nitrate-nitrite was observed at both Rodman Reservoir sites in concentrations above those observed in 70% of other Florida lakes. All other nutrient concentrations at those two sites were below the 50th percentile concentrations for other lakes. Moreover, with two exceptions (Lake Johnson nitrate-nitrate below 50% of other lakes and ammonia below 10th percentile concentration of other lakes), all other lakes in this study exhibited nutrient concentrations that were below the lower 5th percentile concentrations for other Florida Lakes. These results are in keeping with the characterization of the Trail Ridge Lakes region as containing oligotrophic lakes (Griffin et al., 1997). The acidity and clarity of the five lakes from this study that are in the Trail Ridge Lakes region (Rodman Reservoir is in the Central Valley region) also are in keeping with that characterization.

Exceedance of the State of Florida Class III surface water quality criterion for dissolved oxygen (5.0 mg/L) occurred at the Rodman Reservoir West site (3.8 mg/L). D.O. concentrations for all other sites from this study were good, ranging from 6.5 to 8.1 mg/L.

Water column TOC concentrations for Rodman Reservoir (16-19 mg/L) were elevated and sediment organic matter percentages were high (48.1 to 53.75%). TOC and sediment organic content were low for all other sites from this study.

Habitat assessment scores were in the "suboptimal" range for all sites except Cowpen Lake, which was in the "optimal" range. Contributors to

lowered habitat quality ("suboptimal" ratings) at the other sites included a "poor" score at Rodman Reservoir and a "marginal" score at Kingsley Lake for bottom substrate diversity, "marginal" scores for submerged and floating vegetation quality at Rodman Reservoir and Lake Johnson, and a "marginal" score for Secchi depth at Rodman Reservoir.

Macroinvertebrate metrics values appeared to be moderate to good for most sites of the six waterbodies studied, with the possible exception of Rodman Reservoir East. However, it recently has been determined that macroinvertebrate measures are not sensitive indicators of biological condition for lakes in Ecoregion 75. Thus, no definitive conclusions regarding biological condition can be drawn from those data at this time.

Phytoplankton communities at all sites exhibited very low biomass, no doubt in relation to the low nutrient conditions, and in lesser part in relation to the acidity and low conductivity at most sites. For those phytoplankton that were present, diversity was fairly low at most sites, being highest at Rodman Reservoir where nutrient concentrations were highest. This condition is not unexpected since moderate nutrient enrichment may sometimes be correlated with increased algal diversity.

The assessment of lake condition will be more meaningful when biological indicators are used in conjunction with physical/chemical measurements. Development of an algal sensitivity index currently is underway and there are plans to develop a biological index for aquatic macrophytes for use as lake condition assessment tools. Such indices are particularly needed for areas like Ecoregion 75, where macroinvertebrate measures recently have been judged not to be useful. The phytoplankton data collected for the waterbodies for this study can be reassessed once an algal sensitivity index is available.

Rodman Reservoir should be considered for placement on the 303(d) list as a result of moderate nutrient enrichment in the form of nitrate-nitrite, lowered D.O., elevated water column TOC and sediment organic content as determined from the October, 1998, sampling event and because of the reservoir's location in the Oklawaha River Basin, which is on the 303(d) list. At a minimum, once algal and/or macrophyte biological indices are available, Rodman Reservoir should be reassessed to determine if it should be added to the 303(d) list. All other lake sites monitored for this report showed overall good water quality in keeping with their designation as reference lakes or potential reference lakes.

Literature Cited

Florida Department of Environmental Protection (FDEP). SOP #BA-4. Phytoplankton Sample Collection. Version 1:7/22/93.

FDEP. 1996. SOP #BA-28. Benthic Macroinvertebrate Composite Grab Sample Collection for Lakes. Version 2:1/17/96.

FDEP. 1997a. SOP #BA-18. Habitat Assessment Techniques. Version 2:1/9/97.

FDEP. 1997b. SOP #BA-17. Physical/Chemical Characterization techniques. Version 2:4/9/97.

FDEP. 1997c. SOP #BA-5. Phytoplankton Sample Handling for Taxonomic Analysis. Version 2:1/9/97.

FDEP. 1997d. SOP #BA-6. Phytoplankton Taxonomic Analysis. Version 3:8/20/97.

Griffin, G. et. al. 1997. Map and descriptions of the Lake Regions of Florida.

Hulbert, J.L. 1990. A proposed lake condition index for Florida. North Amer. Benth. Soc. 38th Ann. Mtg., Blacksburg, VS, 11 pp.

Raschke, R.L. and D.A. Schultz. 1987. The use of the algal growth potential test for data assessment. J. Wat. Poll. Contr. Fed. 59(4): 222-227.