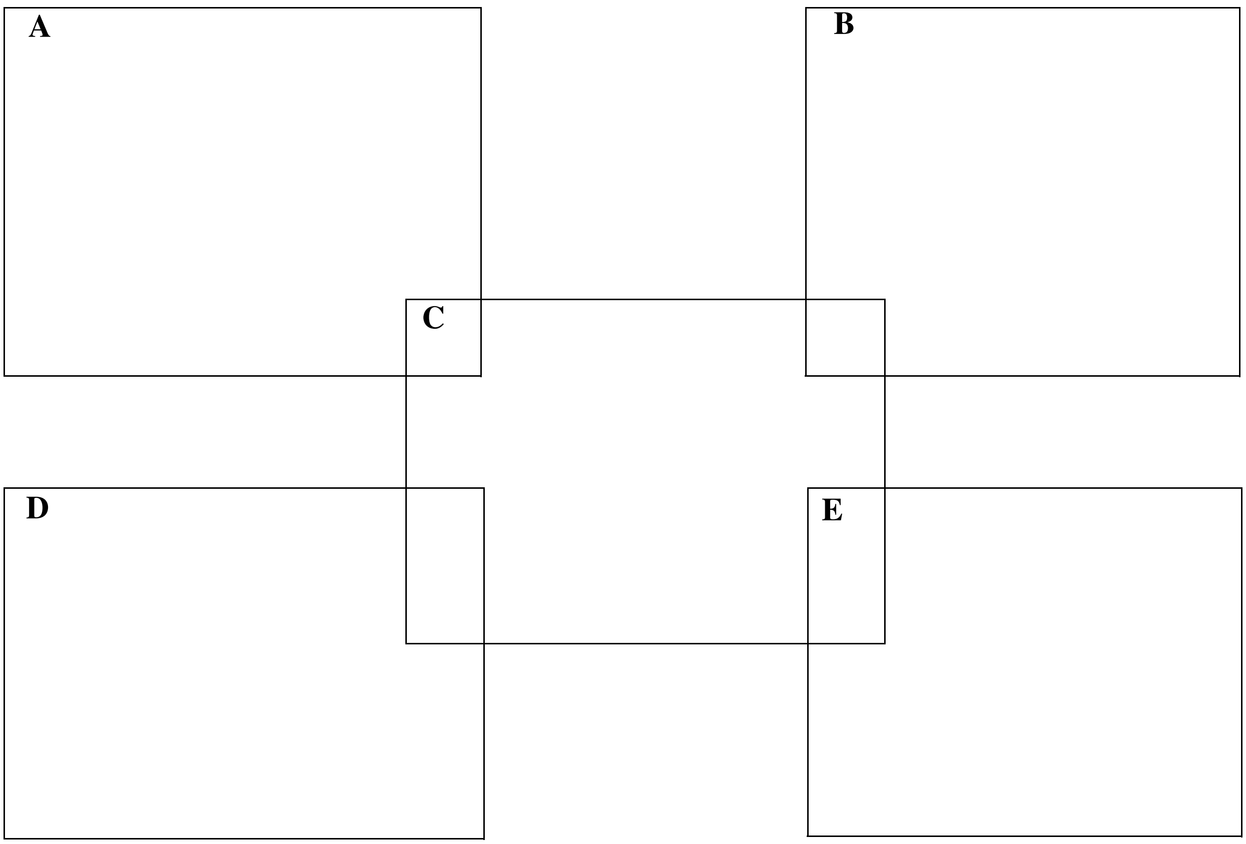
Water Quality of Eleven Lakes in Eastern and Southern Arkansas from August 2004 - July 2005

Prepared in cooperation with the
U.S. Environmental Protection Agency, Region VI

Scientific Investigations Report 2006-5047

U.S. Department of the Interior
U.S. Geological Survey



Front cover:
A - First Old River Lake
B - Lake Frierson
C - Old Town Lake
D - Stave Lake showing cypress forest buffer
E - Horseshoe Lake showing fishing piers near the northern site

All photographs by Billy G. Justus, U.S. Geological Survey.

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U.S. Department of the Interior
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Water Quality of Eleven Lakes in Eastern and Southern Arkansas from August 2004 - July 2005

By B.G. Justus

Abstract

In 2002, the U.S. Environmental Protection Agency Region VI (USEPA), determined that historic data and observations indicated that nine lakes were in violation of either narrative or numeric water-quality standards for Arkansas. Using a weight of evidence approach, USEPA determined that the narrative nutrient (nitrogen and phosphorus, for example) standard was violated at six lakes—five lakes located in eastern Arkansas in the Mississippi Alluvial Plain Ecoregion and one lake located in southeastern Arkansas in the South Central Plains Ecoregion. USEPA also determined that chloride standards were violated at two lakes located in the South Central Plains Ecoregion in south-central Arkansas, and that turbidity standards were violated at one lake located on Crowleys Ridge in northeastern Arkansas in the Mississippi Alluvial Plain Ecoregion. USEPA added all nine lakes to the Arkansas 2002 Clean Water Act section 303(d) list of impaired waterbodies.

This report documents methods used and describes the results for a water-quality study at 11 lakes—the 9 lakes in eastern and southern Arkansas that had been previously placed on the 2002 Clean Water Act section 303(d) list, as well as 2 reference lakes. The study was conducted by the U.S. Geological Survey in cooperation with the USEPA. The scope of the project included lake reconnaissance, selection of the 2 reference lakes, a 48-hour dissolved-oxygen investigation, water-quality sampling in the 11 lakes between August 2004 - July 2005, and a basic interpretation of the data.

At all seven lakes selected for the 48-hour dissolved-oxygen investigation, except Bear Creek Lake, dissolved-oxygen concentrations declined below the State standard of 5 milligrams per liter at some time in the 48-hour monitoring period. Dissolved-oxygen concentrations (and, to a lesser extent, pH) demonstrate large diurnal fluctuations at five of the lakes—First Old River, Grand, Horseshoe, Mallard, and Old Town Lakes. Dissolved-oxygen concentrations were less than 1.5 milligrams per liter at Mallard Lake and Grand Lake for short periods near daybreak. The State pH standard of “9” was exceeded at all lakes except Stave Lake (the nutrient reference lake).

Highest concentrations for most nutrients and nutrient response variables were measured at Old Town Lake followed by First Old River, Grand, and Mallard Lakes. Observations made as samples were collected may provide some insight for potential sources of nutrients (aside from row crop agriculture) at three of the four lakes. Cattle usually were grazing along the banks of First Old River Lake and Grand Lake. A small community is located along the edge of Old Town Lake, and given the age of many of the structures, it is possible that septic systems are outdated and untreated waste may be entering the lake.

Aside from ammonia nitrogen concentrations at Bear Creek Lake, concentrations of both nutrients and nutrient response variables generally were lowest at Bear Creek, Horseshoe, and Upper White Oak Lakes, and were comparable to concentrations at Stave Lake—the reference lake. Of all samples, highest concentrations for ammonia nitrogen were observed at Bear Creek Lake; however, decomposition of large amounts of leaves deposited near where water-quality samples were collected probably resulted in ammonia nitrogen being cycled into the aquatic environment.

Turbidity results indicate that Lake Frierson is impaired by clay turbidity. Highest median turbidity concentrations were observed at Lake Frierson and values measured at the site were never below the Arkansas Department of Environmental Quality numeric criteria of 25 nephlometric turbidity units. Secchi depth (an indication of light penetration) also was consistently lower at Lake Frierson than at other lakes.

Concentrations of chloride, sulfate, and total dissolved solids were similar at the two lakes listed as being impaired by chlorides (Lake Calion and Lake June) and were not close to exceeding State standards of 250, 250, and 500 milligrams per liter, respectively. However, concentrations for chloride at Lake Calion and Lake June were about six to nine times higher than concentrations at Upper White Oak Lake (the chloride reference lake), and concentrations of sulfate and total dissolved solids at Lake Calion and Lake June were about two times higher than concentrations at Upper White Oak Lake.

Introduction

In 2002, U.S. Environmental Protection Agency, Region VI (hereafter referred to as USEPA) evaluated historic water-quality data and observations collected by the Arkansas Department of Environmental Quality (ADEQ) and the Arkansas Natural Resources Commission (ANRC) at nine lakes (table 1, fig. 1) located in eastern and southern Arkansas. Historic data and observations indicated the nine lakes were in violation of either narrative or numeric water-quality standards for Arkansas. Using a weight of evidence approach, USEPA determined that the narrative nutrient (nitrogen and phosphorus, for example) standard was violated at six lakes—five lakes located in eastern Arkansas in the Mississippi Alluvial Plain Ecoregion and one lake located in southeastern Arkansas in the South Central Plains Ecoregion. USEPA also determined that chloride standards were violated at two lakes located in the South Central Plains Ecoregion in south-central Arkansas, and that turbidity standards were violated at one lake located on Crowleys Ridge in northeastern Arkansas in the Mississippi Alluvial Plain Ecoregion. USEPA added these nine lakes to the Arkansas 2002 Clean Water Act section 303(d) list of impaired waterbodies (Arkansas Department of Environmental Quality, 2002).

Much of the current criteria used by ADEQ for assessing lake water quality is a derivation of criteria developed for Arkansas streams, and depending on the constituent, can be narrative rather than numeric, in nature (Arkansas Department of Environmental Quality, 2005). As an example of narrative criteria, ADEQ narrative nutrient regulations for 2005 are as follows, "Materials stimulating algal growth shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation or otherwise impair any designated use of the waterbody.....Because nutrient water column concentrations do not always correlate directly with stream impairments, impairments will be assessed by a combination of factors such as water clarity, periphyton or phytoplankton production, dissolved oxygen values,.....dissolved oxygen saturation, diurnal dissolved oxygen fluctuations, pH values, aquatic-life community structure and possibly others." In 2002 and 2004, narrative criteria also included a guideline for total phosphorus of 0.05 milligrams per liter (mg/L).

Concerning numeric criteria (and also related to nutrients), ADEQ has established numeric criteria for both dissolved oxygen and pH. A dissolved-oxygen criterion of 5 mg/L is in place for lakes and reservoirs. ADEQ numeric criteria for lakes also state that pH of "lakes must not fluctuate in excess of 1.0 unit over a period of 24 hours and pH values shall not be below 6.0 or above 9.0."

ADEQ criteria related to chlorides and turbidity also are numeric in nature. Lake June and Lake Calion were listed in 2002 for chlorides because the chloride concentration exceeded 19 mg/L more than 50 percent of the time; a chloride criterion established for the South Central Plains Ecoregion (however, the assessment methodology was changed and now states that waters will be listed as impaired for minerals if they fail to meet the 250, 250, 500 mg/L criteria for chlorides, sulfates and total dissolved solids, respectively more than 10 percent of the time). Numeric turbidity values for lakes and reservoirs and normal stage conditions are 25 NTU.

After the USEPA listed the nine lakes on the Arkansas 2002 Clean Water Act section 303(d) (referred to hereafter as Arkansas 2002 303(d)) list, additional data were needed to characterize water quality. A study was conducted by the U.S. Geological Survey (USGS) in cooperation with the USEPA to monitor water quality at the nine lakes in eastern and southern Arkansas and at two reference lakes from August 2004 - July 2005 (fig. 1).

Table 1. Information for lakes sampled in Arkansas, August 2004 - July 2005.

[Most details (with exception of latitude and longitude of the sampling site and information for the two reference lakes) are from Arkansas Department of Environmental Quality, 2000. Approximate maximum depths were determined using profile data. The horizontal datum for latitude and longitude was North America Datum of 1983 (NAD83)]

Name	County	Latitude	Longitude	Lake size (acres)	Approximate maximum depth (feet)	Basin size (square miles)	Water-quality concern	Lake type
Bear Creek Lake	Lee	344232	904140	625	40	6.0	Nutrients	Upland
First Old River Lake	Miller	332955	934614	200	14	2.0	Nutrients	Oxbow
Grand Lake North	Chicot	330505	911243	1,400	10	5.5	Nutrients	Oxbow
Grand Lake South	Chicot	330335	911212	1,400	16	5.5	Nutrients	Oxbow
Horseshoe Lake North	Crittenden	335622	902007	1,200	30	13.5	Nutrients	Oxbow
Horseshoe Lake West	Crittenden	345456	902152	1,200	18	13.5	Nutrients	Oxbow
Lake Calion	Union	331921	923207	510	11	6.7	Chlorides	Lowland
Lake Frierson	Greene	355816	904322	335	15	7.3	Turbidity	Upland
Lake June	Lafayette	332110	932936	60	10	4.0	Chlorides	Lowland
Mallard Lake	Mississippi	355209	900559	300	11	0.5	Nutrients	Lowland
Old Town Lake	Phillips	342454	904801	900	6.0	23	Nutrients	Oxbow
Stave Lake	Mississippi	352618	901145	300	6.0	2.0	Nutrient reference	Oxbow
Upper White Oak	Ouachita	333958	930514	630	20	21	Chloride reference	Upland

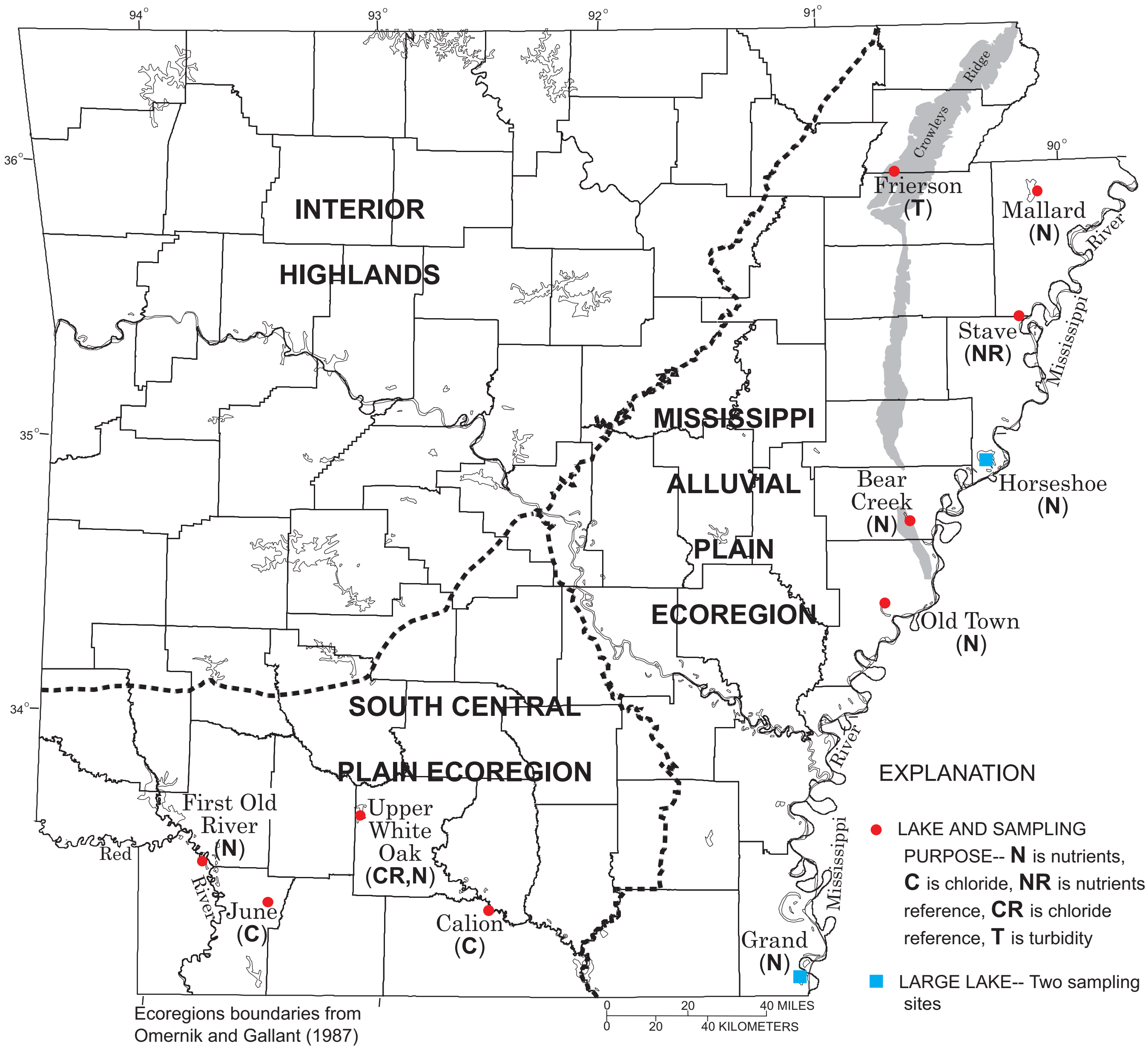

Figure 1. Location of lakes sampled in Arkansas.

Purpose and Scope

The purpose of this report is to document the methods used and describe the results for a water-quality study conducted at 11 lakes in Arkansas. As assurance that USEPA would have sufficient data to determine if the nine lakes should remain on the Arkansas 2004 303(d) list, sampling intensity exceeded that of past sampling efforts (Arkansas Department of Environmental Quality, 2000). The scope of the project included lake reconnaissance and selection of two reference lakes (one each for nutrients and chlorides), a 48-hour dissolved-oxygen investigation, water-quality sampling in 11 lakes between August 2004 - July 2005, and a basic interpretation of the data.

Lake Description

Lakes in two level-3 ecoregions within Arkansas (Omernik, 1987), the Mississippi Alluvial Plain (MAP) and South Central Plains (SCP) Ecoregions, were evaluated for this study. Within both Ecoregions, three distinct lake types were studied—five lakes were oxbows that exist within the remnant channel of the Red and Mississippi Rivers, three lakes were lowland reservoirs, and three lakes were upland reservoirs (table 1).

Land use surrounding the five oxbow lakes historically was dominated by bottomland hardwood; currently, however, land use is dominated by row crop agriculture (Chapman and others, 2004). For most oxbow lakes, a water-control structure or levy has been constructed to improve isolation from the river channel or to maintain higher dry-season water levels. Because oxbow lakes usually are isolated from the main channel, most oxbow lakes have small watersheds (Arkansas Department of Environmental Quality, 2000) and nonpoint surface runoff can be from cattle grazing and residential land use, in addition to row crop agriculture.

Lowland and upland reservoirs in the SCP Ecoregion and on Crowleys Ridge (located in the MAP Ecoregion), have watersheds that generally include timberlands of hardwoods and pines. Pastureland and row crop agriculture are common land uses. Most reservoirs in SCP Ecoregion and on Crowleys Ridge were constructed specifically for public fishing with other types of recreation as secondary uses (Arkansas Department of Environmental Quality, 2000).

Methods

Site Reconnaissance

In late July 2004, lake reconnaissance was conducted at the nine lakes listed on the Arkansas 2002 303(d) list and at candidate reference lakes. Prior to the reconnaissance effort, candidate reference lakes were selected using USGS topographic maps, aerial photography, and by communication with area resource managers.

The site reconnaissance was used to determine site-specific information for the nine target lakes and the potential reference lakes (sampling locations, latitude, longitude, lake access, travel time between sites, and proximity to sample shipping locations). During this effort, sampling sites were identified at the nine lakes and tentative sampling sites were identified at candidate reference lakes. Sampling sites were selected, using a depth finder, near the deepest part of the lake. At most lakes, the deepest part of the lake was near the center of the lake; however, Old Town Lake was deepest near the boat ramp and samples were collected there. At the two larger lakes, Grand and Horseshoe Lakes, sites were selected in the deepest part of the lake that also was near the first and third quarter point of the lakes' length.

Lake-profile data were recorded during the reconnaissance by lowering a water-quality monitor (WQM) through the water column and recording data at 1-foot intervals after the WQM (Yellow Springs Instrument, model 6920) was allowed to stabilize. Field measurements with the WQM during the reconnaissance included dissolved oxygen, specific conductance, pH, and water temperature. Secchi-disc measurements were made and other selected field observations were recorded at each site.

Reference Lake Selection

The buffering capacity of surrounding vegetation (an observation made during the reconnaissance effort) was the key factor that determined the selection of the two reference lakes. Stave Lake, a privately owned lake in southern Mississippi County in northeastern Arkansas, was selected as a reference lake for nutrient concentrations. Stave Lake is between, and connected to, Mink and Menesha Lakes. No water-quality data had been collected at Stave Lake prior to this study but both Mink and Menesha Lakes, as well as a cypress/tupelo gum swamp that borders Stave Lake, were anticipated to buffer Stave Lake from nutrient enriched surface runoff. Upper White Oak Lake, a State-owned lake in Ouachita County in south-central Arkansas that has a fishery managed by the Arkansas Game and Fish Commission (AGFC) and a surrounding land use dominated by forest, was selected as a reference lake for chloride concentrations.

Dissolved-Oxygen Investigation

During the first and second weeks of August 2004, a 48-hour dissolved-oxygen investigation was conducted at seven lakes targeted for nutrient sampling (Bear Creek, First Old River, Grand, Horseshoe, Mallard, Old Town, and Stave Lakes). In addition to dissolved oxygen, WQMs were programmed and calibrated to collect pH data because of its relation to photosynthesis. WQMs were deployed from boat docks or submerged logs near shore. WQMs were placed at a depth of approximately 1.5 feet and were programmed to collect data at

30-minute intervals. WQMs used in this study were calibrated according to USGS protocols (Wagner and others, 2000) immediately before and after deployment. WQMs at six of the seven lakes were retrieved after approximately 48-hours; however, logistics prevented the retrieval of the WQM deployed at First Old River Lake for 7.5 days.

The quality of the dissolved-oxygen and pH data recorded during deployment was evaluated with calibration data and also with a visual inspection of the dissolved-oxygen probe (at the time of retrieval) for biofouling (algae growth or presence of macroinvertebrate cases) or damage that may have occurred during deployment. Calibration records show that dissolved-oxygen and pH data at the time the WQMs were retrieved were within 1.5 percent of expected values (Wilde and others, 1998) at all monitoring lakes except First Old River Lake. Because of the extended deployment at First Old River Lake (approximately 180 hours), the dissolved-oxygen probe of the WQM was biofouled upon retrieval and dissolved-oxygen values were greater than 5 percent different than expected values. USGS protocols (Wagner and others, 2000) recommend correcting data for biofouling when data are greater than 5 percent different than expected values. However, because biofouling did not occur at the other six lakes that were monitored for 48-hours and because conditions at First Old River (water temperature and nutrient concentration, for example) were comparable to the remaining six lakes, no data correction for biofouling was applied. Once the probe was cleaned, dissolved-oxygen concentrations were within 1 percent of expected values. This indicated that electronic drift was negligible over the 48-hour monitoring period and all data collected from First Old River for the first 48 hours of deployment are considered to be of good quality.

Water-Quality Sampling and Analysis Procedures

At the request of the cooperator, two sampling frequencies were used based on the presumed impairment (nutrient, chloride, or turbidity). Lakes presumed to be impaired by nutrients were sampled 9 times over 12 months while lakes presumed to be impaired by chloride and turbidity were sampled 6 times over 12 months (table 2).

Water samples from all 11 lakes were collected using the same methods. Water samples were collected approximately 1 foot below the water surface with a Van Dorn sampler from an anchored boat (Wilde and others, 1999). Acid preservation of nutrient samples was conducted in the field. As one team member collected and processed samples, a second team member completed a field form that documented environmental conditions and observations during sample collection. The second team member also measured and recorded lake profile data using a WQM (using the same methods as for the reconnaissance effort). At the three deepest lakes—Bear Creek, Horseshoe, and Upper White Oak—lake profile data were recorded at 2- or 5-foot intervals when lake conditions were uniform throughout all depths or within a stratification layer (Wilde and others, 1998). Field measurements included dissolved oxygen, specific conductance, pH, water temperature, and secchi depth.

Field blanks were collected at a rate of 10 percent of all environmental samples and were collected at all sites at different times. Field blanks were processed in the field by adding standard de-ionized water to the Van Dorn sampler and decanting the sampler into an empty sample bottle. Duplicate water samples were collected at five different lakes during the last three sampling events. Blank and duplicate samples were preserved and shipped in the same manner as environmental water samples.

Each sample was checked to be sure that it was properly sealed and labeled with sample information (site name, time and date of collection, preservative). Sample custody seals were placed on each bag of sample bottles, and bags containing sample bottles from one or more sites were placed inside two larger bags. Ice was placed in the cooler until it was filled to capacity. Chain-of-custody (COC) forms were completed (sample dates, sample analyses, preservatives, and shipping carrier) and were shipped along with the water samples. All samples were shipped to the USEPA laboratory in Houston, Texas, within 24 hours of collection. COC forms also were transferred electronically to the laboratory after all sampling had been completed.

Table 2. Sampling or frequency schedule for 11 lakes sampled in Arkansas, August 2004 - July 2005.

Presumed impairment (number of lakes)	2004					2005						
	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
Nutrient (7)	X	X	X		X		X		X	X	X	X
Chloride (3)	X		X		X		X		X		X	
Turbidity (1)	X		X		X		X		X		X	

Water-quality constituents were selected by USEPA prior to the study. All chemical analyses were conducted at the USEPA laboratory in Houston, Texas, or were contracted to a laboratory operated by the Texas Commission on Environmental Quality. All analyses were conducted using USEPA approved laboratory methods (table 3). Water-quality constituents for the nutrient lakes were chosen based on the potential relations of the constituents to lake trophic status (an indication of nutrient enrichment) (Wetzel, 2001). Nutrients (total ammonia plus organic nitrogen; dissolved ammonia, nitrite, nitrate, orthophosphorus; and total phosphorus) were the primary group of constituents analyzed, but additional constituents were selected as nutrient response variables because of potential relations to phytoplankton density (chlorophyll *a*, pheophytin *a*, turbidity, nonpurgeable organic carbon, suspended solids, and biochemical oxygen demand) (Cooke and others, 2005).

Total nitrogen was calculated by adding concentrations (as nitrogen) of total ammonia plus organic nitrogen and nitrate. Nitrite concentrations also are a component of total nitrogen; however, concentrations were always at or near laboratory detection limit and, for this study, were considered to be zero for all samples at all sites. In some cases, total ammonia plus organic nitrogen and nitrate concentrations used in these calculations were below laboratory detection limits; therefore, one-half the laboratory detection limit was used to calculate total nitrogen concentrations.

Water-quality constituents for the chloride and turbidity lakes were chosen based on the potential relations of the constituents to chloride concentration or turbidity. Constituents analyzed at the three chloride lakes were chloride, sulfate, and total dissolved solids. Lake Frierson, the only turbidity lake, was sampled for turbidity and constituents known to be related to turbidity (chlorophyll *a* and total suspended solids) and also for all but one of the same nutrient constituents (ammonia nitrogen) as the seven nutrient lakes. Upper White Oak Lake (the lake selected as a reference lake for chloride concentration) also was sampled for nutrients at the request of the AGFC but only for 6 months (the same frequency as the chloride lake sampling schedule). The AGFC expressed an interest in nutrient concentrations in Upper White Oak Lake because AGFC fertilizes this lake each spring to promote algal production and supplement the lake fishery.

For the last 3 months of sampling, and at the request of USEPA, samples were collected for identification and enumeration of phytoplankton at the nutrient lakes. Phytoplankton were identified and counted by Dr. Russell Rhodes, Missouri State University. Phytoplankton analyses were not within the scope of this report, and a report describing these results has been provided to USEPA by Dr. Rhodes (Russell Rhodes, Missouri State University, written commun., February 2006).

Table 3. U.S. Environmental Protection Agency methods used to analyze water-quality samples for the lake study in Arkansas, August 2004 - July 2005.

[Constituents are dissolved unless noted otherwise; **bold**, samples analyzed using two different methods; A, U.S. Environmental Protection Agency, 1983; B, U.S. Environmental Protection Agency, 1993; C, American Public Health Association, 1998; D, U.S. Environmental Protection Agency, 1986; na, not applicable]

Constituent	Laboratory method	Method reference	Laboratory detection limit	Laboratory reporting limit
Orthophosphorus	**300 / 365.1**	B	0.06/0.02	0.06/0.02
Phosphorus (total)	365.1	B	0.05	0.05
Ammonia nitrogen	350.1	A	0.05	0.05
Ammonia plus organic nitrogen (total)	351.2	A	0.05	0.05
Nitrate	**300 / 353.2**	B/A	0.05/0.02	0.05/0.02
Nitrite	**300 / 353.2**	B/A	0.05/0.02	0.05/0.02
Pheophytin *a*	10200H	C	0.01	1.0/5.0
Chlorophyll *a*	10200H	C	0.01	1.0/5.0
Turbidity	180.1	B	na	na
Nonpurgeable organic carbon	415.2	D	1.0	1.0
Total suspended solids	160.2	A	1.0	1.0
Volatile suspended solids	160.4	A	1.0	1.0
Biochemical oxygen demand	405.1	A	2.0	3.0
Chloride	300	B	1.0	1.0
Sulfate	300	A	1.0	1.0
Total dissolved solids	160.1	A	1.0	1.0

Quality Assurance Evaluation

Results of blank and duplicate samples were evaluated to determine the data quality. Blank sample results were evaluated to determine if results were above detection limits. Duplicate samples were compared to environmental samples by determining the percent difference between the duplicate sample result and the environmental sample result. Percent differences were calculated by dividing the result of the sample having the highest value by the result of the sample having the lowest value, subtracting that quotient from 1, and then multiplying that result times 100.

Water Quality of Lakes

Dissolved-Oxygen and pH Fluctuation Investigation

Dissolved-oxygen data (and, to a lesser extent, pH data) for the 48-hour investigation demonstrate large diurnal fluctuations at five of the seven nutrient lakes, and concentrations declined below the State standard of 5 mg/L for six of the seven lakes. Large diurnal fluctuations were apparent at First Old River, Grand, Horseshoe, Mallard, and Old Town Lakes (fig. 2). Dissolved-oxygen concentrations also declined below 4 mg/L for varying periods at those same five lakes, and were less than 1.5 mg/L at Mallard Lake and Grand Lake for short periods near daybreak. Dissolved-oxygen fluctuations were smaller at Stave Lake and Bear Creek Lake, and never declined below 4 mg/L. Heavy cloud cover that was prevalent for the first 24-hours of the 48-hour investigation may have influenced dissolved oxygen at Mallard Lake and concentrations never exceeded 5 mg/L.

Comparing data collected in the 48-hour monitoring period to ADEQ criteria, dissolved-oxygen concentration declined below the State standard of 5 mg/L at some time in the monitoring period at all lakes (including Stave Lake) except Bear Creek Lake. The State pH standard of "9" was exceeded at all lakes except Stave Lake (table 4).

Dissolved-oxygen percent saturation (and concentrations) at Bear Creek Lake near daybreak was substantially higher than at other lakes and was greater than 100 percent for most of the 48-hour monitoring period. Unlike the WQMs at other lakes, the WQM at Bear Creek was deployed beneath, and a few feet from the edge of a large fishing dock; thus, placing it in the shade for most or all of the 48-hour monitoring period. Water temperature at all the lakes monitored for the 48-hour period was comparable (about 30 °C) (appendix 1); however, reduced light penetration at the Bear Creek Lake monitoring site may have negatively affected photoplankton density and (indirectly) photosynthetic processes in the immediate area of the WQM.

Table 4. Minimum and maximum values for pH, dissolved-oxygen concentration, and dissolved-oxygen percent saturation for two 24-hour periods at seven Arkansas lakes.

		pH (standard units)			Dissolved oxygen (milligrams per liter)			Dissolved oxygen (percent saturation)	
Lake	Date	Minimum	Maximum	pH 24-hour fluctuation	Minimum	Maximum	Dissolved oxygen 24-hour fluctuation	Minimum	Maximum
Bear Creek	08/02/04	9.1	9.5	0.4	9.3	12.3	3.0	122	167.1
	08/03/04	9.1	9.6	0.5	9.6	12.6	3.0	126	173.2
First Old River	08/05/04	9.3	9.9	0.6	4.9	14.4	9.5	64.8	201.4
	08/06/04	9.1	9.8	0.7	3.4	13.0	9.7	43.9	176.3
Grand Lake	08/02/04	8.1	9.9	1.8	1.3	13.6	12.3	17.1	185.9
	08/03/04	9.2	10.1	0.9	4.9	14.1	9.2	64.6	192.6
Horseshoe	08/02/04	8.9	9.8	0.9	6.0	14.5	8.6	78.1	195.4
	08/03/04	8.0	9.9	1.9	1.9	15.2	13.4	24.1	216.4
Mallard Lake	07/30/04	7.7	8.5	0.8	1.0	4.7	3.8	12.1	110.0
	07/31/04	8.2	9.5	1.4	3.2	13.7	10.6	40.8	187.5
Old Town Lake	08/04/04	7.5	9.2	1.7	2.3	9.6	7.2	30.6	128.8
	08/05/04	7.3	8.7	1.4	1.9	7.7	5.9	23.4	99.2
Stave Lake	08/02/04	7.3	8.4	1.1	4.0	9.4	5.4	52.1	126.0
	08/03/04	7.3	8.2	0.8	4.5	9.3	4.9	58.3	123.0

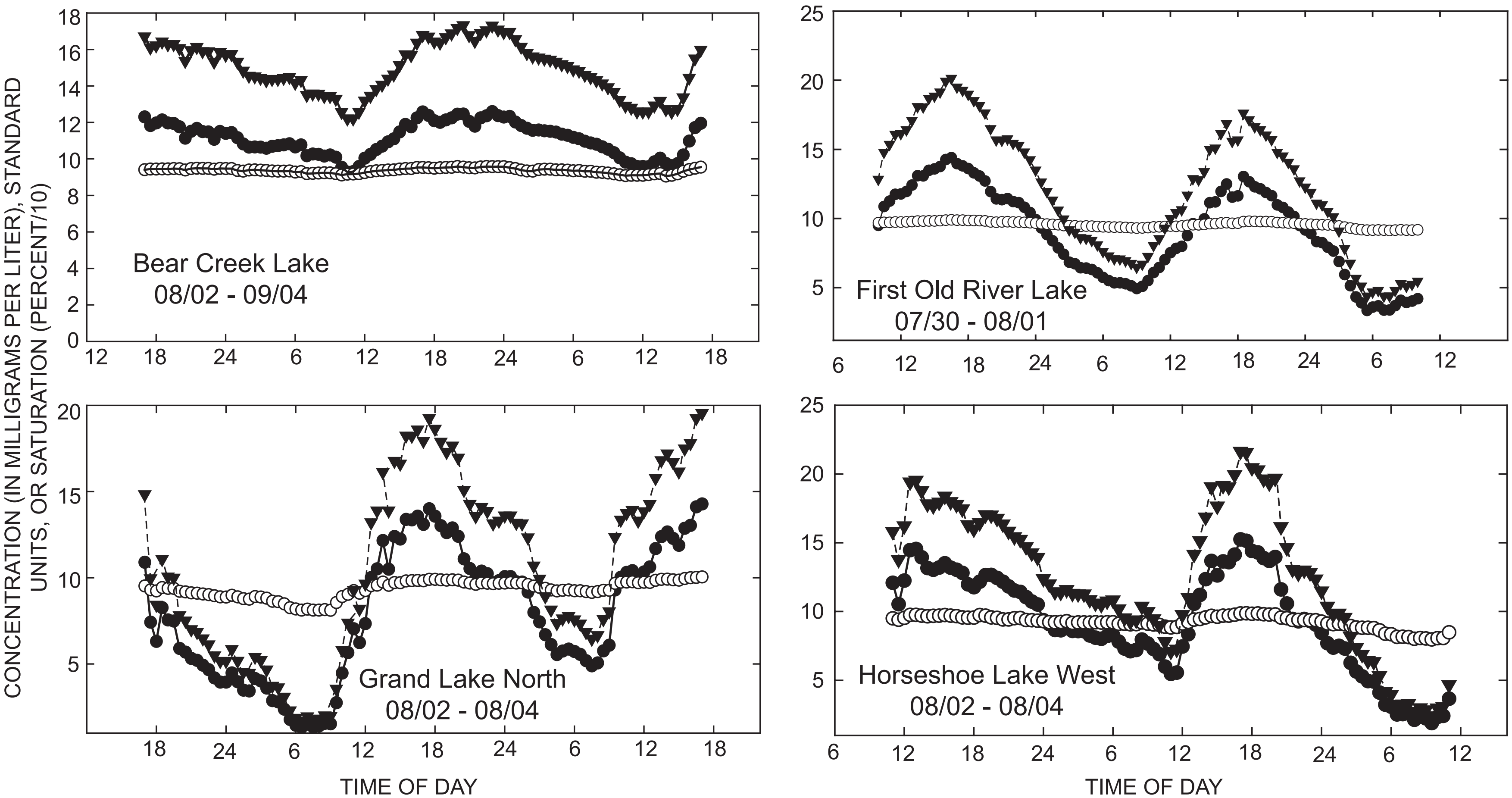

Figure 2. Dissolved-oxygen concentration, pH, and dissolved-oxygen saturation at 30-minute intervals in seven Arkansas lakes for a 48-hour period in August 2004.

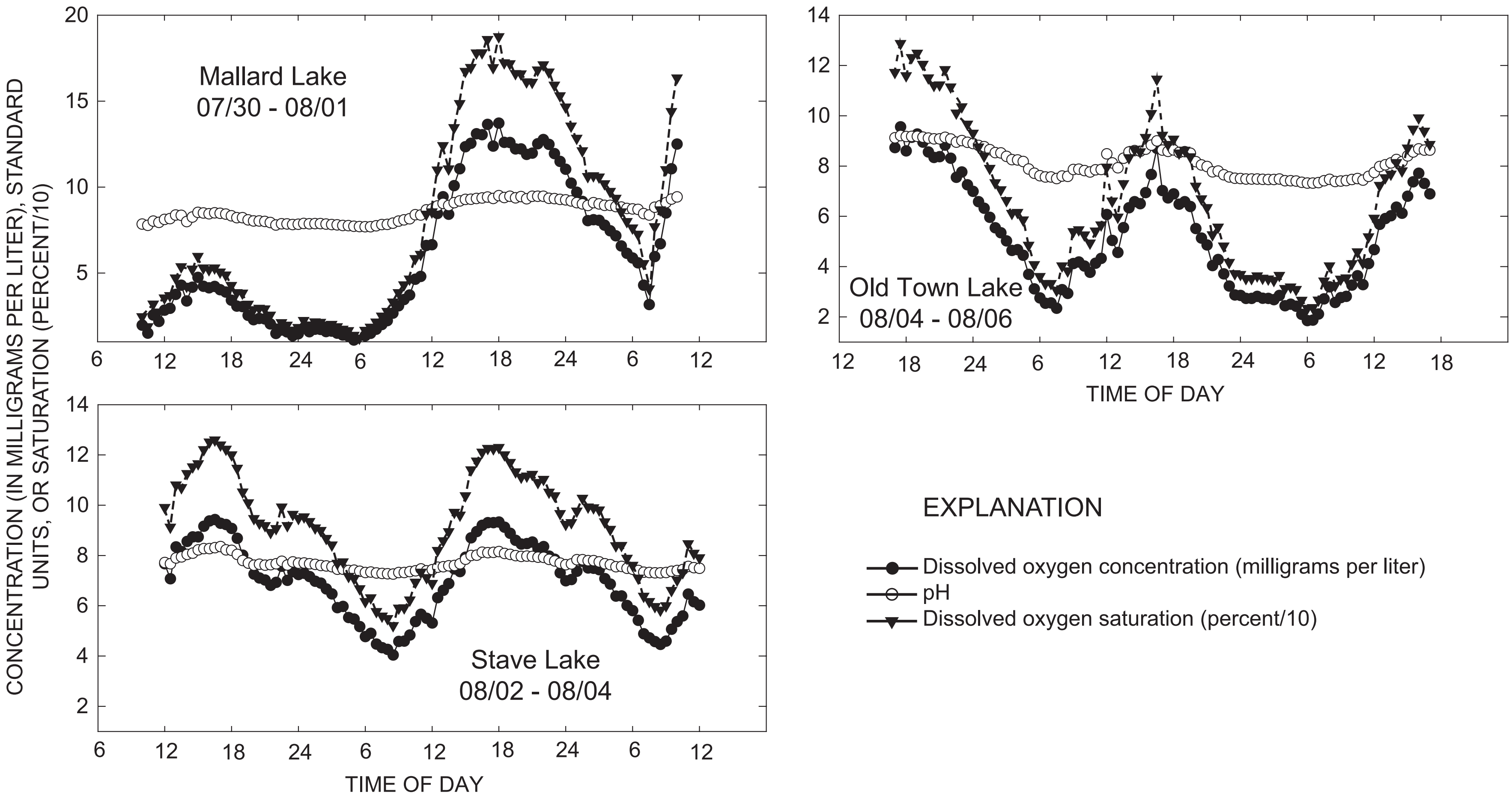

Figure 2. Dissolved-oxygen concentration, pH, and dissolved-oxygen saturation at 30-minute intervals in seven Arkansas lakes for a 48-hour period in August 2004.—Continued

Lower phytoplankton density (and respiration) would result in less demand for oxygen (and higher than normal dissolved-oxygen saturation) during early morning when dissolved-oxygen concentrations typically sag. Another consideration, however, is that concentrations of both nutrients and nutrient response variables at Bear Creek Lake generally were low (and comparable to those of Stave Lake). This indicates that Bear Creek Lake is less productive than the remaining nutrient lakes, and lower productivity could also partially explain the high dissolved-oxygen saturation rates (Wetzel, 2001).

Nutrient Concentrations and Related Measures

Data for 11 of the 14 constituents monitored at the nine nutrient lakes were plotted (ammonia nitrogen, nitrite, and nitrate, which are all dissolved nitrogen constituents, were not detected for most samples and were not plotted) and showed consistent patterns (figs. 3-8). Constituents considered nutrient response variables are shown in figures 7-8 (chlorophyll *a,* pheophytin *a*, turbidity, total suspended solids, nonpurgeable organic carbon, volatile suspended solids, and biochemical oxygen demand). Of these 11 constituents, Old Town Lake had the highest median concentrations for nine constituents (figs. 3-8). The two constituents for which median concentrations at other lakes exceeded those at Old Town Lake were nonpurgeable organic carbon (exceeded by First Old River and Mallard Lakes) and turbidity (exceeded by Lake Frierson). Second highest concentrations for the 11 plotted constituents generally were by First Old River, Grand (both sites), and Mallard Lakes.

Observations made as samples were collected may provide some insight for potential sources of nutrients (aside from row crop agriculture) at three of the nutrient lakes. Cattle usually were grazing along the banks of First Old River Lake and Grand Lake. A small community is located along the edge of Old Town Lake, and given the age of many of the structures, it is possible that septic systems are outdated and untreated waste may be entering the lake.

Ammonia nitrogen concentrations detected at Bear Creek Lake may be related to decomposing leaf litter near the water-quality sampling location. Ammonia nitrogen was not detected in most samples from Bear Creek Lake, but the highest concentrations among all lakes were observed at Bear Creek Lake in October and December 2004, 0.31 and 0.42 mg/L, respectively (table 5). Bear Creek Lake has a long cove extending upgradient into a watershed dominated by forest. Large amounts of leaves are transported during storm events to the spillway that is located adjacent to, but also just upgradient from, the main lake. During storm conditions, it is conceivable that the main lake acts as a large eddie (where water circulates in the horizontal plane). In theory, as water circulated in the eddie, current velocity would decline because of an increase in lake depth, and large amounts of leaves and other organic material could be deposited where water-quality samples were collected. Decomposition of the leaves and organic material would result in ammonia nitrogen being cycled into the aquatic environment (Novotny and Olem, 1994).

Aside from ammonia nitrogen concentrations at Bear Creek Lake, concentrations for nutrient and nutrient response variables generally were lowest at Bear Creek, Horseshoe, and Upper White Oak Lakes, and were comparable to concentrations at Stave Lake—the reference lake. These data are an indication that Bear Creek, Horseshoe Lake, and Upper White Oak Lake were less productive than other lakes that were monitored for nutrients.

Under similar conditions for light transparency, lakes with highest chlorophyll *a* concentrations would be more likely to be impaired by nutrients (and be related to "objectionable algal densities or other nuisance aquatic vegetation" addressed in ADEQ narrative nutrient criteria) (Arkansas Department of Environmental Quality, 2005) while lakes with low chlorophyll *a* concentrations would be less likely to be impaired by nutrients (Wetzel, 2001). Median chlorophyll *a* concentrations for Old Town and Grand Lake (North) were approximately 100 micrograms per liter (µg/L), which was the highest of the nutrient lakes. Median chlorophyll *a* concentrations at First Old River and Grand Lake (South) were second highest (about 63-69 µg/L), followed by Horseshoe Lake (49 µg/L for the two sites). Stave, Bear Creek, and Frierson Lakes had the lowest median chlorophyll *a* concentrations (about 15-28 µg/L). Low chlorophyll *a* concentrations at Stave and Bear Creek Lakes probably are related to low nutrient concentrations measured at these sites (and associated low productivity), while low chlorophyll *a* concentrations at Frierson more likely are related to reduced light transparency as a consequence of high clay turbidity.

As indicated above, when concentrations of both nutrient and nutrient response variables among the oxbow lakes (First Old River, Grand, Old Town, Horseshoe) and the reference lake, Stave Lake, were compared, Horseshoe and Stave Lakes tended to have lower concentrations and the best overall water quality. Two different physical characteristics that distinguish Stave and Horseshoe Lakes from First Old River, Grand, and Old Town Lakes are a wide wetland buffer (Stave Lake) and greater depth (Horseshoe Lake).

Considering oxbow lake depth and how it may be associated with water quality, one would expect there to be an inverse relation between depth and the time of lake isolation from the river channel (lake age). If the assumption that deep oxbow lakes are younger than shallow oxbow lakes is applied to lake trophic-status concepts, then the assumption can be made that the shorter the time of isolation (or the younger the lake), the earlier the stage of eutrophy (Wetzel, 2001). Hence, a question arises concerning the extent of influence imposed on the trophic status of oxbow lakes by the introduction of nutrients from point and nonpoint sources versus the extent of influence imposed on trophic status by lake age. Still another question associated with water quality in deep oxbow lakes is that the deeper the lake the greater the likelihood of connectivity to the alluvial aquifer. In the MAP Ecoregion and for most nutrient and nutrient response variables, dilution of surface water by ground water should improve surface-water quality (U.S. Geological Survey, 2006). Definitive answers to these questions are beyond the scope of this study; however, they do raise considerations that could influence future studies of oxbow-lake water quality.

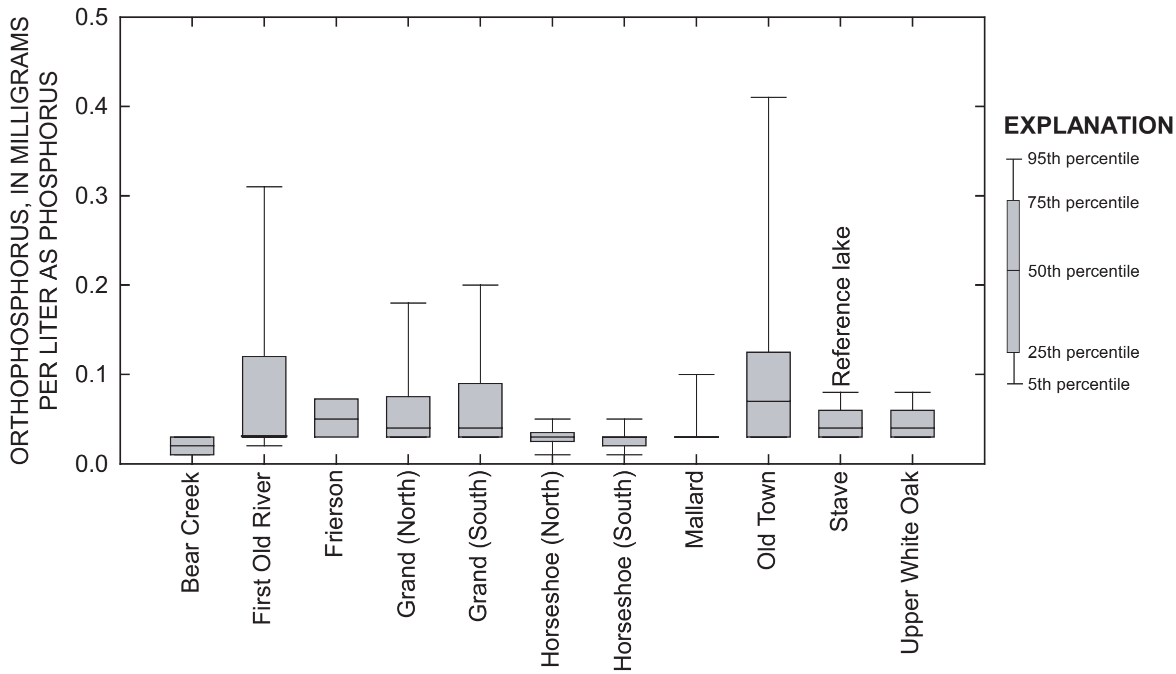

Figure 3. Distribution of orthophosphorus concentrations at 11 lake sampling sites in Arkansas, August 2004 - July 2005.

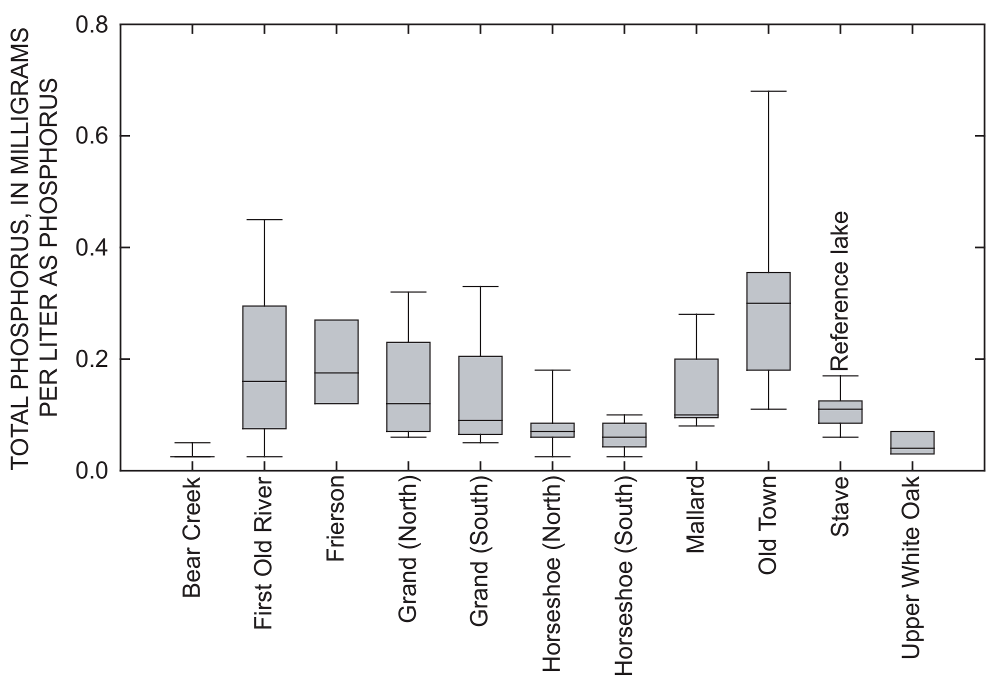

Figure 4. Distribution of phosphorus concentrations at 11 lake sampling sites in Arkansas, August 2004 - July 2005.

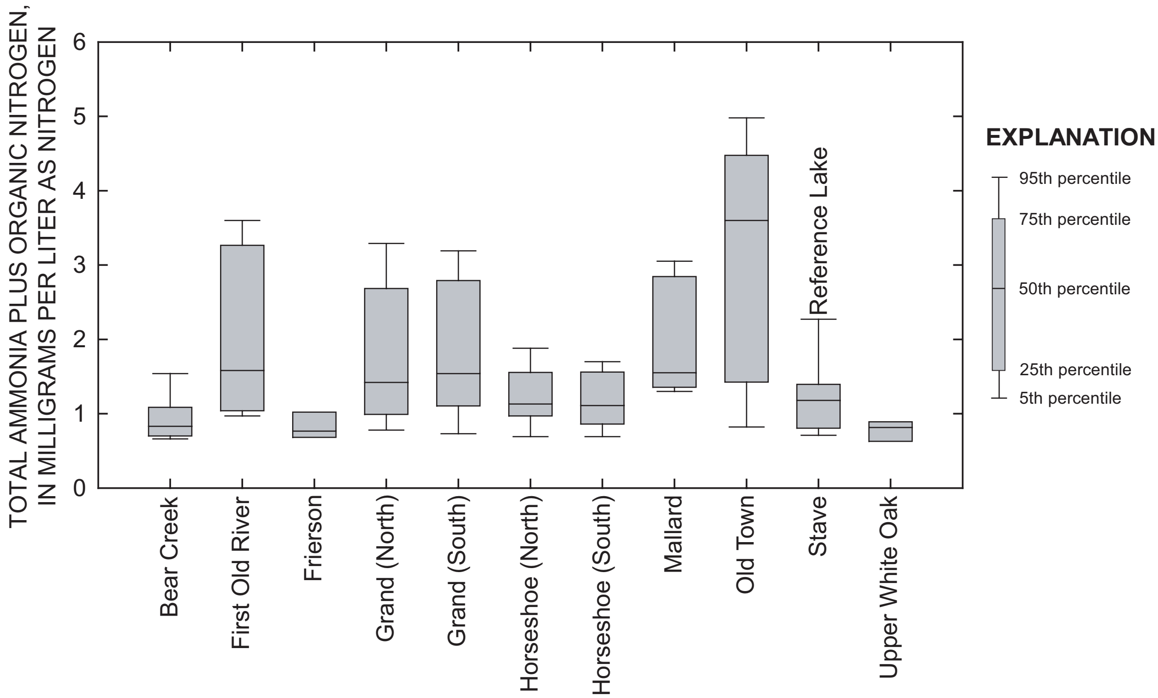

Figure 5. Distribution of total ammonia concentrations at 11 lake sampling sites in Arkansas, August 2004 - July 2005.

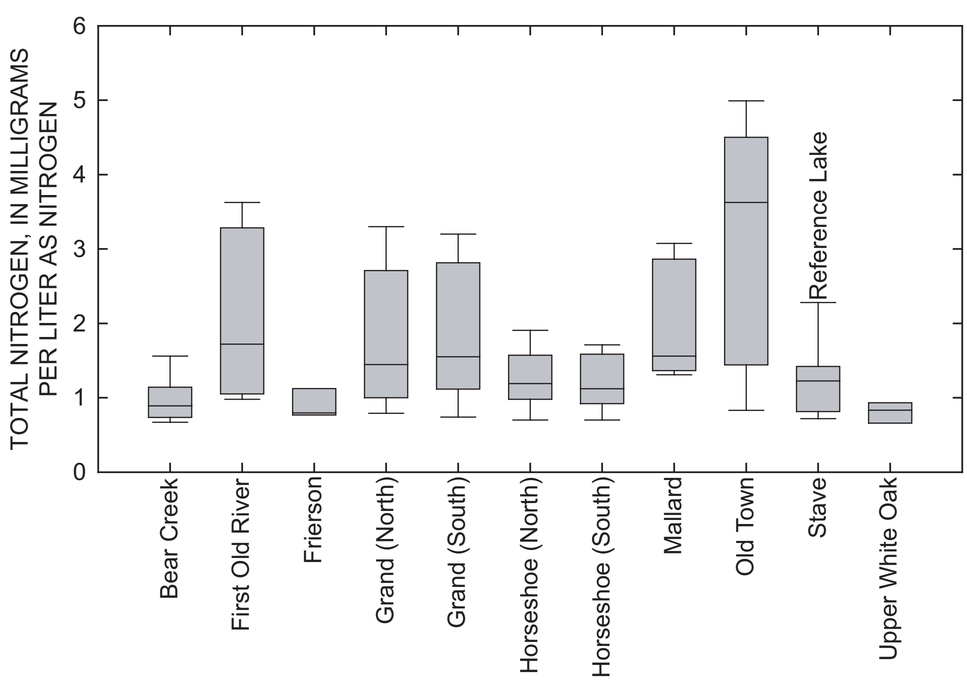

Figure 6. Distribution of nitrogen concentrations at 11 lake sampling sites in Arkansas, August 2004 - July 2005.

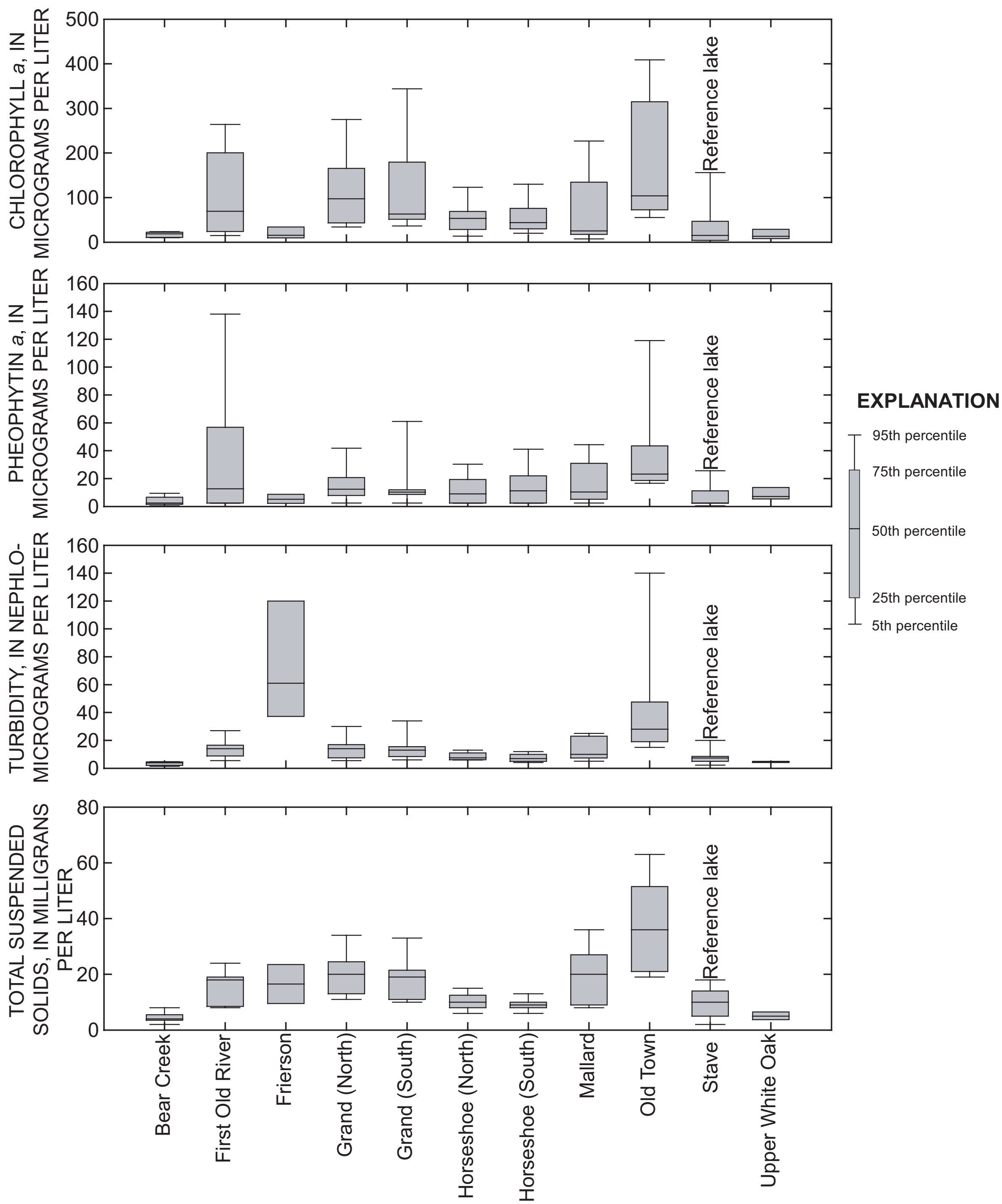

Figure 7. Distribution of chlorophyll *a*, pheophytin *a*, turbidity, and total suspended solids concentrations at 11 lake sampling sites in Arkansas, August 2004 - July 2005.

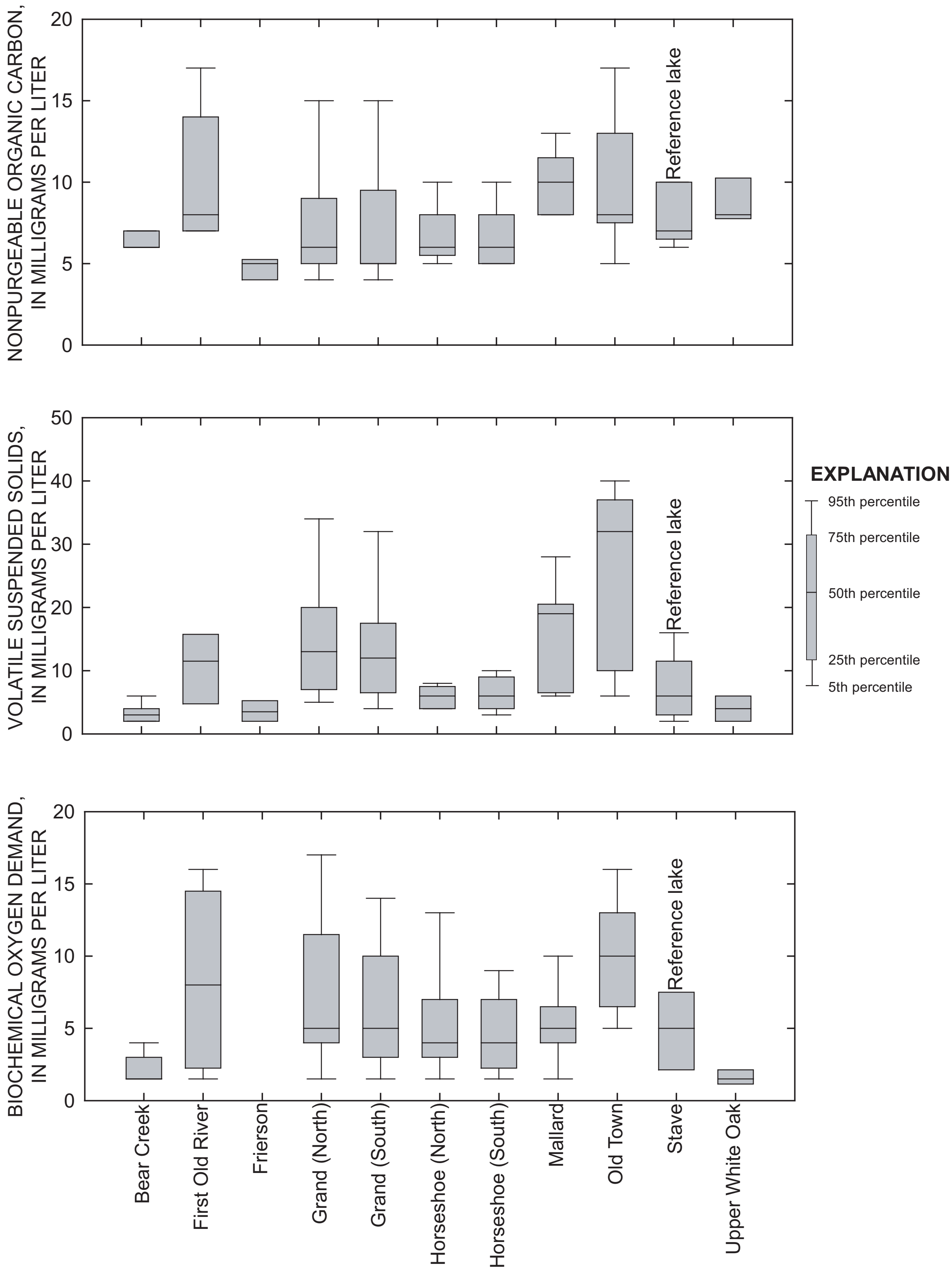

Figure 8. Distribution of nonpurgeable organic carbon, volatile suspended solids, and biochemical oxygen demand (not measured at Lake Frierson) concentrations at 11 lake sampling sites in Arkansas, August 2004 - July 2005.

Table 5. Laboratory results for constituents analyzed at 11 water-quality monitoring sites, August 2004 - July 2005.

[mg/L, milligrams per liter; P, phosphorus; N, nitrogen; µg/L, micrograms per liter; NTU, nephlometric turbidity units; <, less than; **bold**, total nitrogen was calculated by adding “ammonia plus organic nitrogen” concentrations to nitrate concentrations using one-half of the laboratory detection limit when necessary; le; laboratory error, value not reported; md, missing data; --, constituent not sampled at this lake; ortho-phosphorus, nitrate, and nitrite samples were analyzed using two different methods and have two laboratory detection limits reported]

Sample date	Ortho-phosphorus, (mg/L as P)	Phos-phorus. total (mg/L as P)	Ammonia nitrogen, (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Nitrate, (mg/L as N)	Nitrite, (mg/L as N)	Total nitrogen (mg/L)	Pheo-phytin *a* (µg/L)	Chloro-phyll *a* (µg/L)	Turbidity (NTU)	Nonpurge-able organic carbon (mg/L)	Total sus-pended solids (mg/L)	Volatile sus-pended solids (mg/L)	Biochemical oxygen demand (mg/L)
Bear Creek Lake														
08/24/04	<0.06	<0.05	<0.05	1.02	<0.05	<0.05	**1.02**	9.4	23.5	4.6	7	8	6	4
09/21/04	<0.06	<0.05	0.15	0.83	<0.05	<0.05	**0.83**	6.7	13.9	1.4	6	2	2	<3
10/19/04	<0.06	<0.05	0.31	0.94	<0.05	<0.05	**0.94**	<1.0	9.79	2.1	7	4	2	<3
12/06/04	<0.06	<0.05	0.42	1.15	0.09	<0.05	**1.24**	<1.0	10.3	2.2	6	4	2	<3
02/08/05	<0.02	<0.05	0.07	0.68	0.21	<0.02	**0.89**	6.6	23.0	20.0	6	4	2	<3
04/26/05	0.02	<0.05	<0.05	1.54	0.02	<0.02	**1.56**	<5.0	18.7	4.5	7	6	4	<3
05/16/05	<0.02	0.05	0.05	0.73	<0.02	<0.02	**0.73**	<5.0	21.4	4.8	6	5	4	3
06/07/05	<0.02	<0.05	<0.05	0.66	<0.02	<0.02	**0.66**	<5.0	11.2	3.9	6	5	3	3
07/26/05	<0.02	<0.05	<0.05	0.72	<0.02	<0.02	**0.72**	<5.0	20.3	4.3	7	3	3	<3
Minimum	<0.02	<0.05	<0.05	0.66	<0.02	<0.02	0.66	<1.0	9.89	1.4	6	2	2	<3
Maximum	<0.06	0.05	0.42	1.54	0.21	<0.05	1.56	9.4	23.5	4.8	7	8	6	4
Median[1]	0.02	0.03	0.05	0.83	<0.05	<0.02	0.89	6.6	18.7	3.9	6	4	3	<3
First Old River Lake														
08/23/04	0.15	0.31	<0.05	3.47	<0.05	<0.05	**3.50**	47.7	95.0	15.0	12	20	16	16
09/20/04	0.09	0.28	<0.05	3.60	<0.05	<0.05	**3.63**	12.7	254	15.0	15	18	15	16
10/18/04	<0.06	0.16	<0.05	2.83	<0.05	<0.05	**2.86**	138	147	14.0	13	18	15	9
12/06/04	<0.06	0.20	<0.05	1.58	0.14	<0.05	**1.72**	65.9	69.4	27.0	7	24	le	8
02/07/05	0.04	0.09	0.09	1.29	0.05	<0.02	**1.34**	13.8	15.0	12.0	7	8	3	<3
04/25/05	0.02	0.06	<0.05	0.98	<0.02	<0.02	**0.99**	<5.0	17.7	8.2	7	8	4	<3
05/17/05	0.03	<0.05	<0.05	0.97	<0.02	<0.02	**0.98**	<5.0	39.4	9.5	8	9	8	4
06/06/05	0.03	0.09	<0.05	1.10	<0.02	<0.02	**1.11**	9.6	30.3	5.5	7	10	7	3
07/25/05	0.31	0.45	<0.05	3.06	<0.02	0.03	**3.07**	<5.0	264	18.0	17	18	18	13

Table 5. Laboratory results for constituents analyzed at 11 water-quality monitoring sites, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; P, phosphorus; N, nitrogen; µg/L, micrograms per liter; NTU, nephlometric turbidity units; <, less than; **bold**, total nitrogen was calculated by adding “ammonia plus organic nitrogen” concentrations to nitrate concentrations using one-half of the laboratory detection limit when necessary; le; laboratory error, value not reported; md, missing data; --, constituent not sampled at this lake; orthophosphorus, nitrate, and nitrite samples were analyzed using two different methods and have two laboratory detection limits reported]

Sample date	Orthophosphorus, (mg/L as P)	Phosphorus. total (mg/L as P)	Ammonia nitrogen, (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Nitrate, (mg/L as N)	Nitrite, (mg/L as N)	Total nitrogen (mg/L)	Pheophytin *a* (µg/L)	Chlorophyll *a* (µg/L)	Turbidity (NTU)	Nonpurgeable organic carbon (mg/L)	Total suspended solids (mg/L)	Volatile suspended solids (mg/L)	Biochemical oxygen demand (mg/L)
Minimum	0.02	<0.05	<0.05	0.97	<0.02	<0.02	0.98	<5.0	15.0	5.5	7	8	3	<3
Maximum	0.31	0.45	0.09	3.60	0.14	0.03	3.63	138	264	27.0	17	24	18	16
Median[1]	0.04	0.18	0.09	1.58	0.10	0.03	1.72	30.8	69.4	14.0	8	18	12	9
Grand Lake (North)														
08/24/04	0.08	0.20	<0.05	2.78	<0.05	<0.05	**2.78**	23.4	101	16.0	8	25	19	12
09/20/04	0.07	0.26	<0.05	2.59	<0.05	<0.05	**2.59**	18.0	230	14.0	10	22	21	17
10/19/04	<0.06[2]	0.15	<0.05	1.34	<0.05[2]	<0.05[2]	**1.34**	41.8	97.5	16.0	7	20	13	5
12/06/04	<0.06	0.06	<0.05	1.42	<0.05	<0.05	**1.42**	15.8	73.2	6.2	5	11	7	5
02/08/05	0.04	0.06	<0.05	0.78	<0.02	<0.02	**0.78**	12.4	35.8	5.5	4	12	5	<3
04/26/05	0.03	0.08	<0.05	0.92	<0.02	<0.02	**0.92**	<5.0	34.0	8.7	5	14	7	4
05/17/05	0.04	0.09	0.05	1.06	<0.02	<0.02	**1.06**	8.5	50.7	12.0	5	19	9	4
06/07/05	0.07	0.12	<0.05	1.64	<0.02	<0.02	**1.64**	9.2	100	18.0	6	24	17	7
07/25/05	0.18	0.32	<0.05	3.29	<0.02	0.03	**3.29**	7.2	275	30.0	15	34	34	11
Minimum	0.03	0.06	<0.05	0.78	<0.02	<0.02	0.78	<5.0	34.0	5.5	4	11	5	<3
Maximum	0.18	0.32	0.05	3.29	<0.05	<0.05	3.30	41.8	275	30.0	15	34	34	17
Median[1]	0.06	0.12	0.03	1.42	0.01	0.02	1.45	14.1	97.5	14.0	6	20	13	5
Grand Lake (South)														
08/24/04	0.12	0.22	0.10	2.60	<0.05	<0.05	**2.60**	8.8	63.0	14.0	8	21	18	10
09/20/04	<0.06	0.19	<0.05	2.98	<0.05	<0.05	**2.98**	9.1	256	14.0	11	19	17	14
10/19/04	<0.06[2]	0.15	<0.05	1.75	<0.05[2]	<0.05[2]	**1.75**	61.0	80.1	13.0	7	22	13	5
12/06/04	<0.06	0.05	<0.05	1.38	<0.05	<0.05	**1.38**	11.2	56.1	7.8	5	10	7	3
02/08/05	0.04	0.07	<0.05	0.73	<0.02	<0.02	**0.73**	10.4	36.3	6.0	4	11	4	<3
04/26/05	0.03	0.06	<0.05	0.99	<0.02	<0.02	**0.99**	<5.0	46.7	8.9	5	11	6	3
05/17/05	0.04	0.08	<0.05	1.22	<0.02	<0.02	**1.22**	8.5	63.2	10.0	5	15	9	4

Table 5. Laboratory results for constituents analyzed at 11 water-quality monitoring sites, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; P, phosphorus; N, nitrogen; µg/L, micrograms per liter; NTU, nephlometric turbidity units; <, less than; **bold**, total nitrogen was calculated by adding “ammonia plus organic nitrogen” concentrations to nitrate concentrations using one-half of the laboratory detection limit when necessary; le; laboratory error, value not reported; md, missing data; --, constituent not sampled at this lake; ortho-phosphorus, nitrate, and nitrite samples were analyzed using two different methods and have two laboratory detection limits reported]

Sample date	Ortho-phosphorus, (mg/L as P)	Phos-phorus. total (mg/L as P)	Ammonia nitrogen, (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Nitrate, (mg/L as N)	Nitrite, (mg/L as N)	Total nitrogen (mg/L)	Pheo-phytin *a* (µg/L)	Chloro-phyll *a* (µg/L)	Turbidity (NTU)	Nonpurge-able organic carbon (mg/L)	Total sus-pended solids (mg/L)	Volatile sus-pended solids (mg/L)	Biochemical oxygen demand (mg/L)
06/07/05	0.06	0.09	<0.05	1.54	<0.02	<0.02	**1.54**	10.3	103	17.0	5	21	12	6
07/25/05	0.20	0.33	<0.05	3.19	<0.02	0.03	**3.19**	12.6	344	34.0	15	33	32	10
Minimum	0.03	0.05	<0.05	0.73	<0.02	<0.02	0.73	<5.0	36.3	6.0	4	10	4	<3
Maximum	0.20	0.33	0.10	3.19	<0.05	<0.05	3.19	61.0	344	34.0	15	33	32	14
Median[1]	0.04	0.09	0.03	1.54	0.01	0.03	1.55	10.4	63.2	13.0	5	19	12	5
Horseshoe Lake (North)														
08/24/04	<0.06	0.08	<0.05	1.88	<0.05	<0.05	**1.88**	9.1	69.4	13.0	8	15	8	13
09/21/04	<0.06	<0.05	<0.05	1.34	<0.05	<0.05	**1.34**	30.3	68.4	7.5	8	13	7	5
10/18/04	<0.06	0.07	0.07	1.09	<0.05	<0.05	**1.09**	17.7	55.5	6.0	8	9	7	4
12/06/04	<0.06	0.06	<0.05	1.13	0.06	<0.05	**1.19**	21.1	38.7	7.4	5	10	4	3
02/08/05	0.02	0.18	<0.05	0.69	<0.02	<0.02	**0.69**	10.5	13.4	5.9	5	8	4	<3
04/26/05	0.03	0.06	<0.05	0.92	<0.02	<0.02	**0.92**	<5.0	27.4	10.0	6	12	5	3
05/16/05	<0.02	0.08	0.05	1.02	<0.02	<0.02	**1.02**	5.2	29.4	6.3	6	8	6	4
06/07/05	0.04	0.07	<0.05	1.26	<0.02	<0.02	**1.26**	<5.0	53.4	9.2	6	6	4	6
07/26/05	0.05	0.09	<0.05	1.77	<0.02	<0.02	**1.77**	<5.0	123	12.0	10	10	8	8
Minimum	0.02	<0.05	<0.05	0.69	<0.02	<0.02	0.69	<5.0	13.4	5.9	5	6	4	<3
Maximum	<0.06	0.18	0.07	1.88	0.06	0.03	1.88	30.3	123	13.0	10	15	8	13
Median[1]	0.05	0.07	<0.05	1.13	<0.02	<0.02	1.19	9.1	53.4	7.5	6	10	6	4
Horseshoe Lake (West)														
08/24/04	<0.06	0.09	<0.05	1.65	<0.05	<0.05	**1.65**	6.0	67.3	11.0	8	10	9	9
09/21/04	<0.06	<0.05	<0.05	1.47	<0.05	<0.05	**1.47**	41.1	84.1	6.9	8	9	8	6
10/19/04	<0.06	0.07	0.14	1.11	<0.05	<0.05	**1.11**	24.6	43.8	4.5	7	8	5	4
12/06/04	<0.06	0.06	<0.05	0.84	0.11	<0.05	**0.95**	19.4	27.4	5.4	5	8	4	<3
02/08/05	0.02	<0.05	<0.05	0.69	<0.02	<0.02	**0.69**	11.3	20	4.1	5	6	3	<3

Table 5. Laboratory results for constituents analyzed at 11 water-quality monitoring sites, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; P, phosphorus; N, nitrogen; µg/L, micrograms per liter; NTU, nephlometric turbidity units; <, less than; **bold**, total nitrogen was calculated by adding "ammonia plus organic nitrogen" concentrations to nitrate concentrations using one-half of the laboratory detection limit when necessary; le; laboratory error, value not reported; md, missing data; --, constituent not sampled at this lake; orthophosphorus, nitrate, and nitrite samples were analyzed using two different methods and have two laboratory detection limits reported]

Sample date	Orthophosphorus, (mg/L as P)	Phosphorus. total (mg/L as P)	Ammonia nitrogen, (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Nitrate, (mg/L as N)	Nitrite, (mg/L as N)	Total nitrogen (mg/L)	Pheophytin *a* (µg/L)	Chlorophyll *a* (µg/L)	Turbidity (NTU)	Nonpurgeable organic carbon (mg/L)	Total suspended solids (mg/L)	Volatile suspended solids (mg/L)	Biochemical oxygen demand (mg/L)
04/26/05	0.02	0.06	<0.05	0.88	<0.02	<0.02	**0.88**	<5.0	32	8.9	5	10	4	3
05/16/05	<0.02	0.08	<0.05	0.97	<0.02	<0.02	**0.97**	<5.0	39.4	6.4	6	8	6	4
06/07/05	0.03	0.06	<0.05	1.11	<0.02	<0.02	**1.11**	<5.0	48.1	7.8	6	13	10	5
07/26/05	0.05	0.10	<0.05	1.7	<0.02	<0.02	**1.70**	11.2	130	12.0	10	10	9	8
Minimum	<0.02	<0.05	<0.05	0.69	<0.02	<0.02	0.69	<5.0	20.0	4.1	5	6	3	<3
Maximum	0.05	0.10	0.14	1.70	0.11	<0.05	1.70	41.1	130	12.0	10	13	10	9
Median[1]	0.03	0.06	0.03	1.11	<0.02	<0.02	1.11	15.4	43.8	6.9	6	9	6	4
Lake Frierson														
08/24/04	<0.06	0.27	--	1.02	0.14	<0.05	**1.16**	1.3	4.3	120	4	28	6	--
10/20/04	<0.06	0.27	--	1.02	0.09	<0.05	**1.11**	10.2	16.0	120	4	17	3	--
12/06/04	<0.06	0.19	--	0.57	0.21	<0.05	**0.78**	7.74	42.7	78	5	22	4	--
02/09/05	0.08	0.12	--	0.72	0.07	0.02	**0.79**	8.24	31.3	39	5	8	2	--
04/27/05	0.07	0.12	--	0.80	<0.02	0.02	**0.80**	<5	14.7	32	6	16	5	--
06/08/05	0.07	0.16	--	0.73	<0.02	0.03	**0.73**	<5	11.6	44	5	10	2	--
Minimum	<0.06	0.12	--	0.57	<0.02	0.02	0.73	1.34	4.3	32	4	8	2	--
Maximum	0.08	0.27	--	1.02	0.21	0.03	1.16	10.2	42.7	120	6	28	6	--
Mallard Lake														
08/24/04	<0.06	0.28	0.16	2.72	<0.05	<0.05	**2.72**	33.8	24.6	24.0	10	25	20	6
09/22/04	<0.06	0.18	<0.05	3.05	<0.05	<0.05	**3.05**	28.0	168	22.0	12	29	21	7
10/20/04	<0.06	0.20	<0.05	2.79	<0.05	<0.05	**2.79**	44.3	101	20.0	11	36	28	6
12/06/04	<0.06[3]	0.10	<0.05	1.49	<0.05	<0.05	**1.49**	3.9	7.3	10.0	8	24	20	4
02/09/05	0.03	0.09	<0.05	1.35	<0.02	<0.02	**1.35**	15.2	17.8	5.1	8	10	7	5
04/26/05	0.03	0.10	<0.05	1.55	<0.02	<0.02	**1.55**	<5.0	25.4	9.1	9	12	8	4
05/16/05	0.03	0.10	<0.05	1.30	<0.02	<0.02	**1.30**	6.5	28.0	7.1	10	8	6	4

Table 5. Laboratory results for constituents analyzed at 11 water-quality monitoring sites, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; P, phosphorus; N, nitrogen; µg/L, micrograms per liter; NTU, nephlometric turbidity units; <, less than; **bold**, total nitrogen was calculated by adding "ammonia plus organic nitrogen" concentrations to nitrate concentrations using one-half of the laboratory detection limit when necessary; le; laboratory error, value not reported; md, missing data; --, constituent not sampled at this lake; orthophosphorus, nitrate, and nitrite samples were analyzed using two different methods and have two laboratory detection limits reported]

Sample date	Orthophosphorus, (mg/L as P)	Phosphorus. total (mg/L as P)	Ammonia nitrogen, (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Nitrate, (mg/L as N)	Nitrite, (mg/L as N)	Total nitrogen (mg/L)	Pheophytin *a* (µg/L)	Chlorophyll *a* (µg/L)	Turbidity (NTU)	Nonpurgeable organic carbon (mg/L)	Total suspended solids (mg/L)	Volatile suspended solids (mg/L)	Biochemical oxygen demand (mg/L)
06/08/05	0.03	0.08	<0.05	1.36	<0.02	<0.02	**1.36**	6.5	17.4	7.6	8	8	6	<3
07/26/05	0.10	0.20	<0.05	2.90	<0.02	0.03	**2.90**	10.4	227	25	13	20	19	10
Minimum	0.03	0.08	<0.05	1.30	<0.02	<0.02	1.30	3.9	7.3	5.1	8	8	6	<3
Maximum	0.10	0.28	0.16	3.05	<0.05	<0.05	3.05	44.3	227	25	13	36	28	10
Median[1]	0.03	0.10	<0.05	1.55	<0.02	0.03	1.55	10.4	25.4	10	10	20	19	5
Old Town Lake														
08/24/04	<0.06	0.31	<0.05	3.60	<0.05	<0.05	**3.60**	40.4	82.2	28.0	10	41	32	14
09/21/04	<0.06	0.30	<0.05	4.30	<0.05	<0.05	**4.30**	46.5	256	42.0	13	58	40	12
10/19/04	<0.06	0.36	0.12	4.65	<0.05	<0.05	**4.65**	119.0	166	140	13	63	40	11
12/06/04	<0.06	0.11	<0.05	1.78	<0.05	<0.05	**1.78**	22.2	55.3	15.0	8	19	10	6
02/08/05	0.07	0.16	<0.05	1.07	<0.02	<0.02	**1.07**	16.6	63.2	20.0	5	21	6	5
04/26/05	0.07	0.21	<0.05	0.82	<0.02	<0.02	**0.82**	19.8	91.7	18.0	7	21	10	7
05/16/05	0.09	0.20	<0.05	2.05	<0.02	<0.02	**2.05**	17.4	104	22.0	8	23	19	8
06/07/05	0.16	0.35	0.06	4.26	<0.02	0.03	**4.26**	23.2	409	46.0	8	45	32	16
07/26/05	0.41	0.68	<0.05	4.98	<0.02	0.05	**4.98**	26.2	374	49.0	17	36	34	10
Minimum	<0.06	0.11	<0.05	0.82	<0.02	<0.02	0.82	16.6	55.3	15.0	5	19	6	5
Maximum	0.41	0.68	0.12	4.98	<0.05	0.05	4.98	119.0	409	140	17	63	40	16
Median[1]	0.07	0.30	<0.05	3.60	<0.02	<0.05	3.63	23.2	104	28.0	8	36	32	10
Stave Lake														
08/25/04	<0.06	0.11	<0.05	1.20	<0.05	<0.05	**1.2**	2.2	10.2	7.4	7	12	8	4
09/21/04	<0.06	0.06	<0.05	1.34	<0.05	<0.05	**1.34**	<1.0	48.1	7.7	10	12	9	5
10/19/04	<0.06	0.12	<0.05	1.45	<0.05	<0.05	**1.45**	25.6	45.4	8.9	10	18	14	6
12/06/04	<0.06	0.07	<0.05	1.18	0.06	<0.05	**1.24**	4.8	15.1	6.5	6	8	4	<3
02/08/05	0.04	0.13	<0.05	1.06	<0.02	<0.02	**1.06**	3.2	7.6	8.1	6	10	6	8

Table 5. Laboratory results for constituents analyzed at 11 water-quality monitoring sites, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; P, phosphorus; N, nitrogen; µg/L, micrograms per liter; NTU, nephlometric turbidity units; <, less than; **bold**, total nitrogen was calculated by adding "ammonia plus organic nitrogen" concentrations to nitrate concentrations using one-half of the laboratory detection limit when necessary; le; laboratory error, value not reported; md, missing data; --, constituent not sampled at this lake; orthophosphorus, nitrate, and nitrite samples were analyzed using two different methods and have two laboratory detection limits reported]

Sample date	Orthophosphorus, (mg/L as P)	Phosphorus. total (mg/L as P)	Ammonia nitrogen, (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Nitrate, (mg/L as N)	Nitrite, (mg/L as N)	Total nitrogen (mg/L)	Pheophytin *a* (µg/L)	Chlorophyll *a* (µg/L)	Turbidity (NTU)	Nonpurgeable organic carbon (mg/L)	Total suspended solids (mg/L)	Volatile suspended solids (mg/L)	Biochemical oxygen demand (mg/L)
04/27/05	0.07	0.12	<0.05	0.76	<0.02	<0.02	**0.76**	<5.0	<10.0	4.0	7	2	2	md
05/16/05	0.05	0.10	<0.05	0.71	<0.02	<0.02	**0.71**	<5.0	<10.0	2.2	7	2	2	<3
06/07/05	0.04	0.10	<0.05	0.85	<0.02	<0.02	**0.85**	<5.0	27.6	5.9	8	8	4	5
07/26/05	0.08	0.17	<0.05	2.27	<0.02	0.02	**2.28**	17.6	156	20.0	10	16	16	10
Minimum	0.04	0.06	<0.05	0.71	<0.02	0.02	0.71	<1.0	7.6	2.2	6	2	2	<3
Maximum	0.08	0.17	<0.05	2.27	0.06	<0.05	2.28	25.6	156	20.0	10	18	16	10
Median[1]	<0.06	0.11	0.03	1.18	<0.02	0.02	1.20	4.8	27.6	7.4	7	10	6	5
Upper White Oak Lake														
08/23/04	<0.06	0.05	<0.05	0.89	<0.05	<0.05	**0.92**	20.1	28.8	5.0	11	6	6	4
10/18/04	<0.06	<0.05	0.09	0.80	<0.05	<0.05	**0.83**	11.5	14.7	4.2	10	4	2	<3
12/06/04	<0.06	0.06	0.14	0.89	0.10	<0.05	**0.99**	3.7	7.5	4.4	8	4	le	<3
02/07/05	0.02	<0.05	<0.05	0.44	0.09	<0.02	**0.53**	6.5	8.0	4.9	8	3	2	<3
04/25/05	0.05	0.10	<0.05	0.69	<0.02	<0.02	**0.70**	5.9	28.7	4.7	8	8	4	md
06/06/05	<0.02	<0.05	<0.05	0.83	<0.02	<0.02	**0.84**	7.7	11.6	3.7	7	6	6	<3
Minimum	<0.02	<0.05	<0.05	0.44	<0.02	<0.02	0.53	3.7	7.5	3.7	7	3	2	<3
Maximum	0.05	0.10	0.14	0.89	0.10	0.03	0.99	20.1	28.8	5.0	11	8	6	4
Median[1]	0.03	0.05	<0.05	0.82	<0.05	0.02	0.83	7.1	13.2	4.6	8	5	4	<3

[1]Values were calculated using one-half of the laboratory detection limits.

[2]Sampling holding times exceeded.

[3]The continuing calibration blank (CCB) at the laboratory was greater than one-half the method reporting limit for orthophosphorus; however, the sample result of <0.06 mg/L indicated that there was minor CCB contamination.

Turbidity and Related Measures

Turbidity results indicate that Lake Frierson is impaired by clay turbidity. Lake Frierson had highest median turbidity concentrations, and values measured at the site were never below the ADEQ numeric criteria of 25 NTUs (fig. 7). Secchi depth at Lake Frierson also was generally lower than at other lakes (fig. 9, table 6), an indication of low light penetration at Lake Frierson. Suspended-solids concentrations at Lake Frierson were mid-range compared to the other lakes—probably a consequence of high phytoplankton density at lakes with more light transparency.

Chloride, Sulfate, and Total Dissolved Solids

Concentrations of chloride, sulfate, and total dissolved solids were similar at Lake Calion and Lake June and were not close to exceeding State standards of 250, 250, and 500 mg/L more than 10 percent of the time. However, concentrations for chloride at Lake Calion and Lake June were about six to nine times higher than concentrations at Upper White Oak Lake (the chloride reference lake) (fig. 10, table 7), and concentrations of sulfate and total dissolved solids were about two times higher than concentrations at Upper White Oak Lake.

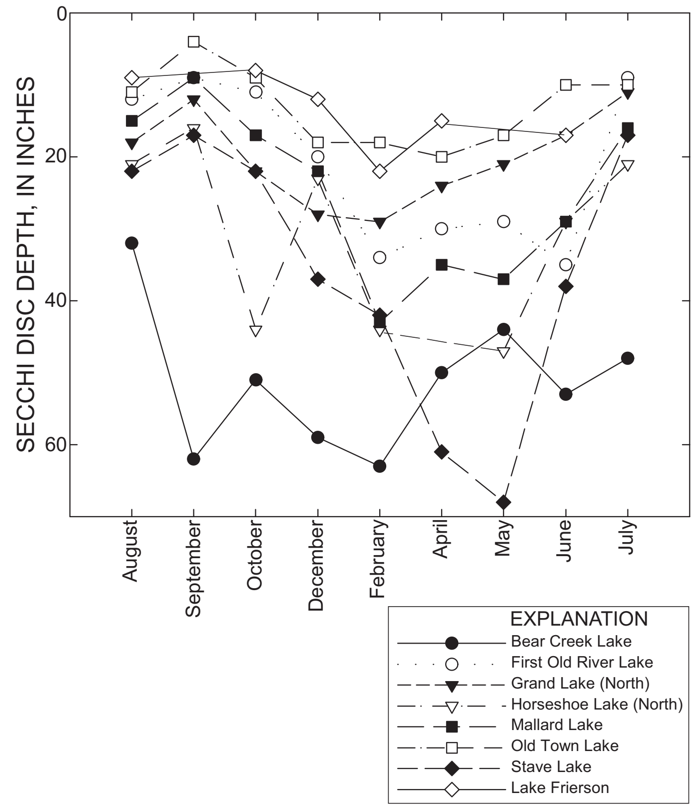

Figure 9. Secchi depth (inches) for eight Arkansas lakes sampled for nutrients from August 2004 - July 2005 (data for each month were collected over a 2 or 3-day period).

Table 6. Secchi disc depth for lake sites sampled from August 2004 - July 2005.

[Data for each month were collected over a 2- or 3-day period. Values in inches; --, site not sampled; md, missing data]

Lake Name	August	September	October	December	February	April	May	June	July	Median
Bear Creek	32	62	51	59	63	50	44	53	48	51
Calion	35	--	28	32	39	30	--	41	--	--
First Old River	12	9	11	20	34	30	29	35	9	20
Frierson	9	--	8	12	22	15	--	17	--	--
Grand (North)	18	12	22	28	29	24	21	17	11	21
Grand (South)	20	10	18	30	28	32	23	19	11	20
Horseshoe (North)	21	16	44	23	44	md	47	29	21	26
Horseshoe (West)	md	22	45	42	47	35	35	30	18	35
June	24	--	22	29	37	27	--	31	--	--
Mallard	15	9	17	22	43	35	37	29	16	22
Old Town	11	4	9	18	18	20	17	10	10	11
Stave	22	17	22	37	42	61	68	38	17	37
Upper White Oak	40	--	40	65	62	42	--	46	--	--

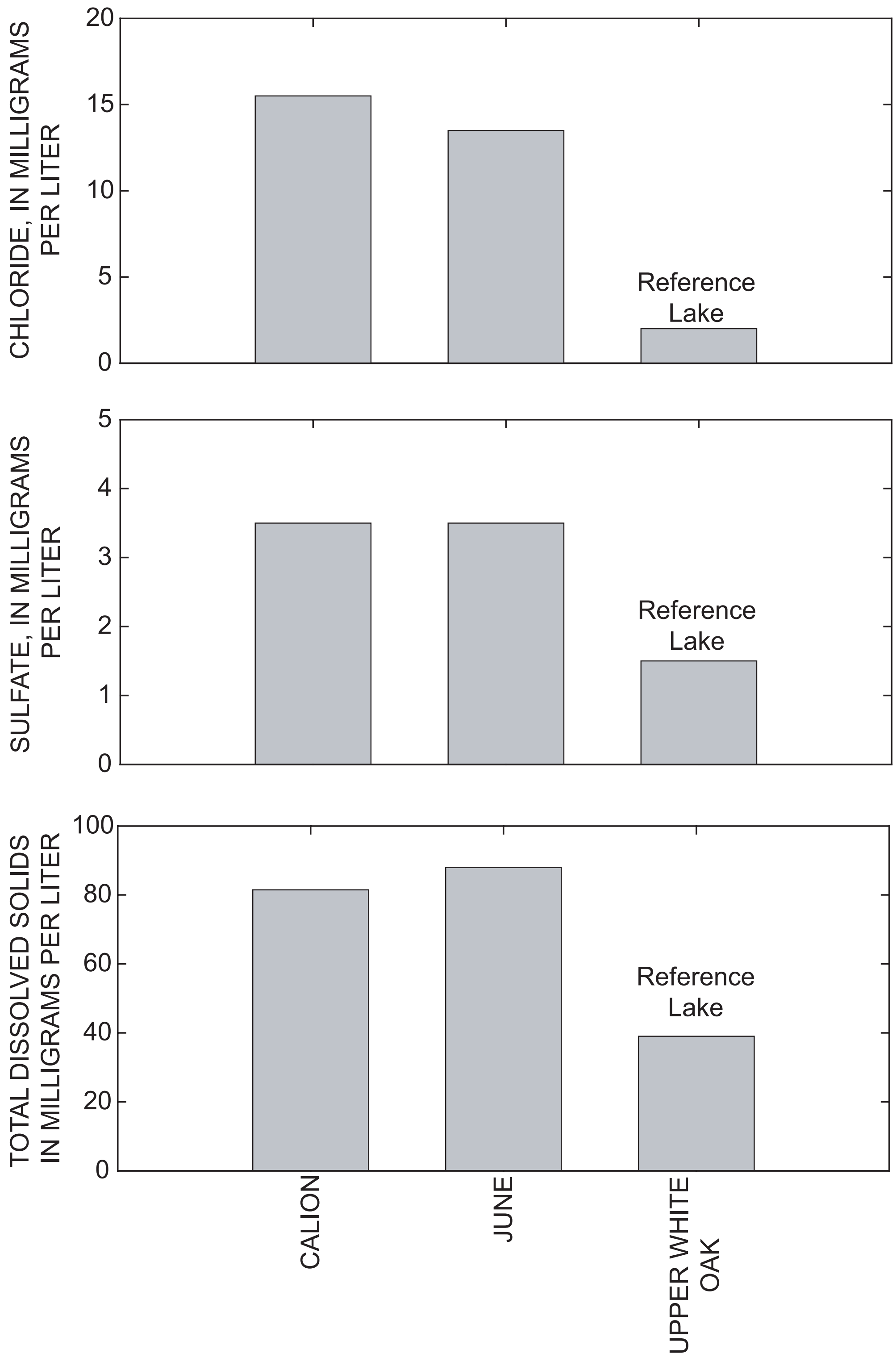

Figure 10. Median concentrations for six chloride, sulfate, and total dissolved solid samples collected at three lakes in southern Arkansas, August 2004 - July 2005.

Table 7. Chloride, sulfate, and total dissolved solids at three lakes in southern Arkansas, August 2004 - July 2005.

[mg/L, milligram per liter]

Sample date	Chloride (mg/L)	Sulfate (mg/L)	Total dissolved solids (mg/L)
Lake Calion			
08/23/04	15.0	1.0	72.0
10/20/04	20.0	3.0	85.0
12/08/04	16.0	4.0	82.0
02/07/05	12.0	4.0	70.0
04/26/05	15.0	4.0	81.0
06/06/05	19.0	3.0	88.0
Minimum	12.0	1.0	70.0
Maximum	20.0	4.0	88.0
Median	15.5	3.5	81.5
Lake June			
08/23/04	12.0	<1.0	104
10/20/04	13.0	4.0	91.0
12/08/04	13.0	5.0	93.0
02/07/05	18.0	5.0	84.0
04/26/05	14.0	3.0	84.0
06/06/05	15.0	2.0	85.0
Minimum	12.0	<1.0	84.0
Maximum	18.0	5.0	104
Median	13.5	4.0	88.0
Upper White Oak Lake[1]			
08/23/04	2.0	1.0	50.0
10/18/04	2.0	1.0	42.0
12/06/04	2.0	2.0	37.0
02/07/05	2.0	2.0	40.0
04/25/05	2.0	2.0	32.0
06/06/05	2.0	1.0	38.0
Minimum	2.0	1.0	32.0
Maximum	2.0	2.0	50.0
Median	2.0	1.5	39.0

[1]See table 5 for other constituent results at Upper White Oak Lake.

Lake Water-Column Profile

Physical and chemical data from a lake water-column profile indicate the limnological characteristics of the lake and possible relations of those characteristics to seasonal variability and physical characteristics. Lake profile data indicate that most of the lakes were stratified from early summer into early fall but were well mixed from late fall through spring (appendix 1). Dissolved-oxygen concentrations were lowest in late summer (August) and for most lakes were less than 1 mg/L throughout the hypolimnion. One exception, however, was Horseshoe Lake where dissolved-oxygen concentrations in the hypolimnion typically were higher than dissolved-oxygen concentrations in the hypolimnion of the other lakes (appendix 1).

Aside from the obvious seasonal pattern, stratification characteristics seemed to vary most by lake depth. The deepest lakes, Bear Creek and Horseshoe, were the last lakes to stratify, and both lakes remained stratified longer than the shallower lakes. Lakes that were less than 6-feet deep, such as Stave and Old Town Lakes, did not stratify.

Quality Assurance Information

A review of the field quality assurance data indicates that data in this report are of good quality. Of the 133 blank samples, laboratory detection limits were slightly exceeded on only six occasions. Four of these instances were associated with the analysis of total ammonia plus organic nitrogen, which had environmental concentrations that were typically one to two orders of magnitude above the laboratory detection levels (appendix 2). Of the 54 duplicate samples, only 11 had results that were more than 5 percent different from the associated environmental sample (appendix 3). Possible analytical issues could be associated to pheophytin *a* analysis. All four duplicate samples were greater than 5 percent different than the environmental samples. Of the 21 laboratory duplicates that were analyzed for turbidity, 18 had a percent error that was less than 5 percent (appendix 4).

Summary

In 2002, USEPA evaluated historic water-quality data and observations collected by the ADEQ and by the ANRC at nine lakes located in eastern and southern Arkansas. Using a weight of evidence approach, the USEPA determined that all nine lakes were in violation of either narrative or numeric water-quality standards for Arkansas and added them to the Arkansas 2002 303(d) list of impaired waterbodies. USEPA determined that the narrative nutrient (nitrogen and phosphorus, for example) standard was violated at six lakes—five lakes located in eastern Arkansas in the MAP Ecoregion and one lake located in southeastern Arkansas in the SCP Ecoregion. USEPA also determined that chloride standards were violated at two lakes located in the SCP Ecoregion in south-central Arkansas, and that turbidity standards were violated at one lake located on Crowleys Ridge in northeastern Arkansas in the MAP Ecoregion.

After the USEPA listed the nine lakes on the Arkansas 2002 303(d) list, additional data were needed to characterize water quality. This report documents methods used and describes the results for a water-quality study at 11 lakes—the nine lakes in eastern and southern Arkansas that had been previously placed on the Arkansas 2002 303(d) list, as well as two reference lakes. The study was conducted by the USGS in cooperation with the USEPA.

The scope of the project included lake reconnaissance, selection of the two reference lakes, a 48-hour dissolved-oxygen investigation, water-quality sampling in the 11 lakes between August 2004 - July 2005, and a basic interpretation of the data. Within both the MAP and SCP Ecoregions, three distinct lake types were studied—five lakes were oxbows that exist within the remnant channel of the Red and Mississippi Rivers, three lakes were lowland reservoirs, and three lakes were upland reservoirs.

At all seven lakes selected for the 48-hour dissolved-oxygen investigation, except Bear Creek Lake, dissolved-oxygen concentrations declined below the State standard of 5 mg/L at some time in the 48-hour monitoring period. Dissolved-oxygen (and, to a lesser extent, pH) demonstrate large diurnal fluctuations at five of the lakes—First Old River, Grand, Horseshoe, Mallard, and Old Town Lakes. Dissolved-oxygen concentrations were less than 1.5 mg/L at Mallard Lake and Grand Lake for short periods near daybreak. The State pH standard of "9" was exceeded at all lakes except Stave Lake (the nutrient reference lake).

Highest concentrations of both nutrient and nutrient response variables (chlorophyll *a*, pheophytin *a*, turbidity, nonpurgeable organic carbon, suspended solids, and biochemical oxygen demand) were measured at Old Town Lake generally followed by First Old River, Grand, and Mallard Lakes. Observations made as samples were collected may provide some insight for potential sources of nutrients (aside from row crop agriculture) at three of these four lakes. Cattle usually were grazing along the banks of First Old River Lake and Grand Lake. A small community is located along the edge of Old Town Lake, and given the age of many of the structures, it is possible that septic systems are outdated and untreated waste may be entering the lake.

Aside from ammonia nitrogen concentrations at Bear Creek Lake, concentrations for nutrients and nutrient response variables generally were lowest at Bear Creek, Horseshoe, and Upper White Oak Lakes, and were comparable to concentrations at Stave Lake—the reference lake. Highest concentrations for ammonia nitrogen among all lakes were observed at Bear Creek Lake; however, decomposition of large amounts of leaves deposited near where water-quality samples were collected may have resulted in ammonia nitrogen being cycled into the aquatic environment.

Under similar conditions for light transparency, lakes with highest chlorophyll *a* concentrations would be more likely to be impaired by nutrients while lakes with low chlorophyll *a* concentrations would be less likely to be impaired by nutrients. Median chlorophyll *a* concentrations for Old Town and Grand Lake (North) were highest of all lakes sampled (about 100 μg/L), followed by chlorophyll *a* concentrations at First Old River and Grand Lake (South) (about 63-69 μg/L), followed by Horseshoe Lake (concentrations averaged 49 μg/L). Stave, Bear Creek, and Frierson Lakes had lowest median chlorophyll *a* concentrations (about 15-28 μg/L). Low chlorophyll *a* concentrations at Stave and Bear Creek Lakes probably are related to low nutrient concentrations measured at these sites (and associated low productivity), while low chlorophyll *a* concentrations at Lake Frierson likely are more related to reduced light transparency as a consequence of high clay turbidity.

Lake profile data collected on each sampling occasion show dissolved-oxygen concentrations in the hypolimnion of Horseshoe Lake typically were higher than dissolved-oxygen concentrations in the hypolimnion of the other lakes. Aside from the obvious seasonal pattern, stratification characteristics seemed to vary most by lake depth. The deepest lakes, Bear Creek and Horseshoe, were the last lakes to stratify, and both lakes remained stratified longer than the shallower lakes. Lakes that were less than 6-feet deep, such as Stave and Old Town Lakes, did not stratify.

When concentrations of both nutrient and nutrient response variables among the oxbow lakes (First Old River, Grand, Old Town, Horseshoe) and Stave Lake, the reference lake (and also an oxbow), were compared, Horseshoe and Stave Lakes tended to have lower concentrations and the best overall water quality. Two different physical characteristics that distinguish Stave and Horseshoe Lakes from First Old River, Grand, and Old Town Lakes are a wide wetland buffer (Stave Lake) and greater depth (Horseshoe Lake).

Horseshoe Lake may be deeper and have better water quality than some other oxbow lakes sampled in this study because it has been isolated from the Mississippi River for a shorter time. Still another scenario is that Horseshoe Lake may be deep enough that it maintains some connectivity to the alluvial aquifer (which would dilute and improve water quality in the MAP Ecoregion for most constituents). The influence that depth can

have on water quality should be considered as future water-quality studies of oxbow lakes are planned.

Turbidity results indicate that Lake Frierson is impaired by clay turbidity. Highest median turbidity concentrations were observed at Lake Frierson, and values measured at the site were never below the ADEQ numeric criteria of 25 NTU. Secchi depth (an indication of low light penetration) also was generally lower at Lake Frierson than at other lakes.

Concentrations of chloride, sulfate, and total dissolved solids were similar at the two lakes listed as being impaired by chlorides (Lake Calion and Lake June) but were not close to exceeding State standards of 250, 250, and 500 mg/L more than 10 percent of the time. However, concentrations for chloride at Lake Calion and Lake June were about six to nine times higher than concentrations at Upper White Oak Lake (the chloride reference lake), and concentrations of sulfate and total dissolved solids at Lake Calion and Lake June were about two times higher than concentrations at Upper White Oak Lake.

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Appendixes

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Bear Creek Lake				
08/24/04	12:28	2	27.1	4.5	57	7.4	147
		3	27.1	4.6	58	7.4	147
		4	26.8	4.6	58	7.4	147
		5	26.6	3.0	38	7.3	147
		6	26.6	2.4	30	7.2	147
		7	26.5	1.5	19	7.2	146
		8	26.4	0.9	11	7.1	147
		9	26.2	0.5	6	7.1	152
		10	26.0	0.5	6	7.1	155
		12	25.5	0.5	6	7.0	159
		14	24.1	0.5	5	7.0	175
		16	21.9	0.4	5	6.8	201
		18	19.3	0.4	4	6.8	195
		20	17.6	0.4	4	6.8	185
		23	15.5	0.4	4	6.7	189
		26	14.2	0.4	4	6.6	200
		29	13.2	0.4	3	6.5	231
		32	12.5	0.3	3	6.5	291
		34	12.2	0.3	3	6.5	313
09/21/04	11:27	1	25.7	3.8	45	7.2	145
		2	25.4	3.8	46	7.2	145
		3	25.2	3.6	43	7.2	145
		4	25.2	3.3	39	7.2	145
		5	25.1	3.2	38	7.1	144
		6	25.1	3.0	35	7.1	145
		7	25.1	3.0	35	7.1	145
		8	25.0	2.9	34	7.1	145
		9	25.0	2.9	34	7.0	145
		10	25.0	2.9	34	7.0	145
		11	25.0	2.9	35	7.1	145
		12	25.0	2.9	34	7.1	145
		13	24.9	2.7	32	7.1	146
		14	24.8	2.5	30	7.1	148
		15	24.6	1.6	19	7.0	153
		16	23.4	0.3	4	6.9	180
		20	17.8	0.2	2	6.9	194
		25	14.5	0.2	2	6.9	213
		30	13.0	0.2	2	6.9	271

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		35	12.2	0.2	2	6.9	405
		36	11.9	0.2	2	6.9	445
10/19/04	12:26	1	19.4	3.8	42	7.1	155
		2	19.4	3.7	40	7.1	155
		3	19.3	3.7	40	7.1	155
		4	19.1	3.6	39	7.0	155
		5	19.0	3.5	38	7.0	155
		6	18.8	3.4	36	7.0	155
		7	18.8	3.2	34	6.9	155
		8	18.8	3.1	34	6.9	155
		9	18.7	3.1	33	6.9	155
		10	18.7	2.8	30	6.9	155
		11	18.7	2.7	29	6.9	155
		12	18.6	2.6	28	6.9	156
		13	18.6	2.4	26	6.9	155
		14	18.6	2.3	24	6.9	156
		15	18.6	2.3	24	6.9	156
		16	18.6	2.1	23	6.9	156
		17	18.6	1.9	20	6.9	156
		18	18.5	1.7	18	6.9	157
		19	18.5	1.1	12	6.9	157
		20	18.4	0.7	7	6.8	158
		21	18.4	0.4	4	6.8	159
		22	18.3	0.3	3	6.8	160
		23	18.1	0.2	2	6.8	166
		24	17.1	0.2	2	6.7	215
		25	15.2	0.2	2	6.7	245
		26	14.5	0.2	2	6.7	253
		27	14.2	0.2	2	6.7	256
		28	13.9	0.2	2	6.7	302
		29	13.6	0.2	2	6.7	296
		30	13.5	0.2	1	6.8	308
		32	12.9	0.1	1	6.9	391
12/07/04	13:25	1	13.1	8.9	85	7.3	143
		2	12.9	7.6	72	7.2	143
		3	12.8	7.1	67	7.1	143
		4	12.4	7.0	66	7.0	143
		5	12.4	6.9	64	7.0	143
		6	12.4	6.8	64	7.0	143

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		8	12.3	6.8	64	7.0	143
		9	12.3	6.8	63	7.0	143
		10	12.3	6.8	63	7.0	143
		12	12.3	6.7	63	6.9	143
		14	12.1	6.6	61	7.0	143
		16	12.1	6.4	59	6.9	143
		18	12.0	6.2	57	6.9	143
		20	11.9	6.1	56	6.9	143
		24	11.8	5.9	55	6.9	143
		26	11.8	5.8	54	6.9	143
		28	11.8	5.8	54	6.9	143
		30	11.8	5.8	53	6.9	142
		32	11.8	5.7	53	6.9	142
		34	11.9	5.6	52	6.8	159
02/08/05	13:45	1	8.6	11.5	98	7.5	138
		3	8.5	11.4	98	7.5	138
		5	8.5	11.4	98	7.5	138
		7	8.5	11.4	97	7.5	138
		9	8.5	11.3	96	7.5	138
		11	8.4	11.2	96	7.5	138
		13	8.4	11.2	96	7.5	138
		15	8.0	10.8	92	7.4	138
		16	7.4	10.6	88	7.4	138
		17	7.3	10.1	84	7.3	138
		19	7.2	9.9	82	7.3	138
		21	7.2	9.8	81	7.3	138
		23	7.2	9.7	80	7.2	138
		25	7.2	9.6	79	7.2	138
		27	7.1	9.5	78	7.2	138
		29	7.1	9.4	78	7.2	138
		31	7.1	9.3	77	7.2	138
		33	7.1	9.3	77	7.2	138
		35	7.2	8.2	68	7.3	170
04/26/05	12:09	1	19.5	7.6	83	7.6	156
		2	19.3	7.0	76	7.5	155
		4	19.1	6.9	75	7.5	154
		6	19.0	6.8	73	7.5	152
		8	19.0	6.6	71	7.4	152
		10	19.0	6.5	70	7.4	151

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		12	18.9	6.3	68	7.4	149
		14	18.8	6.2	66	7.4	148
		16	18.4	5.2	56	7.3	147
		18	17.6	2.1	22	7.0	144
		20	16.7	1.3	14	7.0	144
		22	14.3	0.7	7	6.9	146
		24	12.9	0.5	5	6.9	143
		26	12.6	0.4	4	6.9	145
		28	12.1	0.4	4	6.8	147
		30	11.9	0.4	4	6.8	154
		32	11.7	0.3	3	6.9	163
		33	11.7	0.3	2	7.2	179
05/16/05	14:53	1	25.3	10.6	129	8.7	144
		2	25.2	10.5	127	8.7	144
		3	25.2	10.4	127	8.7	144
		4	25.0	10.3	125	8.7	144
		5	24.4	10.3	124	8.7	144
		6	24.0	10.1	120	8.7	144
		7	22.5	8.6	100	8.2	144
		8	21.8	7.4	84	8.0	143
		9	20.7	5.7	63	7.5	143
		10	20.2	3.9	43	7.2	143
		11	19.8	2.6	29	6.9	143
		12	19.2	1.1	12	6.7	143
		13	18.9	0.6	6	6.7	143
		15	18.0	0.5	6	6.6	144
		17	17.3	0.5	5	6.6	146
		19	16.4	0.4	5	6.6	149
		21	15.0	0.4	4	6.6	151
		23	14.0	0.4	4	6.6	150
		25	13.3	0.4	4	6.5	150
		27	12.9	0.4	3	6.6	152
		29	12.6	0.4	3	6.5	157
		31	12.3	0.4	3	6.6	161
		33	12.1	0.3	3	6.6	180
		35	11.9	0.3	3	6.7	193
		37	11.6	0.3	3	6.7	219
06/07/05	12:53	1	28.7	10.5	135	8.4	149
		2	28.3	10.5	135	8.4	148

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; μS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (μS/cm)
		3	28.2	10.4	133	8.4	148
		4	27.9	10.0	127	8.4	148
		5	27.5	8.8	112	8.2	148
		6	27.2	8.3	105	8.1	148
		7	26.8	7.7	97	8.0	148
		8	26.1	6.5	80	7.9	148
		9	25.4	4.3	52	7.6	148
		10	24.1	2.5	30	7.3	147
		11	22.6	0.7	8	6.9	146
		12	21.2	0.6	6	6.7	149
		13	19.8	0.5	5	6.8	154
		14	18.6	0.5	5	6.2	155
		15	18.0	0.4	4	6.2	153
		16	17.4	0.4	4	6.4	153
		17	16.7	0.4	4	6.4	154
		18	16.4	0.4	4	6.0	154
		19	15.8	0.4	4	6.5	154
		20	15.5	0.3	3	6.3	154
		21	14.9	0.3	3	6.3	154
		22	14.3	0.3	3	6.3	159
		23	13.9	0.3	3	6.3	159
		24	13.6	0.3	3	6.0	156
		25	13.3	0.3	3	6.3	163
		26	13.2	0.3	3	6.7	166
		27	13.1	0.3	3	6.4	169
		28	12.9	0.3	3	6.6	173
		29	12.7	0.3	2	6.5	169
		30	12.5	0.3	2	6.6	171
		31	12.3	0.3	2	6.4	182
		32	12.2	0.3	2	6.5	192
		33	12.0	0.3	2	6.7	206
		34	12.0	0.3	2	6.4	212
		35	12.0	0.3	3	6.2	217
		36	11.9	0.3	3	6.4	245
07/26/05	9:35	1	31.6	10.3	141	8.8	147
		2	31.6	10.3	139	8.8	147
		3	31.4	10.2	138	8.8	147
		4	31.3	9.8	133	8.7	147
		5	30.9	9.6	129	8.6	146
		6	30.3	9.0	119	8.5	145

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		7	29.9	6.9	91	8.0	145
		8	29.6	5.7	75	7.8	145
		9	29.2	4.6	60	7.6	145
		10	28.9	2.9	38	7.4	144
		11	28.4	2.0	26	7.4	143
		12	26.9	1.0	13	7.2	146
		13	25.6	1.0	12	7.0	151
		14	24.5	0.8	10	6.9	157
		15	23.2	1.1	13	6.9	173
		16	22.4	0.8	9	6.9	183
		17	20.3	1.1	12	6.9	192
		18	18.9	0.9	10	6.8	189
		19	17.5	0.8	9	6.7	184
		20	16.3	0.8	8	6.7	183
		21	15.5	0.7	7	6.6	179
		22	15.0	0.6	6	6.6	178
		23	14.6	0.6	6	6.6	178
		24	14.2	0.6	6	6.5	175
		25	13.9	0.5	4	6.5	175
		26	13.6	0.5	4	6.5	177
		27	13.4	0.6	5	6.5	180
		28	13.1	0.6	6	6.4	185
		29	13.0	0.5	5	6.5	198
		30	12.8	0.7	6	6.4	209
		31	12.7	0.8	7	6.4	220
		32	12.8	0.9	9	6.4	221

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			First Old River Lake				
08/23/04	9:15	2	27.5	5.7	72	9.1	180
		3	27.5	5.5	69	9.1	181
		4	27.4	4.8	60	9.0	181
		5	27.4	4.3	55	8.9	182
		6	27.4	3.8	48	8.8	182
		7	27.2	1.2	15	8.6	189
		8	27.0	0.5	6	8.2	193
		9	27.0	0.3	3	8.0	196
		10	26.8	0.2	3	7.9	198
		11	26.8	0.1	2	7.7	207
		12	26.7	0.1	2	7.5	217
09/20/04	10:11	1	26.8	6.8	84	8.8	173
		2	26.8	5.6	69	8.8	173
		3	26.8	5.2	64	8.7	174
		4	26.8	4.6	57	8.6	174
		5	26.7	3.9	48	8.6	175
		6	26.7	3.7	46	8.6	175
		7	26.6	3.3	41	8.6	175
		8	26.5	3.6	45	8.6	174
		9	26.3	2.1	26	8.3	176
		10	26.1	1.9	23	8.2	176
		11	26.1	1.8	22	8.2	177
10/18/04	9:05	1	20.1	8.1	89	8.1	178
		2	20.3	7.9	87	8.3	177
		3	20.3	8.0	88	8.4	177
		4	20.3	8.1	90	8.4	177
		5	20.3	8.1	89	8.4	177
		6	19.3	5.4	59	7.7	178
		7	19.2	4.4	47	7.6	178
		8	19.1	4.7	51	7.6	178
		9	19.0	4.5	49	7.6	178
		10	19.0	4.4	48	7.5	178
		11	19.0	4.1	45	7.5	178
		12	19.0	2.7	29	7.4	180
12/07/04	15:08	1	12.0	10.3	96	7.6	147
		2	12.0	10.2	95	7.6	147
		3	12.0	10.2	94	7.6	147

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		4	12.0	10.2	94	7.5	147
		5	12.0	10.2	94	7.6	147
		6	12.0	10.2	94	7.6	147
		7	12.0	10.2	94	7.5	147
		8	12.0	10.2	94	7.6	147
		10	12.0	10.2	94	7.6	147
		12	12.0	10.2	94	7.6	147
		13	12.0	10.2	94	7.6	147
02/07/05	9:43	1	9.2	10.0	87	7.2	159
		2	9.2	10.0	86	7.2	159
		3	9.1	9.9	86	7.2	159
		4	9.1	9.9	86	7.2	159
		5	9.1	9.9	86	7.2	159
		6	9.0	9.9	86	7.2	159
		7	8.9	9.9	85	7.2	160
		8	8.9	9.8	85	7.2	160
		9	8.8	9.8	84	7.2	160
		10	8.8	9.7	84	7.2	161
		11	8.8	9.6	83	7.2	160
		12	8.7	9.5	82	7.2	161
		13	8.7	9.4	81	7.2	161
		14	8.7	9.1	78	7.1	161
		15	8.7	8.9	76	7.1	161
		16	8.7	8.7	75	7.1	176
04/25/05	9:41	1	21.2	9.7	109	8.0	172
		2	21.2	9.3	104	8.0	170
		3	21.2	9.2	103	7.9	171
		4	21.2	8.9	100	7.9	171
		5	21.1	8.7	98	7.9	173
		6	21.1	8.7	98	7.9	173
		7	21.1	8.9	100	7.9	173
		8	21.1	8.9	100	7.9	174
		9	21.0	8.9	100	7.9	176
		10	21.0	8.3	93	7.8	184
		11	20.8	6.7	75	7.7	185
		12	20.7	5.6	62	7.5	185
		13	20.7	4.9	55	7.4	185
05/17/05	13:11	1	25.6	10.5	128	8.7	182

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		2	25.1	10.8	131	8.7	181
		3	24.5	10.8	130	8.7	181
		4	24.2	10.1	120	8.6	181
		5	24.1	9.6	114	8.5	181
		6	24.0	8.5	101	8.4	183
		7	24.0	8.2	98	8.3	183
		8	23.8	7.9	94	8.3	182
		9	23.7	5.8	69	7.8	185
		10	23.6	3.9	46	7.4	187
		11	23.3	2.8	33	7.3	188
		12	22.5	1.4	16	7.0	192
		13	21.7	0.7	8	6.9	199
06/06/05	9:19	1	27.5	7.7	97	8.0	189
		2	27.5	7.6	96	8.0	189
		3	27.4	7.5	95	8.0	189
		4	27.4	7.4	94	8.0	189
		5	27.2	6.8	86	7.8	190
		6	27.2	6.4	80	7.7	190
		7	26.9	5.4	67	7.6	191
		8	26.6	2.4	30	7.3	193
		9	26.3	1.2	15	7.1	192
		10	26.2	0.7	9	6.9	193
		11	25.6	0.6	7	6.9	196
		12	25.3	0.6	7	6.8	203
07/25/05	10:20	1	33.0	13.2	184	9.3	175
		2	32.7	12.4	171	9.4	174
		3	31.8	6.0	82	9.1	168
		4	31.6	4.3	59	8.9	168
		5	31.6	3.2	43	8.9	168
		6	31.4	2.2	29	8.8	168
		7	31.0	0.7	10	8.5	173
		8	30.4	0.7	9	8.2	181
		9	30.1	1.0	13	7.9	188
		10	29.7	1.1	15	7.6	198
		11	29.3	1.8	24	7.2	212

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Lake Frierson				
08/25/04	12:22	1	25.5	7.7	94	7.3	57
		2	25.5	7.2	88	7.2	57
		3	25.5	7.1	86	7.1	57
		4	25.4	6.7	81	7.0	57
		5	25.4	6.5	79	7.0	57
		6	25.3	6.4	78	6.9	57
		7	25.3	6.4	78	6.9	57
		8	25.3	6.4	78	6.9	57
		9	25.2	6.5	79	6.8	57
		10	25.1	6.4	78	6.8	56
		11	24.7	4.5	54	6.7	60
		12	24.4	2.7	33	6.5	63
		13	23.9	1.7	21	6.5	65
		14	23.5	0.9	11	6.4	73
10/20/04	11:15	1	19.7	9.2	101	7.9	54
		2	19.7	9.2	101	7.8	54
		3	19.7	9.2	101	7.7	54
		4	19.7	9.2	100	7.7	54
		5	19.3	9.2	99	7.6	54
		6	19.3	9.1	99	7.5	54
		7	19.2	9.1	98	7.5	54
		8	18.9	8.9	96	7.4	54
		9	18.4	8.6	91	7.3	55
		10	17.8	7.8	82	7.1	55
		11	17.3	7.0	72	6.9	56
		12	17.2	2.1	22	6.6	88
12/08/04	10:50	1	9.6	10.9	95	7.8	49
		2	9.6	10.8	95	7.8	49
		3	9.6	10.8	95	7.6	49
		4	9.6	10.8	95	7.6	49
		5	9.6	10.8	94	7.6	48
		6	9.6	10.7	94	7.5	48
		7	9.6	10.7	94	7.4	48
		8	9.6	10.7	94	7.3	48
		9	9.5	10.6	93	7.2	48
		10	9.5	10.6	93	7.1	48
		11	9.4	10.6	93	7.0	48
		12	9.4	10.6	92	7.0	48

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		13	9.4	10.5	92	6.9	48
		14	9.4	10.5	92	6.8	48
		15	9.4	10.5	92	6.8	48
		16	9.4	10.5	92	6.8	48
		17	9.4	10.5	92	6.8	48
02/09/05	11:34	1	6.9	12.4	102	7.1	53
		2	6.9	12.5	103	7.1	53
		3	6.9	12.6	104	7.1	53
		4	6.9	12.6	104	7.1	53
		5	6.9	12.6	104	7.1	53
		6	6.9	12.6	104	7.1	53
		7	6.9	12.6	104	7.1	53
		8	6.9	12.6	104	7.0	53
		9	6.9	12.6	104	7.1	53
		10	6.9	12.6	104	7.0	53
		11	6.9	12.6	104	7.0	53
		12	6.9	12.6	104	7.0	53
		13	6.9	12.6	103	7.0	53
		14	6.9	12.6	103	7.0	53
		15	6.9	12.6	103	7.0	53
		16	6.9	12.6	103	7.0	53
04/27/05	8:05	1	17.9	8.5	90	7.6	56
		2	17.9	8.5	90	7.6	56
		3	17.9	8.5	90	7.4	56
		4	17.9	8.4	89	7.4	56
		5	17.9	8.4	89	7.3	56
		6	17.9	8.4	89	7.3	56
		7	17.9	8.4	88	7.3	56
		8	17.9	8.4	88	7.2	56
		9	17.9	8.4	88	7.2	56
		10	17.9	8.4	88	7.2	56
		11	17.9	8.3	88	7.2	56
		12	17.9	8.3	88	7.2	57
		13	17.9	8.3	88	7.2	57
		14	17.8	8.0	84	7.1	58
		15	17.7	7.8	82	7.1	58
06/08/05	12:05	1	28.2	8.0	103	6.7	50
		2	28.2	8.0	102	6.7	49

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		3	28.1	7.9	101	6.7	49
		4	27.9	7.8	99	6.6	50
		5	26.1	5.8	72	6.3	50
		6	25.9	5.9	72	6.2	50
		7	25.7	6.1	75	6.2	50
		8	25.0	5.3	64	6.1	51
		9	24.5	4.9	59	6.1	51
		10	24.2	4.8	57	6.0	51
		11	23.8	4.4	52	6.0	51
		12	22.6	3.2	37	5.9	53
		13	21.9	2.3	26	5.8	58
		14	20.7	1.5	17	5.9	72
		15	19.3	0.7	8	6.0	92

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
Grand Lake (North)							
08/24/04	7:12	2	27.3	6.8	85	9.1	159
		3	27.3	6.7	84	9.1	159
		4	27.3	6.7	85	9.1	159
		5	27.3	6.7	85	9.1	159
		6	27.3	6.7	85	9.1	159
		7	27.3	6.6	83	9.1	159
		8	27.3	6.5	82	9.1	159
09/20/04	15:48	1	27.2	12.4	154	9.0	155
		2	27.2	12.1	150	9.1	154
		3	27.2	11.9	148	9.1	155
		4	27.2	11.8	146	9.0	155
		5	27.2	12.0	148	9.1	154
		6	27.1	11.8	146	9.0	154
		7	26.9	11.0	135	9.0	155
10/19/04	7:46	1	21.5	8.4	96	8.4	170
		2	21.5	8.4	95	8.4	170
		3	21.5	8.4	95	8.4	170
		4	21.5	8.4	95	8.4	170
		5	21.5	8.3	94	8.4	170
		6	21.5	8.3	94	8.4	170
		7	21.5	8.3	94	8.4	170
		8	21.5	8.3	94	8.4	170
		9	21.5	8.2	93	8.3	170
		10	21.5	7.5	85	8.2	170
12/07/04	8:37	1	14.0	10.1	97	7.7	176
		2	14.0	10.0	97	7.7	176
		3	14.0	10.0	97	7.7	176
		4	14.0	10.0	97	7.7	176
		5	14.0	10.0	97	7.7	176
		6	14.1	9.9	96	7.7	177
		7	14.1	9.9	96	7.7	176
		8	14.1	9.9	96	7.7	177
		9	14.1	9.9	96	7.7	177
		10	14.1	9.7	94	7.7	177
		1	10.2	11.9	106	7.6	185

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
02/08/05	8:39	2	10.1	11.5	102	7.6	185
		3	10.1	11.5	102	7.6	185
		4	10.0	11.5	102	7.6	185
		5	9.8	11.5	102	7.6	186
		6	9.7	11.2	99	7.6	186
		7	9.7	11.0	97	7.5	187
		8	9.7	10.6	93	7.5	187
		9	9.7	10.6	93	7.5	187
04/26/05	7:22	1	19.2	8.6	93	8.2	241
		2	19.2	8.6	93	8.1	240
		3	19.1	8.6	93	8.1	239
		4	19.1	8.6	93	8.2	238
		5	19.1	8.6	93	8.2	237
		6	19.1	8.6	93	8.2	236
		7	19.1	8.6	93	8.2	235
05/17/05	8:01	1	23.2	8.7	102	8.6	206
		2	23.2	8.7	101	8.6	206
		3	23.2	8.6	101	8.6	206
		4	23.2	8.5	100	8.6	207
		5	23.2	8.5	99	8.6	207
		6	23.2	8.4	99	8.6	207
		7	23.2	8.4	98	8.6	206
		8	23.4	0.7	8	7.7	276
06/07/05	7:25	1	29.9	10.7	142	9.0	145
		2	29.9	10.7	141	9.0	145
		3	29.9	10.7	141	9.0	145
		4	29.9	10.7	141	9.0	145
		5	29.9	10.6	141	9.0	145
		6	29.9	10.6	140	9.0	145
		7	29.9	10.3	136	8.9	145
07/25/05	15:11	1	35.1	17.0	245	9.9	176
		2	35.0	16.8	242	9.9	173
		3	35.0	16.7	241	9.9	171
		4	35.0	16.5	237	9.9	168
		5	33.9	13.7	194	9.8	155
		6	33.7	6.1	86	8.4	140

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Grand Lake (South)				
08/24/04	7:40	2	26.4	4.3	54	8.4	162
		3	26.4	2.8	35	8.4	163
		4	26.4	2.7	33	8.4	163
		5	26.4	2.7	34	8.4	162
		6	26.4	2.8	35	8.4	162
		7	26.4	2.9	35	8.4	162
		8	26.4	2.8	35	8.4	162
		9	26.4	2.9	35	8.4	162
		10	26.4	2.8	35	8.4	162
		11	26.4	2.9	35	8.4	162
		12	26.4	2.9	36	8.4	162
		13	26.4	2.9	36	8.4	162
		14	26.4	2.8	35	8.4	162
		15	26.4	2.8	35	8.4	162
09/20/04	15:22	1	27.4	11.3	140	9.1	154
		2	27.5	11.3	140	9.1	154
		3	27.4	11.2	139	9.1	154
		4	27.4	10.9	135	9.1	154
		5	27.3	10.6	131	9.1	155
		6	27.0	9.9	123	9.1	154
		7	26.7	8.6	106	9.0	155
		8	26.5	7.0	86	8.8	155
		9	26.5	6.3	76	8.7	156
		10	26.4	5.8	71	8.6	156
		11	26.4	5.5	67	8.6	157
10/19/04	8:06	1	21.3	8.3	94	8.3	171
		2	21.3	8.3	94	8.3	170
		3	21.3	8.3	93	8.3	170
		4	21.3	8.2	93	8.3	171
		5	21.3	8.2	93	8.3	171
		6	21.3	8.2	92	8.3	171
		7	21.2	8.1	92	8.3	171
		8	21.2	8.1	92	8.3	171
		9	21.2	8.1	92	8.3	171
		10	21.2	8.1	91	8.3	171
		11	21.2	8.0	91	8.3	171
		12	21.2	8.0	90	8.3	171
		13	21.1	7.6	86	8.2	171

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		14	21.1	7.4	84	8.1	172
		15	21.1	7.1	80	8.1	172
12/07/04	9:03	1	13.4	9.4	90	7.9	178
		2	13.4	9.3	89	7.8	178
		3	13.4	9.3	89	7.8	178
		4	13.4	9.2	89	7.8	178
		5	13.4	9.2	88	7.8	178
		6	13.4	9.2	88	7.8	178
		7	13.4	9.2	88	7.8	178
		8	13.4	9.2	88	7.8	178
		9	13.4	9.2	88	7.8	178
		10	13.4	9.2	88	7.8	178
		11	13.3	9.2	88	7.8	178
		12	13.4	9.2	88	7.8	178
		13	13.3	9.1	88	7.8	178
		14	13.3	9.1	87	7.8	178
		15	13.3	9.1	87	7.8	178
		16	13.3	9.1	87	7.8	178
02/08/05	9:02	1	9.2	11.3	98	7.7	187
		2	9.2	11.3	98	7.7	187
		3	9.2	11.3	98	7.7	187
		4	9.2	11.2	98	7.7	187
		5	9.2	11.2	97	7.7	188
		6	9.2	11.2	97	7.7	188
		7	9.1	11.2	97	7.7	188
		8	9.1	11.1	96	7.7	188
		9	9.0	11.1	96	7.7	188
		10	9.0	11.0	95	7.7	188
		11	9.0	11.0	95	7.7	188
		12	9.0	11.0	95	7.7	188
		13	9.0	10.8	93	7.6	188
		14	8.9	10.7	92	7.6	188
		15	8.8	10.5	90	7.6	189
04/26/05	7:44	1	19.7	8.7	95	8.3	235
		2	19.7	8.7	95	8.2	235
		3	19.7	8.7	95	8.3	234
		4	19.7	8.7	95	8.3	233
		5	19.7	8.7	95	8.3	233

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		6	19.7	8.7	95	8.3	232
		7	19.7	8.7	95	8.3	231
		8	19.7	8.7	95	8.3	230
		9	19.7	8.6	94	8.3	228
		10	19.7	8.6	94	8.3	227
		11	19.7	8.6	94	8.3	226
		12	19.7	8.6	94	8.2	225
		13	19.7	8.5	93	8.2	224
05/17/05	8:32	1	24.0	8.9	106	8.6	209
		2	24.0	8.9	106	8.6	209
		3	24.0	8.9	105	8.6	209
		4	24.0	8.7	103	8.6	209
		5	24.0	8.6	102	8.6	209
		6	24.0	8.6	102	8.6	209
		7	24.0	8.5	101	8.6	209
		8	24.0	8.4	100	8.6	209
		9	24.0	8.4	100	8.6	209
		10	24.0	8.3	99	8.6	209
		11	24.0	8.3	98	8.6	210
		12	23.9	8.2	98	8.5	209
		13	23.9	8.2	98	8.5	209
		14	23.9	8.0	95	8.5	210
		15	23.9	5.8	69	8.1	243
06/07/05	7:48	1	28.6	11.0	142	8.8	160
		2	28.6	10.8	139	8.8	160
		3	28.6	10.7	138	8.8	160
		4	28.6	10.4	134	8.7	161
		5	28.4	9.8	126	8.7	165
		6	28.1	9.2	118	8.5	171
		7	27.8	8.8	112	8.4	174
		8	27.5	8.6	108	8.3	177
		9	27.3	8.2	104	8.2	179
		10	27.1	7.4	93	8.1	183
		11	26.8	5.7	71	7.7	188
		12	26.5	2.3	29	7.4	198
		13	26.4	1.5	19	7.2	201
		14	26.3	1.3	16	7.1	203

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
07/25/05	15:43	1	33.8	13.8	194	10.0	163
		2	33.6	12.8	180	9.9	160
		3	33.3	11.9	166	9.9	156
		4	33.1	11.0	153	9.8	153
		5	32.8	8.6	119	9.7	149
		6	31.8	4.8	65	9.4	144
		7	30.9	1.7	23	9.1	145
		8	30.3	0.5	7	9.0	148
		9	29.6	0.5	6	8.6	157
		11	29.0	0.5	6	8.2	174
		12	28.7	0.8	10	7.6	186

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Horseshoe Lake (North)				
08/24/04	15:19	1	28.2	11.0	140	8.9	156
		2	28.2	11.0	141	8.9	156
		3	28.2	11.0	140	8.9	155
		4	28.1	10.9	140	8.9	155
		5	28.1	10.8	138	8.9	155
		6	28.1	10.7	137	8.9	156
		7	28.1	10.7	137	8.9	155
		8	28.0	10.6	135	8.9	155
		9	27.8	10.2	130	8.9	156
		10	27.5	9.0	114	8.8	156
		11	27.3	7.8	98	8.6	156
		12	27.2	7.5	94	8.6	157
		13	27.1	7.3	92	8.5	157
		14	27.1	7.1	90	8.5	157
		15	27.1	7.1	90	8.4	157
		16	27.0	6.9	86	8.4	158
		17	26.9	6.5	82	8.3	158
		18	26.8	6.2	77	8.2	158
		19	26.0	1.8	22	7.7	167
		20	25.8	0.4	5	7.4	170
		21	25.7	0.3	3	7.3	172
		23	25.5	0.2	2	7.2	175
		24	25.5	0.2	2	7.1	176
09/21/04	14:25	1	25.7	9.5	115	8.5	155
		2	25.5	9.6	116	8.5	155
		3	25.2	9.6	114	8.5	155
		4	25.1	9.6	115	8.5	155
		5	25.0	9.4	111	8.5	155
		6	25.0	9.3	111	8.5	155
		7	25.0	9.1	108	8.5	155
		8	25.0	9.1	108	8.5	156
		9	25.0	9.2	109	8.4	156
		10	25.0	9.1	108	8.5	155
		12	25.0	9.0	107	8.4	156
		14	24.9	8.6	102	8.3	155
		16	24.7	8.1	95	8.3	156
		18	24.6	7.7	91	8.2	156
		20	24.4	7.2	85	8.0	156
		22	23.9	6.6	77	7.8	156

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		24	23.9	6.3	73	7.8	157
		25	23.9	5.9	69	7.6	157
10/19/04	14:24	1	19.9	10.7	118	8.2	162
		2	19.9	10.7	118	8.2	162
		3	19.9	10.7	117	8.2	162
		4	19.9	10.7	117	8.2	162
		5	19.9	10.6	117	8.2	162
		6	19.9	10.6	117	8.2	162
		7	19.9	10.6	117	8.2	162
		8	19.9	10.6	117	8.2	162
		9	19.9	10.6	117	8.2	162
		10	19.9	10.6	117	8.2	162
		11	19.9	10.6	117	8.2	162
		12	20.0	10.6	116	8.2	162
		13	20.0	10.5	116	8.2	162
		14	19.9	10.5	115	8.2	162
		15	19.6	10.2	111	8.1	162
		16	19.5	9.5	103	7.9	163
		17	19.2	9.3	101	7.9	162
		18	19.1	9.2	100	7.8	163
		19	18.7	8.3	89	7.6	163
		20	18.7	8.3	89	7.6	163
		21	18.7	8.2	88	7.5	163
		22	18.7	8.1	86	7.5	163
		23	18.6	7.9	85	7.5	163
		24	18.6	7.9	84	7.5	163
		25	18.7	7.8	84	7.5	165
12/07/04	15:28	1	12.6	11.0	103	7.9	147
		2	12.6	10.9	103	7.9	147
		3	12.6	10.9	103	7.9	147
		4	12.6	10.9	102	7.9	147
		5	12.6	10.9	102	7.9	147
		6	12.6	10.9	102	7.9	147
		8	12.6	10.8	102	7.9	147
		10	12.6	10.8	102	7.9	147
		12	12.6	10.8	101	7.9	147
		14	12.5	10.7	101	7.9	146
		16	12.5	10.6	100	7.9	146
		18	12.4	10.5	99	7.8	146

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		20	12.4	10.5	98	7.8	146
		22	12.4	10.4	98	7.8	146
		23	12.4	10.4	97	7.8	146
		24	12.4	10.4	97	7.8	146
02/08/05	15:38	1	7.7	12.3	103	7.8	142
		2	7.7	12.2	103	7.8	142
		3	7.7	12.2	103	7.8	142
		5	7.7	12.2	102	7.8	142
		7	7.7	12.2	102	7.8	142
		9	7.7	12.2	102	7.8	142
		11	7.6	12.1	101	7.8	142
		13	7.5	12.0	101	7.8	142
		15	7.4	11.9	99	7.7	142
		17	7.3	11.8	98	7.7	142
		19	7.2	11.8	98	7.7	142
		21	7.2	11.8	98	7.7	142
		23	7.2	11.7	97	7.6	142
		25	7.2	11.6	96	7.6	142
		27	7.2	11.6	96	7.6	142
		28	7.3	10.0	83	7.0	156
04/26/05	14:22	1	18.6	9.1	97	8.0	151
		2	18.5	9.0	97	8.0	150
		4	18.4	9.0	96	8.0	149
		6	18.4	9.0	96	8.0	149
		8	18.3	9.0	95	7.9	149
		10	18.2	8.7	93	7.8	148
		12	18.1	8.4	89	7.7	148
		14	17.9	8.5	89	7.8	147
		16	17.8	8.8	93	7.9	147
		18	17.8	8.7	91	7.8	146
		20	17.8	8.6	91	7.8	146
		22	17.8	8.6	91	7.8	144
		24	17.8	8.6	91	7.8	144
		26	17.8	8.6	90	7.8	144
05/16/05	12:48	1	24.0	9.3	110	8.6	146
		2	23.7	9.3	110	8.6	146
		3	23.3	9.3	109	8.5	146
		4	23.2	9.2	107	8.5	146

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		5	23.1	9.1	106	8.5	146
		6	23.0	8.9	104	8.4	146
		7	23.0	8.7	102	8.4	146
		8	23.0	8.7	101	8.4	146
		9	23.0	8.6	101	8.4	146
		10	22.8	8.4	97	8.3	146
		11	22.7	7.9	92	8.2	145
		12	22.7	7.5	87	8.0	145
		13	21.8	4.6	52	7.5	147
		14	20.5	2.7	30	7.1	146
		15	20.1	2.3	25	7.1	147
		16	19.8	1.6	18	6.9	147
		17	19.3	0.9	10	6.9	149
		18	19.2	0.7	7	6.8	149
		19	18.9	0.5	5	6.8	151
		20	18.0	0.3	4	6.8	152
		21	17.8	0.3	4	6.8	153
		22	17.7	0.3	3	6.7	154
		23	17.7	0.3	3	6.8	154
		24	17.6	0.3	3	6.8	154
		25	17.6	0.3	3	6.7	154
		26	17.6	0.3	3	6.8	154
		27	17.6	0.3	3	6.8	155
06/07/05	15:31	1	29.6	12.2	161	8.9	151
		2	29.5	12.3	161	8.9	151
		3	29.4	12.3	161	8.9	151
		4	29.3	12.4	162	8.9	151
		5	28.9	12.0	156	8.9	151
		6	27.6	11.0	139	8.7	151
		7	27.0	9.1	114	8.4	152
		8	26.9	8.9	111	8.3	152
		9	26.9	8.7	109	8.3	152
		10	26.8	8.6	107	8.3	152
		11	26.8	8.2	103	8.2	153
		12	26.8	8.1	102	8.2	153
		13	26.8	8.1	101	8.2	153
		14	26.8	8.1	101	8.2	153
		15	26.8	8.1	101	8.2	153
		16	26.8	8.0	100	8.2	153
		17	26.0	6.5	80	7.8	154

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		18	25.2	2.4	29	7.3	154
		19	25.0	1.6	19	7.1	154
		20	24.9	0.7	9	7.0	154
		21	24.7	0.5	6	6.9	154
		22	24.6	0.4	4	6.8	154
		23	24.5	0.3	4	6.8	156
		25	23.9	0.3	4	6.7	160
		26	23.8	0.3	3	6.6	179
07/26/05	12:02	1	33.5	12.1	170	9.3	133
		2	33.4	11.9	167	9.3	133
		3	33.4	11.6	163	9.3	133
		4	33.4	11.5	162	9.2	133
		5	33.4	11.5	161	9.3	133
		6	33.3	11.3	158	9.2	133
		7	33.3	11.0	153	9.2	134
		8	33.2	10.9	152	9.2	134
		9	32.3	7.6	104	8.8	141
		10	31.8	5.9	80	8.5	143
		11	30.5	2.9	39	8.0	149
		12	29.2	1.7	23	7.8	158
		13	28.6	1.0	12	7.6	159
		14	28.3	0.9	11	7.4	159
		15	28.2	0.8	10	7.4	159
		16	27.8	0.9	12	7.3	161
		17	27.6	1.1	14	7.2	162
		18	27.1	1.0	12	7.1	166
		19	26.7	1.1	13	7.0	170
		20	26.6	1.2	15	6.9	175
		21	26.0	1.3	15	6.8	190
		22	25.7	1.4	17	6.7	197
		23	25.6	1.6	19	6.7	199
		24	25.6	1.5	19	6.7	200
		25	25.6	2.0	24	6.7	201
		25	25.6	2.0	24	6.6	201

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Horseshoe Lake (West)				
08/24/04	14:45	1	27.4	8.6	109	8.4	158
		2	27.3	8.5	107	8.4	158
		3	27.1	8.2	104	8.4	158
		4	26.8	7.6	95	8.2	158
		5	26.7	7.0	87	8.2	158
		6	26.6	6.5	81	8.1	158
		7	26.3	5.5	69	7.9	160
		8	26.2	3.9	48	7.7	161
		9	26.0	3.1	39	7.5	161
		10	26.0	3.0	37	7.4	161
		11	25.9	3.0	37	7.4	161
		12	25.9	3.1	38	7.3	161
		13	25.9	3.1	39	7.4	161
		14	25.9	3.2	39	7.3	161
		15	25.9	3.2	39	7.3	161
		16	25.9	3.2	39	7.3	161
		17	25.8	2.2	28	7.2	163
		18	25.8	1.8	22	7.2	163
09/21/04	13:52	1	26.1	9.3	113	8.5	154
		2	25.8	9.5	114	8.6	154
		3	25.3	8.8	105	8.4	154
		4	25.1	7.7	92	8.3	154
		5	25.0	7.2	86	8.1	155
		6	24.9	6.7	80	8.1	156
		7	24.9	6.3	75	7.9	155
		8	24.8	5.8	68	7.8	156
		9	24.8	5.8	68	7.8	156
		10	24.8	5.8	68	7.8	156
		11	24.8	5.9	69	7.8	156
		12	24.7	5.7	68	7.8	156
		13	24.7	5.7	67	7.8	156
		14	24.6	5.7	67	7.7	156
		15	24.6	5.7	67	7.7	156
		16	24.6	5.3	62	7.7	157
		17	24.6	5.0	58	7.6	157
		18	24.6	4.7	55	7.5	157
		19	24.6	4.5	54	7.5	157
		20	24.6	4.7	55	7.5	157
		21	24.6	4.6	55	7.5	158

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
10/19/04	13:59	1	19.5	9.3	101	7.8	163
		2	19.5	9.3	101	7.8	163
		3	19.5	9.2	100	7.8	163
		4	19.5	9.2	100	7.8	163
		5	19.5	9.2	100	7.8	163
		6	19.4	9.1	99	7.8	163
		7	19.3	9.1	98	7.8	162
		8	19.2	8.8	95	7.7	162
		9	18.9	8.4	90	7.6	163
		10	18.5	7.7	82	7.5	164
		11	18.5	7.3	78	7.5	165
		12	18.4	6.6	70	7.4	165
		13	18.3	5.7	61	7.3	165
		14	18.3	5.4	57	7.3	165
		15	18.3	5.1	54	7.2	165
		16	18.3	4.9	52	7.2	165
		17	18.3	4.8	51	7.2	169
12/06/04	10:03	1	11.4	8.7	79	7.0	160
		2	11.4	8.6	78	7.0	160
		3	11.4	8.5	78	7.1	160
		4	11.3	8.5	78	7.1	160
		5	11.3	8.4	77	7.1	160
		6	11.1	8.2	75	7.1	160
		7	11.0	7.9	72	7.0	160
		8	11.0	7.8	70	7.1	160
		9	11.0	7.7	69	7.1	160
		10	11.0	7.7	69	7.1	160
		11	11.0	7.5	68	7.1	160
		12	10.9	7.4	67	7.0	160
		13	10.9	7.3	66	7.0	160
		14	10.9	7.0	64	7.0	160
02/08/05	15:13	1	7.4	12.5	104	7.6	142
		2	7.4	12.6	105	7.6	142
		3	7.4	12.6	105	7.6	142
		4	7.4	12.4	103	7.6	142
		5	7.3	12.4	103	7.6	142
		7	7.3	12.3	102	7.6	142
		9	7.3	12.3	102	7.6	142
		10	7.3	12.3	102	7.6	142

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		11	7.3	12.3	102	7.6	142
		12	7.3	12.3	102	7.6	142
		13	7.3	12.3	102	7.6	142
		14	7.3	12.3	102	7.6	142
		15	7.3	12.3	102	7.6	142
		16	7.3	12.3	102	7.6	142
		17	7.2	12.3	102	7.6	142
		18	7.2	12.2	101	7.6	142
		19	7.2	12.2	101	7.6	142
		20	7.2	12.2	101	7.6	142
		21	7.2	12.2	101	7.6	142
04/26/05	13:59	1	18.6	8.2	88	7.6	152
		2	18.6	8.2	87	7.6	152
		3	18.5	8.2	87	7.6	151
		4	18.5	8.2	87	7.6	151
		5	18.5	8.1	87	7.6	151
		6	18.5	8.1	87	7.6	150
		7	18.4	8.1	86	7.6	150
		8	18.4	8.1	86	7.6	150
		9	18.4	8.1	86	7.6	150
		10	18.4	8.1	86	7.6	149
		11	18.4	8.1	86	7.6	149
		12	18.4	8.1	86	7.6	148
		13	18.4	8.0	86	7.6	147
		14	18.4	8.0	86	7.6	146
		15	18.4	8.0	85	7.6	145
		16	18.4	8.0	85	7.6	146
05/16/05	12:16	1	23.8	9.9	118	8.8	144
		2	23.7	9.9	116	8.8	144
		3	23.5	9.7	115	8.7	144
		4	23.4	9.6	113	8.7	144
		5	23.2	9.4	110	8.7	144
		6	23.2	9.1	107	8.6	144
		7	23.2	8.9	105	8.5	144
		8	23.1	8.7	102	8.5	144
		9	23.1	8.5	100	8.4	144
		10	23.1	8.4	98	8.4	144
		11	23.0	8.1	95	8.3	145
		12	22.9	7.8	91	8.2	145

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		13	22.8	7.6	88	8.1	145
		14	22.8	7.4	86	8.1	145
		15	22.7	7.3	84	8.0	145
		16	22.6	6.9	80	7.9	145
		17	22.3	6.4	73	7.8	146
		18	20.3	3.3	37	7.4	150
		19	19.3	1.5	16	7.1	151
06/07/05	15:02	1	28.9	11.2	146	8.6	151
		2	27.7	11.8	150	8.6	150
		3	27.2	12.3	154	8.6	150
		4	27.0	11.3	141	8.7	150
		5	26.9	10.1	126	8.5	151
		6	26.6	8.9	111	8.3	151
		7	26.5	8.3	103	8.3	152
		8	26.4	8.2	102	8.3	152
		9	26.4	8.2	102	8.1	152
		10	26.4	7.8	97	8.1	152
		11	26.2	7.0	86	7.8	153
		12	26.1	6.2	76	7.2	153
		13	25.5	3.6	43	6.9	154
		14	25.2	1.9	23	7.2	155
		15	25.1	1.5	18	6.6	156
		16	25.0	1.0	12	7.0	156
		17	24.5	0.5	6	6.7	157
		18	23.8	0.3	4	6.9	161
		19	23.4	0.3	3	6.9	165
07/26/05	11:37	1	31.0	10.6	142	8.5	143
		2	30.9	10.3	139	8.5	143
		3	30.8	10.2	137	8.6	143
		4	30.7	9.9	133	8.5	144
		5	30.4	8.4	112	8.4	145
		6	30.3	5.6	75	8.1	146
		7	30.1	4.6	61	7.9	147
		8	29.9	4.3	56	7.8	148
		9	29.7	2.9	38	7.6	149
		10	29.4	2.8	36	7.5	153
		11	28.9	1.8	23	7.5	156
		12	28.8	1.3	17	7.4	157
		13	28.6	1.2	15	7.3	161
		14	28.4	2.2	29	6.9	167

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Lake Calion				
08/23/04	14:33	2	28.4	6.8	87	6.5	94
		3	27.9	6.5	83	6.5	94
		4	27.8	6.5	82	6.5	94
		5	27.4	4.8	61	6.3	93
		6	27.0	2.9	36	6.2	88
		7	26.5	1.2	15	6.0	82
		8	26.3	0.7	8	5.9	77
		9	26.1	0.5	6	5.8	119
		10	25.7	0.4	5	6.0	138
		11	25.4	0.4	5	6.1	155
10/18/04	14:16	1	22.4	9.4	108	7.4	108
		2	22.4	9.3	107	7.2	108
		3	22.3	9.3	107	7.1	108
		4	22.3	9.2	105	7.0	109
		5	22.1	9.1	104	6.8	109
		6	22.0	8.9	102	6.7	109
		7	21.9	8.8	101	6.6	109
		8	21.8	8.7	99	6.6	109
12/06/04	14:53	1	13.9	10.2	99	6.4	94
		2	12.7	10.1	96	6.1	94
		3	12.0	9.5	88	5.9	94
		4	11.8	8.9	82	5.8	94
		5	11.7	8.7	80	5.7	91
		6	11.4	8.7	80	5.7	86
		7	11.2	8.6	78	5.7	78
		8	11.1	8.2	74	5.6	70
		9	11.0	7.8	70	5.6	67
		10	11.0	7.5	68	5.5	66
		11	11.0	7.4	67	5.6	66
02/07/05	15:40	1	9.8	11.0	97	5.8	79
		2	9.7	11.0	97	5.8	79
		3	9.7	11.0	96	5.8	80
		4	9.5	10.9	96	5.8	80
		5	9.4	10.9	95	5.8	80
		6	9.3	10.8	94	5.8	80
		7	9.3	10.7	93	5.8	79
		8	9.3	10.7	93	5.8	80

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		9	9.0	10.6	92	5.7	78
		10	8.6	10.2	87	5.7	68
		11	8.4	9.7	82	5.6	65
04/25/05	14:20	1	21.9	8.8	101	6.3	122
		2	21.9	8.8	101	6.3	121
		3	21.7	8.8	100	6.3	119
		4	21.6	8.6	98	6.3	118
		5	21.4	8.6	97	6.3	117
		6	21.2	8.3	94	6.3	116
		7	21.0	8.2	92	6.2	117
		8	21.0	8.0	90	6.2	117
		9	20.6	7.8	87	6.2	115
		10	20.3	7.1	79	6.1	110
06/06/05	14:10	1	31.4	9.8	133	7.8	103
		2	30.1	9.6	127	7.7	103
		3	29.4	9.7	126	7.6	103
		4	28.9	9.4	122	7.4	103
		5	27.6	5.8	74	6.4	103
		6	26.4	3.3	41	5.9	107
		7	24.9	0.8	10	5.9	132
		8	24.2	0.7	8	5.9	136
		9	23.1	0.6	7	6.1	163
		10	22.4	0.6	7	6.2	201

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Lake June				
08/23/04	10:40	2	27.3	3.6	45	6.3	106
		3	27.3	3.1	40	6.3	106
		4	27.2	2.5	32	6.2	106
		5	27.2	1.4	18	6.2	107
		6	27.0	0.9	11	6.1	111
		7	26.8	0.6	7	6.1	126
10/18/04	10:22	1	20.6	8.7	97	7.2	109
		2	20.6	8.5	95	7.1	109
		3	20.5	8.5	94	7.0	109
		4	20.5	8.4	93	6.9	109
		5	20.4	8.1	90	6.8	109
		6	19.4	4.6	50	6.5	111
12/06/04	11:24	1	11.7	5.2	48	5.8	102
		2	10.9	5.0	46	5.8	102
		3	10.5	4.8	43	5.7	102
		4	10.4	4.6	41	5.7	103
		5	10.3	4.4	39	5.7	103
		6	10.2	4.2	38	5.7	102
		7	10.2	4.0	36	5.7	101
02/07/05	11:03	1	9.9	9.4	83	6.0	111
		2	9.9	9.4	83	6.0	111
		3	9.7	9.4	83	6.0	112
		4	9.5	9.3	81	6.0	112
		5	9.0	9.1	78	6.0	112
		6	8.6	8.7	75	5.9	112
		7	8.2	8.2	70	5.9	111
		8	8.1	7.8	66	5.8	118
04/25/05	10:54	1	21.8	9.3	106	6.6	137
		2	21.1	8.9	100	6.6	135
		3	20.9	8.3	93	6.4	134
		4	20.8	7.7	86	6.3	133
		5	20.7	6.1	68	6.2	130
		6	20.3	4.4	49	6.1	131
		7	20.1	3.2	35	6.1	144
06/06/05	10:33	1	28.0	9.8	125	6.9	99

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		2	27.5	7.3	92	6.4	100
		3	27.2	4.8	60	6.1	101
		4	26.9	2.7	34	6.0	101
		5	26.2	1.8	22	5.9	110
		6	24.5	1.3	16	6.2	142
		7	23.6	1.2	15	6.3	166

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Mallard Lake				
08/25/04	10:15	1	26.1	3.8	47	7.7	178
		2	26.1	3.8	47	7.7	178
		3	26.1	3.7	46	7.7	178
		4	26.1	3.6	44	7.7	178
		5	26.0	3.3	41	7.7	178
		6	25.9	2.9	36	7.6	178
		7	25.9	2.6	32	7.6	178
		8	25.9	2.5	31	7.5	178
		9	25.9	2.3	29	7.5	178
		10	25.9	1.9	23	7.5	181
09/22/04	7:53	1	23.2	4.9	56	7.9	178
		2	23.2	4.7	55	7.9	178
		3	23.2	4.8	55	7.9	178
		4	23.2	4.7	55	8.0	178
		5	23.2	4.7	55	8.0	178
		6	23.2	4.8	55	8.0	178
		7	23.2	4.9	56	8.0	178
		8	23.2	4.8	55	8.0	178
		9	23.2	3.7	43	7.9	178
10/20/04	8:56	1	19.2	8.6	94	8.5	183
		2	19.2	8.6	93	8.5	183
		3	19.2	8.6	93	8.5	183
		4	19.2	8.5	92	8.5	183
		5	19.2	8.3	90	8.5	184
		6	19.2	8.2	89	8.5	183
		7	19.2	8.3	90	8.4	184
		8	19.1	8.0	87	8.4	184
		9	19.1	7.9	86	8.4	184
12/08/04	8:53	1	10.2	10.8	96	8.2	171
		2	10.2	10.8	96	8.2	171
		3	10.2	10.8	96	8.2	171
		4	10.2	10.8	96	8.3	171
		5	10.2	10.8	96	8.3	171
		6	10.2	10.8	96	8.3	171
		7	10.2	10.8	96	8.3	171
		8	10.2	10.8	96	8.3	171
		9	10.2	10.8	96	8.3	171

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		10	10.2	10.8	96	8.3	171
02/09/05	9:49	1	7.4	12.3	102	7.5	167
		2	7.4	12.1	101	7.5	167
		3	7.4	12.1	101	7.5	167
		4	7.4	12.1	101	7.5	167
		5	7.4	12.1	101	7.5	167
		6	7.4	12.1	101	7.5	167
		7	7.4	12.1	101	7.5	167
		8	7.4	12.1	101	7.5	167
		9	7.4	12.1	101	7.5	167
		10	7.4	12.1	101	7.5	167
04/26/05	16:42	1	19.2	9.4	102	7.8	172
		2	18.9	9.3	100	7.8	172
		3	18.8	9.0	97	7.7	172
		4	18.7	8.8	94	7.7	172
		5	18.5	8.8	94	7.7	171
		6	18.4	8.7	93	7.7	171
		7	18.2	8.6	91	7.6	171
		8	17.9	7.9	83	7.5	171
		9	17.8	7.2	76	7.3	171
05/16/05	8:18	1	23.6	6.7	79	7.7	169
		2	23.6	6.6	78	7.7	169
		3	23.7	6.6	78	7.7	169
		4	23.6	6.4	76	7.7	169
		5	23.6	6.3	75	7.7	169
		6	23.6	6.1	73	7.6	169
		7	23.6	6.1	72	7.6	169
		8	23.6	6.1	72	7.6	169
		9	23.6	5.9	70	7.6	169
		10	23.5	5.3	62	7.1	171
06/08/05	9:41	1	27.8	9.5	121	8.0	180
		2	27.6	9.6	121	8.0	179
		3	27.5	9.5	120	8.0	179
		4	27.3	9.0	114	7.9	179
		5	27.1	7.0	88	7.5	180
		6	26.6	4.8	60	7.3	181
		7	26.2	3.5	44	7.1	181

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		8	25.7	1.9	23	6.9	182
		9	24.9	1.0	12	6.8	193
07/26/05	16:04	1	31.8	8.0	109	8.7	154
		2	31.4	5.9	80	8.5	155
		3	31.2	4.3	58	8.3	156
		4	31.0	3.0	41	8.2	156
		5	30.5	1.7	22	7.9	162
		6	30.1	1.2	17	7.6	171
		7	28.8	1.3	17	7.2	194
		8	28.1	1.5	19	7.0	204

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Old Town Lake				
08/24/04	11:12	2	27.7	8.1	103	8.6	139
		3	27.7	8.1	103	8.6	139
		4	27.7	8.0	102	8.5	139
09/21/04	10:07	1	22.5	8.3	94	8.8	138
		2	22.5	8.3	94	8.8	138
		3	22.4	8.2	92	8.8	138
		4	22.5	8.2	92	8.8	138
10/19/04	11:18	1	20.9	7.3	81	7.3	149
		2	20.9	7.4	83	7.3	149
		3	20.8	7.4	83	7.3	149
		4	20.8	7.4	83	7.3	149
12/07/04	12:21	1	12.9	10.4	99	7.5	113
		2	12.9	10.5	100	7.4	113
		3	12.9	10.6	100	7.4	113
		4	12.8	10.6	100	7.4	114
02/08/05	12:39	1	9.7	12.4	109	7.4	119
		2	9.8	11.3	100	7.3	118
		3	9.7	11.3	99	7.3	119
		4	9.5	11.1	97	7.3	119
		5	9.5	10.9	95	7.3	119
		6	9.5	10.8	94	7.2	119
04/26/05	10:58	1	17.9	8.7	92	7.9	129
		2	17.9	8.8	93	7.9	129
		3	17.9	8.8	93	7.9	128
		4	17.9	8.8	92	7.8	130
05/16/05	16:50	1	25.5	12.0	147	9.2	120
		2	24.8	9.7	117	8.9	119
		3	24.5	8.2	98	8.5	119
		4	24.2	7.6	91	8.2	120
		5	24.2	7.5	89	8.2	120
06/07/05	11:19	1	30.6	16.0	214	9.7	142
		2	30.6	16.0	213	9.7	142
		3	30.5	15.5	207	9.7	139

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		4	29.2	9.1	119	9.0	123
		1	33.0	4.7	66	9.0	128
07/26/05	8:05	2	33.0	4.5	63	9.0	129
		3	33.0	4.5	63	9.0	129
		4	33.0	4.2	59	9.0	128
		5	32.9	3.6	50	8.8	128

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Stave Lake				
08/25/04	8:15	2	26.8	5.7	71	7.6	170
		3	26.8	5.7	71	7.6	170
		4	26.7	5.6	69	7.5	170
		5	26.7	5.2	65	7.5	170
09/21/04	16:43	1	25.6	9.3	112	8.4	171
		2	25.5	9.4	113	8.4	172
		3	25.3	9.4	112	8.4	172
		4	24.3	9.0	106	8.1	172
10/19/04	16:02	1	21.4	11.9	135	8.3	175
		2	21.1	12.0	134	8.3	174
		3	20.0	11.5	126	8.2	174
		4	19.7	10.6	116	7.9	175
12/07/04	17:02	1	11.9	8.9	83	7.3	125
		2	11.9	8.9	82	7.2	125
		3	11.9	8.9	82	7.2	125
		4	11.9	8.9	82	7.1	125
		5	11.9	8.8	82	7.1	125
		6	11.9	8.8	82	7.1	125
02/08/05	17:23	1	8.6	14.0	120	8.2	110
		2	8.6	13.6	117	8.2	110
		3	8.6	13.5	116	8.1	110
		4	8.5	13.5	115	8.1	110
		5	8.5	13.4	115	8.1	110
04/27/05	10:21	1	18.2	6.6	71	7.2	115
		2	18.1	6.6	70	7.2	114
		3	17.9	6.6	70	7.2	114
		4	17.9	6.9	73	7.2	114
		5	17.9	7.0	73	7.2	114
05/16/05	10:07	1	23.3	8.7	103	8.0	107
		2	23.4	8.7	102	8.0	107
		3	23.3	8.7	102	8.0	107
		4	23.0	8.7	102	7.9	106
		5	23.1	9.1	106	8.1	106

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
06/07/05	17:16	1	29.4	9.6	125	7.5	123
		2	29.4	9.5	124	7.5	123
		3	28.7	8.5	110	7.3	123
		4	27.9	7.0	89	7.1	123
		5	27.1	2.2	27	6.4	285
07/26/05	14:14	1	32.9	10.6	147	8.2	175
		2	31.3	5.4	72	7.5	176
		3	31.1	4.6	62	7.4	177
		4	31.1	4.0	54	7.3	178
		5	31.1	3.4	46	7.1	185

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
			Upper White Oak Lake				
08/23/04	12:38	2	28.9	8.0	104	6.9	36
		3	28.9	8.0	104	6.9	36
		4	28.9	7.9	103	6.9	36
		5	28.8	7.9	102	6.9	36
		6	28.8	7.9	102	6.9	36
		7	28.8	7.8	102	6.9	35
		8	28.8	7.8	101	6.9	36
		9	28.2	6.5	84	6.6	37
		10	27.6	5.4	68	6.5	38
		11	26.2	2.8	35	6.3	52
		12	24.8	1.0	12	6.1	79
		13	24.2	0.6	7	6.0	105
		14	23.1	0.5	6	6.0	147
		15	22.5	0.4	5	6.1	174
		16	21.5	0.4	5	6.1	227
10/18/04	12:07	1	21.0	9.6	107	6.6	38
		2	21.0	8.8	99	6.6	38
		3	21.0	8.7	98	6.6	38
		4	21.0	8.7	97	6.6	38
		5	20.9	8.7	97	6.6	38
		6	21.0	8.6	97	6.6	38
		7	21.0	8.6	97	6.6	38
		8	21.0	8.6	96	6.6	38
		9	21.0	8.6	96	6.6	38
		10	21.0	8.6	96	6.6	38
		11	21.0	8.6	96	6.6	38
		12	21.0	8.6	96	6.6	38
		13	21.0	8.5	96	6.6	38
		14	20.9	8.5	96	6.6	38
		15	20.9	8.5	95	6.6	38
		16	20.9	8.4	94	6.5	38
12/06/04	13:15	1	12.4	8.6	81	6.4	37
		2	12.2	8.3	78	6.0	37
		3	12.1	8.2	77	5.8	37
		4	12.0	8.2	76	5.8	37
		5	11.9	8.1	75	5.7	37
		6	11.9	7.7	72	5.6	38
		7	11.9	7.4	68	5.6	38

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		8	11.9	7.2	67	5.6	38
		9	11.9	7.2	66	5.6	38
		10	11.8	7.3	68	5.6	38
		11	11.8	7.4	68	5.6	38
		12	11.8	7.4	69	5.6	38
		13	11.8	7.4	68	5.6	38
		14	11.8	7.3	68	5.6	38
		15	11.8	7.3	67	5.6	38
		16	11.8	7.2	67	5.6	38
		17	11.8	7.2	66	5.6	38
02/07/05	12:41	1	9.5	10.7	94	5.8	39
		2	9.5	10.7	94	5.8	39
		3	9.5	10.7	94	5.8	39
		4	9.4	10.7	94	5.8	39
		5	9.4	10.7	93	5.8	39
		6	9.3	10.7	93	5.8	39
		7	9.4	10.7	93	5.8	39
		8	9.2	10.7	93	5.8	39
		9	9.1	10.7	92	5.8	39
		10	9.0	10.6	92	5.8	39
		11	9.0	10.6	91	5.8	39
		12	9.0	10.5	91	5.8	39
		13	8.9	10.5	90	5.8	39
		14	8.9	10.5	90	5.8	39
		15	8.8	10.4	89	5.8	39
		16	8.8	10.1	87	5.7	40
04/25/05	12:46	1	21.3	9.3	105	6.4	66
		2	21.3	9.2	104	6.4	65
		4	21.3	9.2	104	6.4	64
		6	21.3	9.2	104	6.5	63
		8	21.3	9.2	104	6.5	60
		10	21.3	9.2	104	6.5	56
		12	21.3	9.2	104	6.5	61
		14	21.2	9.1	103	6.4	59
		16	17.2	5.1	53	6.4	84
06/06/05	12:16	1	30.5	8.5	113	6.8	30
		2	30.3	8.4	112	6.9	30
		3	30.2	8.4	112	6.9	30

Appendix 1. Physical and chemical field data collected as lake profiles, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Sample date	Time	Sample depth (feet)	Water temperature (degrees Celsius)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (percent)	pH	Specific conductance (µS/cm)
		4	30.1	8.4	111	6.9	30
		5	30.1	8.3	111	6.9	30
		6	29.6	8.2	108	6.9	30
		7	26.5	6.0	75	6.5	31
		8	25.4	2.9	36	5.9	31
		9	24.3	1.4	17	5.7	31
		10	23.0	0.6	7	5.7	38
		11	21.8	0.5	6	5.7	45
		12	20.4	0.5	5	5.8	49
		13	19.6	0.4	5	6.0	58
		14	18.9	0.4	4	6.1	68
		15	18.4	0.4	4	6.2	83
		16	18.2	0.3	4	6.3	111

Appendix 2. Laboratory results for blank water samples analyzed as part of a lake study in Arkansas, August 2004 - July 2005.

[mg/L, milligrams per liter; µg/L, micrograms per liter; P, phosphorus; N, nitrogen; <, less than; NTU, nephlometric turbidity units; --, constituent not analyzed at this site; 0.06/0.02, limits changed at some time during the study; **bold** numbers reflect blank analyses that were above the laboratory detection level or reporting limit; n/a, turbidity does not have a laboratory detection or reporting limit]

Lake name	Sample date	Ortho-phosphate (mg/L as P)	Phos-phorus, total (mg/L as P)	Ammonia nitrogen (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Nitrate (mg/L as N)	Nitrite (mg/L as N)	Pheo-phytin-a (µg/L)	Chloro-phyll *a* (µg/L)
Stave	08/25/04	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<1.0	<1.0
First Old River	09/20/04	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<1.0	<1.0
Mallard	10/20/04	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<1.0	<1.0
Upper White Oak	12/06/04	<0.06	<0.05	<0.05	**0.09**	<0.05	<0.05	<1.0	**1.6**
Upper White Oak	02/07/05	<0.02	<0.05	<0.05	**0.06**	<0.02	<0.02	<1.0	<1.0
Mallard	04/26/05	<0.02	<0.05	<0.05	**0.08**	<0.02	<0.02	<5.0	<10.0
Bear Creek	05/16/05	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<5.0	<10.0
Bear Creek	06/07/05	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<5.0	<10.0
Frierson	06/08/05	<0.02	<0.05	--	**0.06**	<0.02	<0.02	<5.0	<10.0
Laboratory method detection limit		0.06/0.02	0.05	0.05	0.05	0.05/0.02	0.05/0.02	0.01	0.01
Laboratory reporting limit		0.06/0.02	0.05	0.05	0.05	0.05/0.02	0.05/0.02	1.0/5.0	1.0/10.0

Lake name	Sample date	Turbidity (NTU)	Nonpurge-able organic carbon (mg/L)	Total sus-pended solids (mg/L)	Volatile sus-pended solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total dis-solved solids (mg/L)	Biochemical oxygen demand (mg/L)
Calion	08/23/04	--	--	--	--	<1.0	<1.0	<10.0	--
Stave	08/25/04	0.2	<1.0	<1.0	<1.0	--	--	--	<3.0
First Old River	09/20/04	0.2	<1.0	<1.0	<1.0	--	--	--	<3.0
Mallard	10/20/04	0.5	<1.0	<1.0	<1.0	--	--	--	<3.0
June	10/20/04	--	--	--	--	<1.0	<1.0	**11**	--
Upper White Oak	12/06/04	0.1	<1.0	<1.0	le	<1.0	<1.0	<10.0	<3.0
Upper White Oak	02/07/05	0.0	<1.0	<1.0	<1.0	<1.0	<1.0	<10.0	<3.0
June	04/26/05	--	--	--	--	<1.0	<1.0	<10.0	--
Mallard	04/26/05	0.2	<1.0	<1.0	<1.0	--	--	--	<3.0
Bear Creek	05/16/05	0.4	<1.0	<1.0	<1.0	--	--	--	<3.0
Calion	06/06/05	--	--	--	--	<1.0	<1.0	<10.0	--
Bear Creek	06/07/05	0.7	<1.0	<1.0	<1.0	--	--	--	<3.0
Frierson	06/08/05	0.2	<1.0	<1.0	<1.0	--	--	--	--
Laboratory method detection limit		n/a	1.0	1.0	1.0	1.0	1.0	1.0	2.0
Laboratory reporting limit		n/a	1.0	1.0	1.0	1.0	1.0	10.0	3.0

Appendix 3. Constituent results for duplicate water samples collected as part of a lake study in Arkansas compared to the result of related environmental samples, August 2004 - July 2005.

[mg/L, milligrams per liter; µg/L, micrograms per liter; P, phosphorus; N, nitrogen; <, less than; NTU, nephlometric turbidity units; **bold** numbers reflect duplicate analyses where results were more than 5 percent different from environmental results; --, duplicate samples for this constituent not analyzed at this site on this date; laboratory reporting limits were used to calculate percent differences between samples]

Lake name	Sample date	Ortho-phosphorus (mg/L as P) (duplicate)	Ortho-phosphorus (mg/L as P) (environ-mental)	Phos-phorus total (mg/L as P) (duplicate)	Phos-phorus total (mg/L as P) (environ-mental)	Ammonia nitrogen (mg/L as N) (duplicate)	Ammonia nitrogen (mg/L as N)	Ammonia plus organic nitrogen total (mg/L as N) (duplicate)	Ammonia plus organic nitrogen total (mg/L as N) (environ-mental)
Old Town	05/16/05	0.09	0.09	**0.22**	**0.20**	<0.05	<0.05	1.99	2.05
First Old River	05/17/05	0.03	0.03	**0.06**	**<0.05**	<0.05	<0.05	1.07	0.97
June	06/06/05	--	--	--	--	--	--	--	--
Mallard	06/08/05	0.03	0.03	0.08	0.08	<0.05	<0.05	1.21	1.36
First Old River	07/25/05	0.30	0.31	0.44	0.45	<0.05	<0.05	3.07	3.06

Lake name	Sample date	Nitrate (mg/L as N) (duplicate)	Nitrate (mg/L as N) (environ-mental)	Nitrite dissolved (mg/L as N) (duplicate)	Nitrite (mg/L as N) (environ-mental)	Pheo-phytin *a* (µg/L) (duplicate)	Pheo-phytin *a* (mg/L) (environ-mental)	Chloro-phyll *a* (µg/L) (duplicate)	Chloro-phyll *a* (mg/L) (environ-mental)
Old Town	05/16/05	<0.02	<0.02	<0.02	<0.02	**13.20**	**17.40**	105	104
First Old River	05/17/05	<0.02	<0.02	<0.02	<0.02	**9.08**	**<5.00**	38.3	39.4
June	06/06/05	--	--	--	--	--	--	--	--
Mallard	06/08/05	<0.02	<0.02	<0.02	<0.02	**<5.00**	**6.47**	**19.4**	**17.4**
First Old River	07/25/05	--	--	0.03	0.03	**6.54**	**<5.00**	262	264

Appendix 3. Constituent results for duplicate water samples collected as part of a lake study in Arkansas compared to the result of related environmental samples, August 2004 - July 2005.—Continued

[mg/L, milligrams per liter; µg/L, micrograms per liter; P, phosphorus; N, nitrogen; <, less than; NTU, nephlometric turbidity units; **bold** numbers reflect duplicate analyses where results were more than 5 percent different from environmental results; --, duplicate samples for this constituent not analyzed at this site on this date; laboratory reporting limits were used to calculate percent differences between samples]

Lake name	Sample date	Turbidity (NTU) (duplicate)	Turbidity (NTU) (environmental)	Non-purgeable organic carbon (mg/L) (duplicate)	Non-purgeable organic carbon (mg/L) (environmental)	Total suspended solids (mg/L) (duplicate)	Total suspended solids (mg/L) (environmental)	Volatile suspended solids (mg/L) (duplicate)	Volatile suspended solids (mg/L) (environmental)
Old Town	05/16/05	22	22	8.0	8.0	22	23	18	19
First Old River	05/17/05	9.4	9.5	8.0	8.0	**10**	**9.0**	7.0	8.0
June	06/06/05	--	--	--	--	--	--	--	--
Mallard	06/08/05	**6.9**	**7.6**	8.0	8.0	8.0	8.0	6.0	6.0
First Old River	07/25/05	18	17	17	17	18	18	18	18

Lake name	Sample date	Chloride (mg/L) (duplicate)	Chloride (mg/L) (environmental)	Total dissolved solids (mg/L) (duplicate)	Total dissolved solids (mg/L) (environmental)	Sulfate (mg/L) (duplicate)	Sulfate (mg/L) (environmental)	Biochemical oxygen demand (mg/L) (duplicate)	Biochemical oxygen demand (mg/L) (environmental)
Old Town	05/16/05	--	--	--	--	--	--	8.0	8.0
First Old River	05/17/05	--	--	--	--	--	--	**5.0**	**4.0**
June	06/06/05	15	15	89	85	2	2	--	--
Mallard	06/08/05	--	--	--	--	--	--	<3.0	<3.0
First Old River	07/25/05	--	--	--	--	--	--	**12**	**13**

Appendix 4. Results of duplicate laboratory analyses for turbidity samples collected as part of a lake study in Arkansas, August 2004 - July 2005.

[NTU, nephlometric turbidity units]

Sample date	Environmental sample (NTU)	Duplicate sample (NTU)	Percent difference
08/25/04	11	11	0
09/24/04	15	15	0
09/24/04	42	42	0
10/20/04	140	140	0
10/20/04	4.7	4.2	12
10/21/04	18	20	11
12/08/04	26	27	4
12/08/04	14	15	7
12/08/04	10	10	0
02/09/05	5	4.9	2
02/09/05	6	5.9	2
02/10/05	39	39	0
04/27/05	4.6	4.7	2
04/27/05	8.6	8.7	1
05/17/05	2.2	2.2	0
05/19/05	9.7	9.4	3
06/08/05	5.7	5.5	4
06/08/05	9	9.2	2
06/09/05	44	44	0
07/27/05	30	30	0
07/27/05	50	49	2