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Assessment of Water-Quality Conditions in the J.B. Converse Lake Watershed, Mobile County, Alabama, 1990–98

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U.S. Geological Survey
Water-Resources Investigations Report 01–4225

Prepared in cooperation with the
Mobile Area Water and Sewer System

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

Cover photographs: Plant nursery, private pond, and cattle grazing in the J.B. Converse Lake watershed (*taken by Will S. Mooty, U.S. Geological Survey*).

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By C.A. Journey and A.C. Gill

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Montgomery, Alabama
2001

U.S. DEPARTMENT OF THE INTERIOR
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Multiply	by	To obtain
	Length	
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
	Area	
square mile (mi^2)	259	hectare
square mile (mi^2)	2.590	square kilometer
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile ($[ft^3/s]/mi^2$)	0.01093	cubic meter per second per square kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Temperature: Temperature is given in degrees Fahrenheit (°F), which can be converted to degrees Celsius (°C) as follows:

$$^{\circ}C = 5/9\,(^{\circ}F - 32).$$

Acronyms and abbreviations:

ADEM	Alabama Department of Environmental Management
ANC	acid-neutralizing capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DEM	digital elevation model
DBP	disinfection by-product
DOC	dissolved organic carbon
GIS	geographic information system
HAA	haloacetic acid
ICR	Information Collection Rule
LOWESS	Locally Weighted Regression and Smoothing of Scatter Plots
MAWSS	Mobile Area Water and Sewer System
MBAS	methylene blue activated substances
MCL	maximum contaminant level
MRLC	Multi-Resolution Land Characteristic
MVUE	Minimum Variance Unbiased Estimator
NRCS	Natural Resource Conservation Service
NWIS	National Water Information System (U.S. Geological Survey database)
OECD	Organization for Economic Cooperation and Development
PCS	permit compliance system
PVC	polyvinyl chloride
STATSGO	State Soil Geographic Data Base
STORET	Storage and Retrieval System (U.S. Environmental Protection Agency database)

Acronyms and abbreviations (continued):

SUVA	specific ultraviolet absorbance
THM	trihalomethane
THM-FP	trihalomethane-formation potential
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TRI	Toxic Release Inventory
TSI	trophic state index
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UVA	ultraviolet absorbance
UV-Vis	Ultraviolet -Visible Spectrum

acre-foot	acre-ft
B	boron
Br	bromine
C	carbon
Ca	calcium
$CaCO_3$	calcium carbonate
Cl	chlorine
cm	centimeter
col/100 mL	colonies per 100 milliliters
CO_3	carbonate
F	fluorine
Fe	iron
ft^3/s	cubic feet per second
g/d	gram per day
g/yr	gram per year
HCO_3	bicarbonate
Hg	mercury
K	potassium
kg	kilogram
kg/d	kilogram per day
(kg/ha)/yr	kilogram per hectare per year
kg/yr	kilogram per year
m	meter
m^2	square meter
Mg	magnesium
mg/L	milligram per liter
(mg/L)/yr	milligram per liter per year
mL	milliliter
mm	millimeter
Mn	manganese
m/yr	meter per year
N	nitrogen
Na	sodium
nm	nanometer
P	phosphorus
ppm	parts per million
SiO_2	silica
SO_4	sulfate
µg/L	microgram per liter
µS/cm	microsiemens per centimeter
UVA-DOC	ultraviolet absorbance of dissolved organic carbon at 254 nanometers
UVA-TOC	ultraviolet absorbance of total organic carbon at 254 nanometers

Water year is the period October 1 through September 30 and is identified by the year in which it ends.

Assessment of Water-Quality Conditions in the J.B. Converse Lake Watershed, Mobile County, Alabama, 1990–98

By C.A. Journey and A.C. Gill

ABSTRACT

J.B. Converse (Converse) Lake is a 3,600-acre, tributary-storage reservoir in Mobile County, southwestern Alabama. The lake serves as the primary drinking-water supply for the city of Mobile. The Converse Lake watershed lies within the Coastal Plain Physiographic Province. Semiconsolidated to unconsolidated sediments of sand, silt, gravel, and clay underlie the watershed, and are covered by acidic soils. Land use in the watershed is mainly forest (64 percent) and agriculture (31 percent). Residential and commercial development account for only 1 percent of the total land use in the watershed.

Converse Lake receives inflow from seven major tributaries. The greatest inflows are from Big Creek, Crooked Creek, and Hamilton Creek that had mean annual streamflows of 72.2, 19.4, and 25.0 cubic feet per second, respectively, for the period 1990 to 1998, which represents about 72 percent of the total annual streamflow to the lake. The total mean annual inflow to the lake is estimated to be about 163 cubic feet per second.

In general, water quality in Converse Lake and its tributaries meets the criteria established by the Alabama Department of Environmental Management (ADEM) for drinking-water supplies, whole-body contact, and aquatic life. The exceptions include acidic pH levels, iron and manganese levels above secondary or aesthetic criteria, and fecal bacterial levels in some tributaries above whole-body contact (swimmable) criteria. The pH levels throughout the watershed were commonly below the criteria level of 6.0, but this appears to have been a naturally occurring phenomenon caused by poorly buffered soil types, resistant sediments, and forested land use. Median iron and manganese levels were above aesthetic criteria levels of 300 and 50 micrograms per liter, respectively, in some tributaries. All tributary sites in the Converse Lake watershed had median and minimum dissolved-oxygen concentrations above the ADEM criteria level of 5 milligrams per liter except for Boggy Branch, which had a minimum dissolved-oxygen concentration of 3.7 milligrams per liter.

The degree to which nutrient contributions from tributaries were causing nutrient enrichment and eutrophication in Converse Lake was assessed. Trend analysis detected little or no change in nutrient concentrations at the tributary and lake sites in the Converse Lake watershed from the 1991 to 1998 water years. Nutrient concentrations at most tributary sites exhibited a significant, positive relation with streamflow that indicated the dominant source of nutrient input to the watershed is from nonpoint contributions. From 1990 to 1998, computed mean annual loads of 75,400 kilograms of total nitrogen, 36,950 kilograms of total Kjeldahl nitrogen, 28,870 kilograms of total inorganic nitrogen, and 3,480 kilograms of total phosphorus were contributed to the lake by Big Creek, Hamilton Creek, and Crooked Creek combined. These mean

annual loads of nutrients corresponded to borderline eutrophic/mesotrophic conditions in the lake. Of the combined loads, 62 percent of the total nitrogen, 70 percent of the total Kjeldahl nitrogen, 54 percent of the total inorganic nitrogen, and 47 percent of the total phosphorus originated from the forested subbasin of Big Creek. The more residential and agricultural subbasins of Crooked Creek and Hamilton Creek, however, yielded over twice the total phosphorus load per hectare of land use. Crooked and Hamilton Creek subbasins also had higher yields of the more bioavailable total inorganic nitrogen. A simplistic empirical model could not explain the relation between year-to-year nutrient contributions to Converse Lake from the tributaries and the lake's ability to assimilate those contributions.

The potential presence of pathogens in the lake and its tributaries was assessed based on fecal bacterial concentrations. Fecal bacterial concentrations at some tributary sites were above existing criteria for swimmable uses. Contributions of fecal bacteria from tributaries to the lake, however, did not appear to affect the lake because fecal bacterial concentrations at lake sites were one to two orders of magnitude lower than tributary sites and well below criteria levels. Juniper Creek had the highest fecal bacterial concentrations during the study. Trend analysis showed that flow-adjusted fecal streptococcus concentrations increased at Juniper Creek during the 8 years of data collection. *Giardia* cysts and *Cryptosporidium* oocysts were detected infrequently at sites in the lake and the raw-water intake during the monitoring effort. Most of the detections occurred during the summer months, but no clear relation between season and cyst density or cyst concentrations in the water supply can be established because of the infrequent detections.

Naturally occurring organic carbon compounds derived from the decay of plant material on land were the major source of organic carbon in the Converse Lake watershed. Reactive organic carbon had a greater potential to form trihalomethanes as a result of chlorination during water treatment. In the lake, algae was considered an important source of organic carbon as indicated by strong, positive, statistically significant correlations among chlorophyll *a*, total organic carbon, and dissolved organic carbon. The algal-derived organic carbon, however, was not considered the major source of the reactive organic carbon as indicated by the absence of significant statistical correlations between chlorophyll *a*, total organic carbon, dissolved organic carbon, ultraviolet absorbance at 254 nanometers, and trihalomethane-formation potential.

INTRODUCTION

J.B. Converse Lake, formerly known as Big Creek Lake and hereafter referred to as Converse Lake, is a 3,600-acre tributary-storage reservoir in Mobile County in southwestern Alabama (fig. 1). The lake is the primary source of drinking water for the Mobile area and a popular recreational spot for fishing and boating activities, although swimming and water skiing are prohibited. The warm Gulf Coast climate attracts recreational fishermen year round to the lake, and supports a growing plant nursery industry in the watershed. At present (2001), the watershed is mostly forested and rural, although residential development has increased throughout the area during the past 10 years.

Rapid, unmanaged, and(or) pervasive changes in human activities in a watershed can have profound, long-term effects on the water quality of a lake or reservoir. Because Converse Lake serves as a source of drinking water, it is important to understand the effects that land use and future development may have on water quality. To effectively manage and protect the water resources of the lake, the following three questions must be answered.

1. Does the water quality of the lake and its tributaries meet the intended uses of the water?
2. Is the water quality of the lake and its tributaries changing over time?
3. What real or potential sources of water-quality problems exist in the watershed?

This report addresses these questions and also serves as a source-water assessment, which is a required part of the new protection strategy for public water supplies in Alabama.

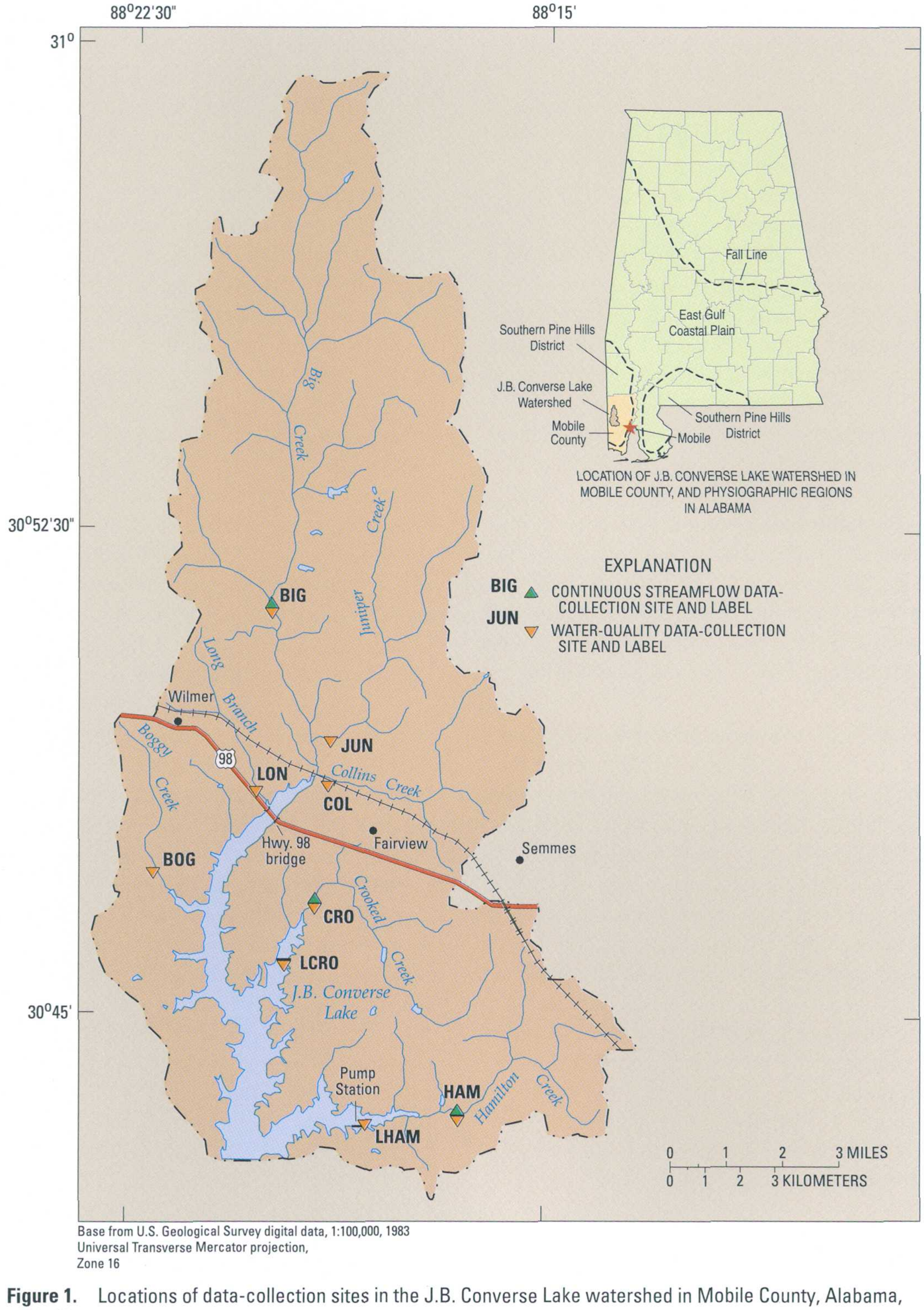


Figure 1. Locations of data-collection sites in the J.B. Converse Lake watershed in Mobile County, Alabama, 1990–98.

The Mobile Area Water and Sewer System (MAWSS) manages Converse Lake and the E. Morgan Stickney and Harry E. Myers Water Filtration Facilities. These two facilities treat the raw water withdrawn by a pumping station on Converse Lake (site LHAM; fig. 1), and then deliver treated water to the city of Mobile. Much of the land surrounding the lake is covered by a combination of evergreen and deciduous forest and is owned by the MAWSS. The remaining part of the watershed consists of a combination of forest, pastures and dairy farms, plant nurseries, pecan groves, and residential areas that include septic-tank systems for sewage disposal. These land uses contribute nonpoint sources of pollutants that influence the water quality in Converse Lake and its tributaries. Runoff from rainfall in the watershed washes contaminants from the land surface into the tributaries, which in turn deliver contaminants to the lake. Sediment, fecal indicator bacteria, organic carbon compounds, and nutrients commonly are present in runoff from agricultural and rural residential areas, and can impair the quality of water. Effluent from septic-tank systems also can contribute similar contaminants during periods of little or no runoff if the density of the tanks exceeds the capacity of the soil to assimilate the sewage.

Elevated nutrient concentrations in lake water can produce excessive algal growth and increase the total organic carbon present in the water. The presence of fecal indicator bacteria in the lake water requires treatment of drinking water with chlorine-related disinfectants. During this disinfection process, however, the chlorine can react with naturally occurring or culturally derived organic carbon compounds to produce by-products that are suspected carcinogens. Any process that increases the level of total organic carbon present in the raw water, increases the chances for these by-products to form during the disinfection processes.

Purpose and Scope

The purpose of this report is to describe the assessment of water quality in the Converse Lake watershed during 1990–98 and the influence of land-use practices on water quality in the watershed. The U.S. Geological Survey (USGS), in cooperation with the MAWSS, began monitoring streamflow and water quality in the Converse Lake watershed in October 1990. The focus of this monitoring program is on the temporal and spatial distribution of concentrations of nutrients, fecal bacteria, and organic carbon in the lake and its tributaries. The water-quality data and analytical results presented in this report will be useful in managing and protecting the drinking-water supply for the city of Mobile. Providing information to better define and manage the quality of water resources is among the highest priority issues of the Cooperative Water Program of the USGS. This investigation also provides information to improve watershed characterization of local sources of water supply, determine the effects of land-use practices on surface-water quality, and identify waterborne microbiological threats to human health, all of which are priority issues of the Cooperative Water Program.

A data-collection network was established at seven tributary sites and two lake sites in the Converse Lake watershed (fig. 1; table 1). Concentrations of nutrients and fecal bacterial indicator levels have been monitored at these sites at varying frequencies (monthly to quarterly) since October 1990, and concentrations of organic carbon have been monitored monthly since October 1996. Three gaging stations located on major tributaries to Converse Lake (fig. 1) collect continuous streamflow record.

This report consists of four sections that discuss spatial and temporal variations in basic water chemistry, nutrients, fecal indicators, and organic carbon and their relation to land-use practices in the watershed. Additionally, the nutrient section includes the estimated annual nutrient load data from three gaged tributary sites in the watershed, an 8-year trend analysis of the nutrient concentrations in the lake and its tributaries, and a comparison of annual nutrient loads to the trophic state of the lake. The microbiological assessment section describes the 8-year trend analysis of fecal coliform and fecal streptococcus concentrations in the lake and its tributaries and compares the levels of fecal indicator bacteria to the Alabama Department of Environmental Management (ADEM) water-quality standards and criteria. The organic carbon section characterizes the reactive nature of organic carbon and its probable source (algal, terrestrial).

Previous Investigations

States are required by section 314(a) of the Clean Water Act to conduct assessments of the water quality of publicly owned lakes (U.S. Environmental

Table 1. Descriptions of data-collection sites and sampling characteristics in the Converse Lake watershed, Alabama, 1990–98

[USGS, U.S. Geological Survey; mi^2, square mile; Q, quarterly; M, monthly; —, not applicable]

Site label (fig. 1)	USGS station number	Station name	Drainage area (mi^2)	Sampling frequency				
				Streamflow	Major ions	Nutrients	Fecal bacteria	Organic carbon
BIG	02479945	Big Creek at County Road 63 near Wilmer	31.5	Continuous record	Q	M[a] Q[b]	M[c] Q[d]	M[e]
JUN	02479948	Juniper Creek at Glenwood Road near Fairview	9.22	Partial record	Q	M[a] Q[b]	M[c] Q[d]	M[e]
COL	02479950	Collins Creek at Glenwood Road near Fairview	8.54	Partial record	Q	M[a] Q[b]	M[c] Q[d]	M[e]
LON	02479955	Long Branch near Wilmer	2.85	Partial record	Q	M[a] Q[b]	M[c] Q[d]	M[e]
BOG	02479960	Boggy Branch near Wilmer	3.17	Partial record	Q	M[a] Q[b]	M[c] Q[d]	M[e]
CRO	02479980	Crooked Creek near Fairview	8.08	Continuous record	Q	M[a] Q[b]	M[c] Q[d]	M[e]
LCRO	02479985	Crooked Creek at mouth (Lake) near Wilmer	—	—	Q[f]	Q[f]	M[f]	M[e]
HAM	02480002	Hamilton Creek at Snow Road near Semmes	8.22	Continuous record	Q	M[a] Q[b]	M[c] Q[d]	M[e]
LHAM	02480004	Hamilton Creek (Lake at the intake) near Semmes	—	—	Q	M[a] Q[b]	M[c] Q[d]	M[e]

[a]Monthly samples were collected for the period October 1990 to September 1992.
[b]Quarterly samples were collected for the period October 1992 to June 1998.
[c]Monthly samples were collected for the periods October 1990 to September 1992 and October 1996 to June 1998.
[d]Quarterly samples were collected for the period October 1992 to September 1996.
[e]Monthly samples were collected for the period October 1996 to June 1998.
[f]All samples were collected in October 1996.

Protection Agency, 1981, 1989). In compliance with the Clean Water Act requirements, the ADEM initiated the Reservoir Water Quality Monitoring Program in 1990 to address trophic-state trends in lakes. The results of ADEM's monitoring program were published for 1985 to 1995 (Alabama Department of Environmental Management, 1996) and for 1997 (Alabama Department of Environmental Management, 1999).

Development of anoxic, or oxygen-depleted, conditions during stratification is a common occurrence in mesotrophic and eutrophic lakes. Vertical profiles of dissolved-oxygen concentrations, specific conductance, and water temperature at several cross sections in Converse Lake have helped to identify the seasonal occurrence of anoxic conditions (Journey and others, 1995; Bayne and others, 1998).

In 1995, the USGS published a report that describes streamflow and nutrient contributions of major tributaries to Converse Lake (Journey and others, 1995). Nutrient loads to the lake were computed for 1991 and 1992. Big Creek and Hamilton Creek were estimated to have the highest nitrogen loads. Crooked and Juniper Creeks also had relatively high nitrogen loads compared to Collins Creek, an adjacent tributary basin with similar drainage area and land use. Big Creek, Crooked Creek, and Hamilton Creek subbasins contributed the highest phosphorus loads, and these subbasins also had a variety of land-use practices, such as pastures, plant nurseries, and residential areas.

In its two water-treatment plants, the MAWSS monitors raw and finished water for microbial contaminants and disinfection by-products in compliance with the 1996 amendments to the Safe Drinking Water Act: Information Collection Rule and the Enhanced Surface Water Treatment Rule (U.S. Environmental Protection Agency, 1996a,b,c). In 1995, concentrations of total organic carbon (TOC) periodically increased in raw and finished water at both treatment facilities. The treatment of the increased TOC concentrations resulted in higher concentrations of disinfection by-products in the finished water. In 1995, the sources of the periodic increases in TOC were not understood.

WATERSHED CHARACTERIZATION

Converse Lake was formed from the impoundment of Big Creek in 1952 and was previously known as Big Creek Lake. The drainage area of the watershed is 103 mi^2 at the dam (table 2). The lake volume is 52,000 acre-ft, or approximately 17 billion gallons of water at the normal operational pool level of 110 ft above mean sea level (City of Mobile, Board of Water and Sewer Commissioners, written commun., October 5, 1994). Converse Lake has a mean depth of 14.4 ft at full pool, with maximum depths of over 50 ft near the dam and spillway (table 2). The pump station is located in a small embayment below the mouth of Hamilton Creek (site LHAM, fig. 1). The embayment has a maximum depth of 27 ft.

Table 2. Physical characteristics of Converse Lake

Characteristic	Value
Total volume	52,000 acre-feet
Surface area	3,600 acres
Mean depth	14.4 feet
Maximum depth	50 + feet
Mean annual inflow	163 cubic feet per second
Hydraulic residence time	0.44 year 160 days
Drainage area of watershed	103 square miles

The Converse Lake watershed is located in Mobile County west of the city of Mobile near the Alabama-Mississippi State line. The lake is designated by the ADEM for aquatic life and public water-supply use (Alabama Department of Environmental Management, 1994b). Management of the lake requires an understanding of all factors influencing the water quality. A sound science-based management plan for development and growth in the watershed considers all aspects of naturally occurring and culturally induced factors in order to aid in the protection of the water quality of the lake and its tributaries.

For this investigation, spatial coverages of natural and cultural features in the watershed were obtained from geographic information system (GIS) databases. ArcInfo and ArcView 3.2 GIS coverages were developed and used to integrate the information on environmental factors and water quality. The coverages include basin and major tributary subbasin drainage areas (1:24,000 scale); streams, roads, railroads, and major geologic units (1:250,000 scale); major soil types (State Soil Geographic [STATSGO] database, 1:250,000 scale); Landsat satellite imagery of major land use and land cover (1992 Multi-Resolution Land Characteristics [MRLC], 30-meter resolution); and locations of point sources in the watershed (U.S. Environmental Protection Agency [USEPA] Toxic Release Inventory [TRI], hazardous-waste permit compliance system [PCS], and Superfund [Comprehensive Environmental Response, Compensation, and Liability Act—CERCLA] sites). Spatial differences in water quality were compared to the spatial coverage of environmental factors to identify potential relations. This integrated approach helped identify key factors that influence water quality, and evaluate the present conditions in the lake and its tributaries.

Natural Factors

The interaction of many environmental factors affects the quality of the water in a watershed. Some natural factors in a watershed, such as climate, topography, rock and soil types, and vegetation, can influence water quality differently.

Climate

The study area is close to the Gulf Coast and, thus, the climate is subtropical. Precipitation occurs almost exclusively as rainfall. Snowfall accumulation is rare. Several types of weather patterns influence the climate. The Gulf of Mexico produces warm, humid air masses that move inland and provide precipitation in the form of sporadic thunderstorms, especially during the summer. Extremely high-intensity rainfall is produced from tropical systems that enter the Gulf of Mexico (tropical depressions, storms, and hurricanes) and move inland in late summer and early fall (July to September). In winter, the climate is further influenced by arctic fronts that move south from the Midwest. Frontal storms contribute more continuous precipitation and cooler temperatures.

The mean annual precipitation in the Mobile area for the 30-year period 1961–90 was 64 in. and ranged from 44 to 86 in. (National Oceanic and Atmospheric Administration, 1998). Mean monthly precipitation ranged from 3 in. in October to 7 in. in August (fig. 2). A distinct dry period occurred during late fall (October to November). Two wet periods were identified during

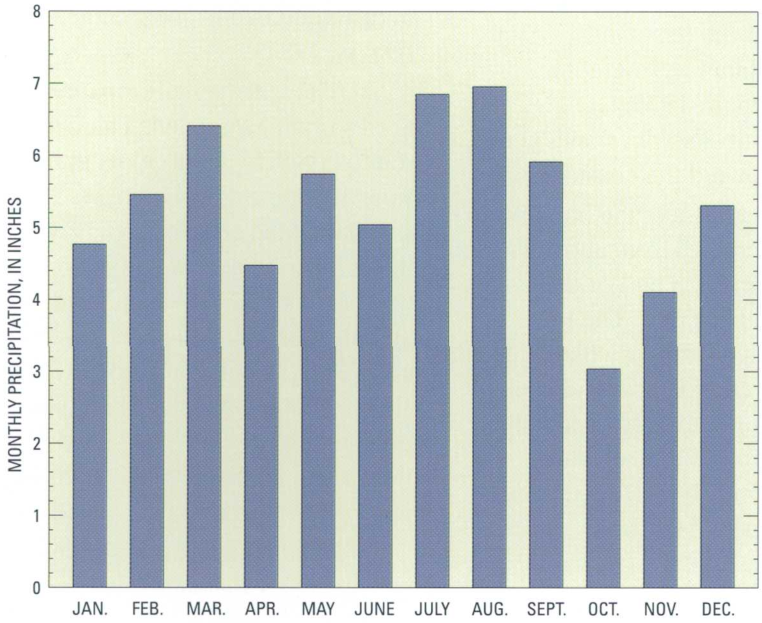


Figure 2. Mean monthly precipitation for 1961–90 at the Mobile Regional Airport, Alabama.

early spring (March) and late summer (July to August). The late summer wet period was related to tropical storms moving inland from the Gulf of Mexico.

During the study period, the driest years were 1990 and 1994 when annual precipitation was about 8 in. below the normal mean annual precipitation of 64 in. (fig. 3). The wettest years were 1991 and 1995 when annual precipitation was more than 15 in. above the normal mean annual precipitation.

The mean annual temperature during the study period was 67.5 °F. Temperatures in the study area generally are above freezing throughout most of the year, and mean monthly temperatures range from 50 °F in January to 82 °F in July (National Oceanic and Atmospheric Administration, 1998).

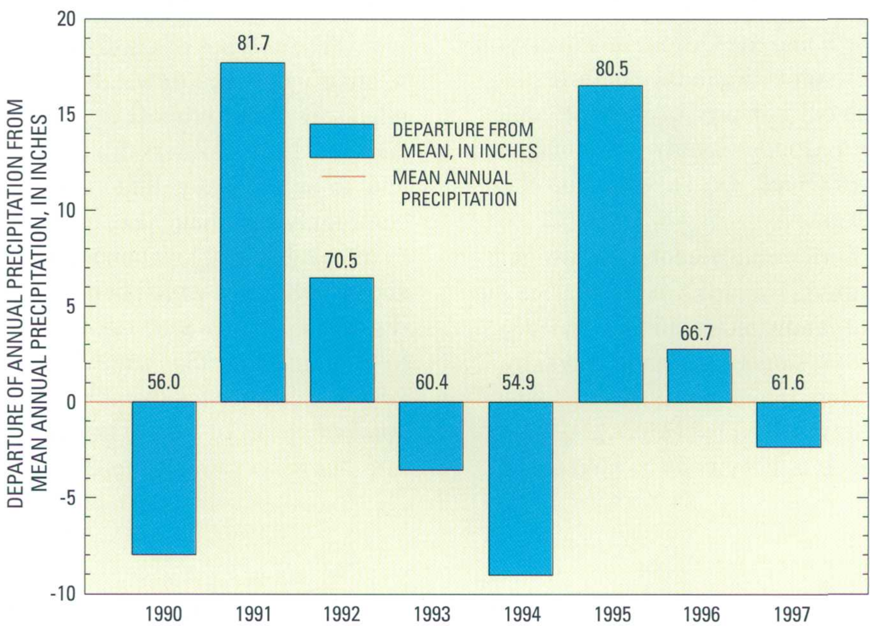


Figure 3. Total annual precipitation (1990–97) and departure from the mean annual precipitation (1961–90) of 64 inches.

Physiography

The Converse Lake watershed lies within the Southern Pine Hills District of the East Gulf Coastal Plain section of the Coastal Plain Physiographic Province (Sapp and Emplaincourt, 1975; fig. 1). Land surface in the Southern Pine Hills District slopes gently in a southwesterly direction toward the coast.

In the Converse Lake watershed, the maximum altitude of the land surface decreases from about 290 ft above mean sea level in the northern part of the watershed to 250 ft in the southern part. The lowest point in the watershed is the lake surface, which has an altitude ranging between 105 and 115 ft above mean sea level. A spatial coverage of land-surface slope for the watershed was obtained from digital elevation models (DEMs). The majority of the watershed has a gentle slope of less than 1 degree. Maximum slopes of 4 degrees are found at altitudes ranging between 150 and 200 ft (fig. 4); steeper slopes may result from changes in lithology. Because of the steeper slopes, which allow for greater erosion and quicker transport of contaminants, this area has a greater potential for contributing contaminants to the lake and its tributaries during runoff conditions.

Major Hydrogeologic Units

Two geologic units consisting of semi-consolidated to unconsolidated sand, silt, gravel, and clay of Tertiary age underlie the Converse Lake watershed (fig. 5). The two units are undifferentiated sedimentary deposits of Miocene age (named Miocene Series undifferentiated) and the Citronelle Formation of Pliocene age. These units dip to the southwest at about 5 ft/mi near the outcrop area of the Citronelle Formation in northern Mobile County to as much as 50 ft/mi near the coast (Reed, 1971). The units also thicken to the southwest.

The Miocene Series undifferentiated, which is the older of the two units, is marine and estuarine in origin and consists of laminated to thinly bedded, laterally extensive clays, sands, and sandy clays (fig. 6; Reed, 1971). The texture ranges from fine to coarse sands that are locally cross bedded (Mooty, 1988). Some outcrops of this unit have beds of sand that contain gravel and petrified plant fossils, and clays that contain carbonized leaf remains. The Miocene Series undifferentiated is about 3,000 ft thick near the coast (Davis, 1987).

The Citronelle Formation overlies the Miocene Series undifferentiated. The Citronelle Formation is relatively thin (about 30 ft) in the northern part of the watershed, but thickens toward the south to about 130 ft near the coast (fig. 6; Davis, 1987). Sediments of this unit consist of gravelly sands and sandy clays. Thin (5 to 15 ft thick) lenses of sandy clay and clayey sand are interbedded with gravelly sand in some areas of the unit. The base of the Citronelle Formation has a high clay and iron content and includes limonite-cemented (iron hydroxide) gravelly sand. The Citronelle Formation grades into discontinuous, sandy-clay and clayey-sand lenses interbedded with gravelly sand.

The major aquifer system contributing ground water to the streams and lakes in the Converse Lake watershed is the Pliocene-Miocene aquifer, which consists of the Citronelle Formation (of Pliocene age) and the Miocene Series undifferentiated (Mooty, 1988). Although clayey sediments in the Miocene Series cause the aquifer to behave as if it were semiconfined at depth, the sand and gravel beds of the Citronelle Formation and upper part of the Miocene Series are hydraulically connected to the land surface. As a result, ground water is susceptible to contamination from the watershed surface. Areas in the watershed most susceptible to contamination from the surface are those that are relatively flat with very permeable soils.

These types of clastic sediments tend to be relatively resistant to weathering and contribute relatively little to runoff or surface-water chemistry (Drever, 1988). Waters draining resistant sediments tend to be relatively dilute in total dissolved solids, commonly less than 100 mg/L. The dilute waters tend to have relatively low concentrations of base cations and bicarbonate, which help to neutralize acid. As a result, the pH of waters draining clastic sediments tend to be more acidic than waters draining other rock types. Also, the iron-rich cement in the sediment can elevate concentrations of iron in the ground water, which in turn discharges to streams and lakes.

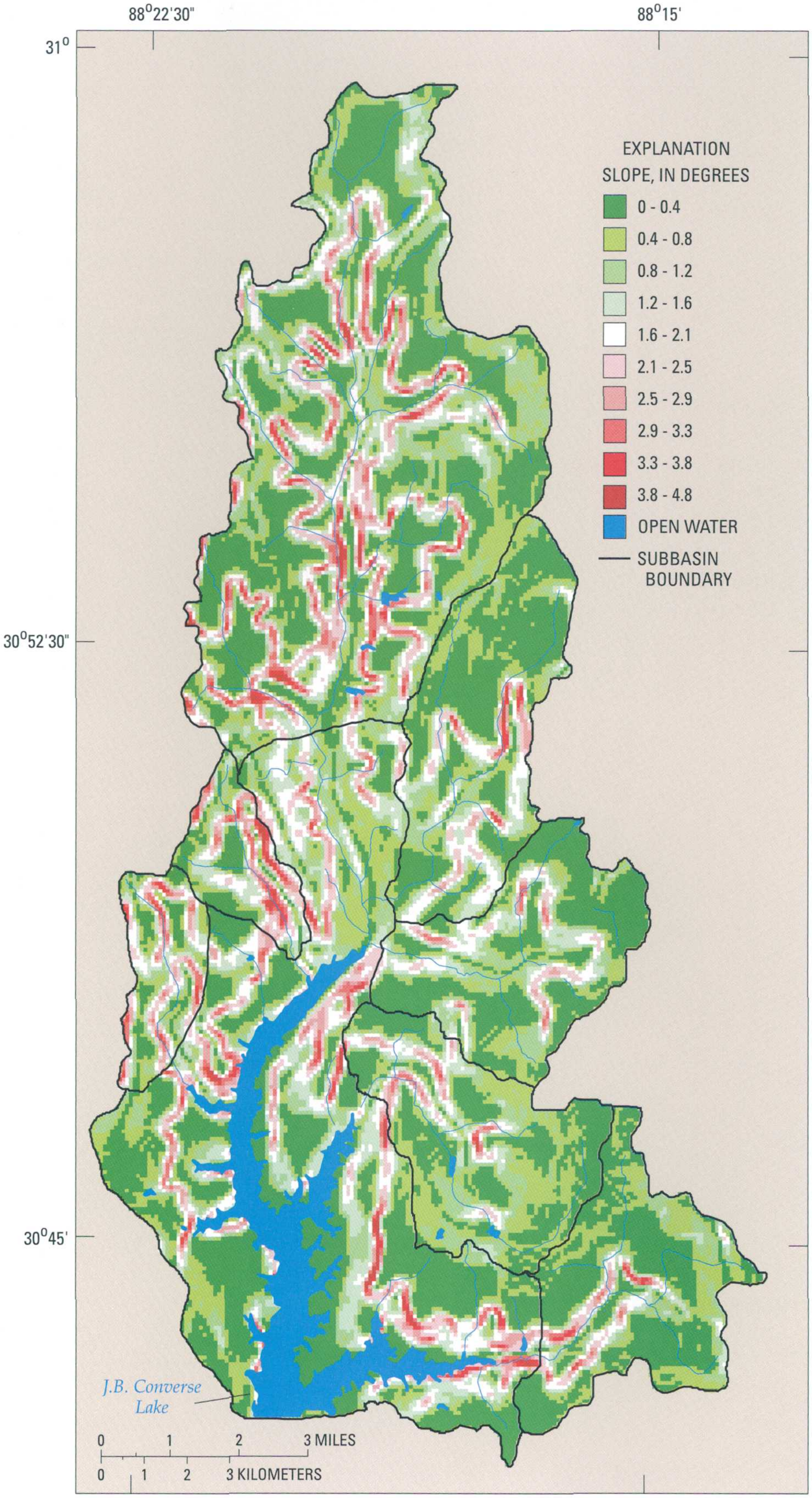


Figure 4. Digital elevation model (DEM) coverage of land-surface slope in subbasins of the Converse Lake watershed, Alabama.

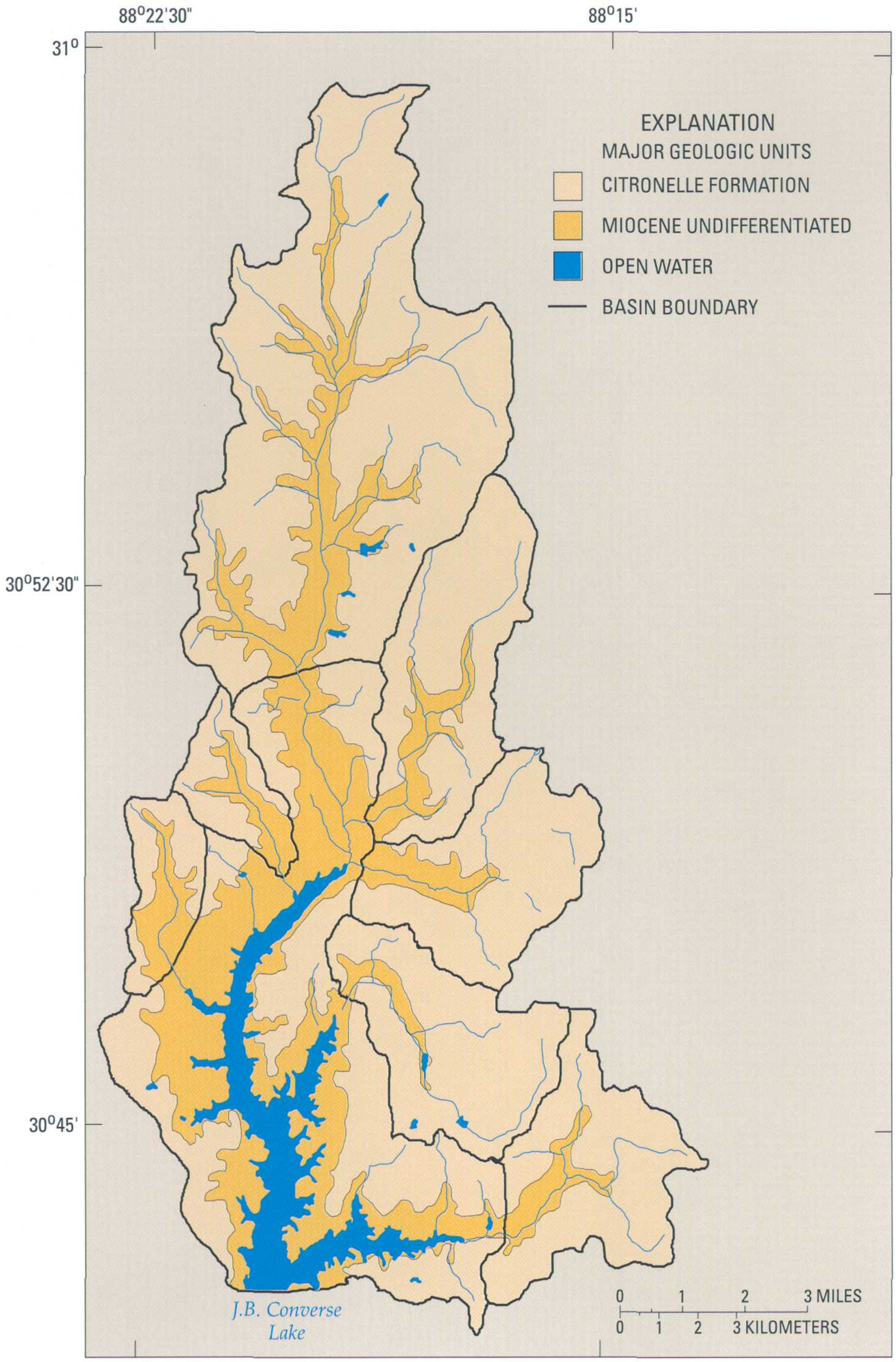


Figure 5. Major geologic units in the Converse Lake watershed, Alabama.

System	Series	Geologic unit	Thickness (feet)	Lithology	Aquifer	Yield	Quality of ground water
Tertiary	Pliocene	Citronelle Formation	0–130	Sand, brown, red, and orange, fine- to coarse-grained, gravelly in places; contains clay balls and partings; gray, orange, and brown lenticular sandy clay, ferruginous sandstone.	Pliocene-Miocene aquifer	Will yield 2 million gallons of water per day or more per well.	Water is low in total dissolved solids, contains iron in excess of 0.3 milligram per liter, and acidic.
	Miocene	Miocene Series undifferentiated	30–3,000	Sand, gray, orange, and red, very fine- to coarse-grained, contains gravel in places; gray thin-bedded to massive sandy silty clay.			

Figure 6. Stratigraphy and lithology of the geologic units and water-bearing properties in the Converse Lake watershed, Alabama.

Major Soil Types

The type of soil in a particular region is influenced by climate, the nature of the bedrock, landscape relief, vegetation, and the time over which the soil-forming process occurs. These factors interact to produce characteristic soil profiles that vary with depth and complexity. The major soil type in the Converse Lake watershed is classified as ultisol (Hajek and others, 1975). These deeply weathered soils are common in the Southeast because of the humid climate.

The State Soil Geographic (STATSGO) database for Alabama contains digital geographic data created by generalizing more detailed soil survey maps onto USGS 1:250,000-scale topographic quadrangle series maps (U.S. Department of Agriculture, 1994). This database provides soil types in a particular area on a regional scale. Four major soil associations are present in the Converse Lake watershed (fig. 7)—Troup-Smithton-Bibb (AL 213), Troup-Heidel-Bama (AL 221), Notcher-Saucier-Malbis (AL 223), and Esto-Troup-Benndale (AL 226). The Troup-Heidel-Bama soil series covers 77.8 percent of the watershed. The Troup-Smithton-Bibb soil series covers 21.3 percent of the watershed, all of which is in the Big Creek subbasin. The major soil associations of Notcher-Saucier-Malbis and Esto-Troup-Benndale account for less than 1 percent of the watershed's soil cover.

Each soil series has certain properties or characteristics associated with it. All of the major soils are deep and highly acidic (Hajek and others, 1975). Troup, Benndale, and Bama soil series are classified as well drained with moderate permeability. Smithton soil series is poorly drained with moderately slow permeability, and potentially has a perched water table. Malbis soil series is moderately well drained and tends to have a perched water table.

Hydrology

Understanding the hydrologic cycling of water in the Converse Lake watershed is necessary to identify the potential and actual sources of contaminants to the lake and its tributaries. Ground water in the surficial aquifer system discharges to the lake and its tributaries. Contaminants can infiltrate from the land surface into the ground water in the surficial aquifer. Ground water then can be a source of contamination to the lake and tributaries. The tributaries supply varying amounts of annual inflow to the lake, carrying loads of nutrients, bacteria, and organic carbon. The ability of the lake to assimilate the contaminant loads is, in part, related to the amount of inflow to and outflow from the lake. The

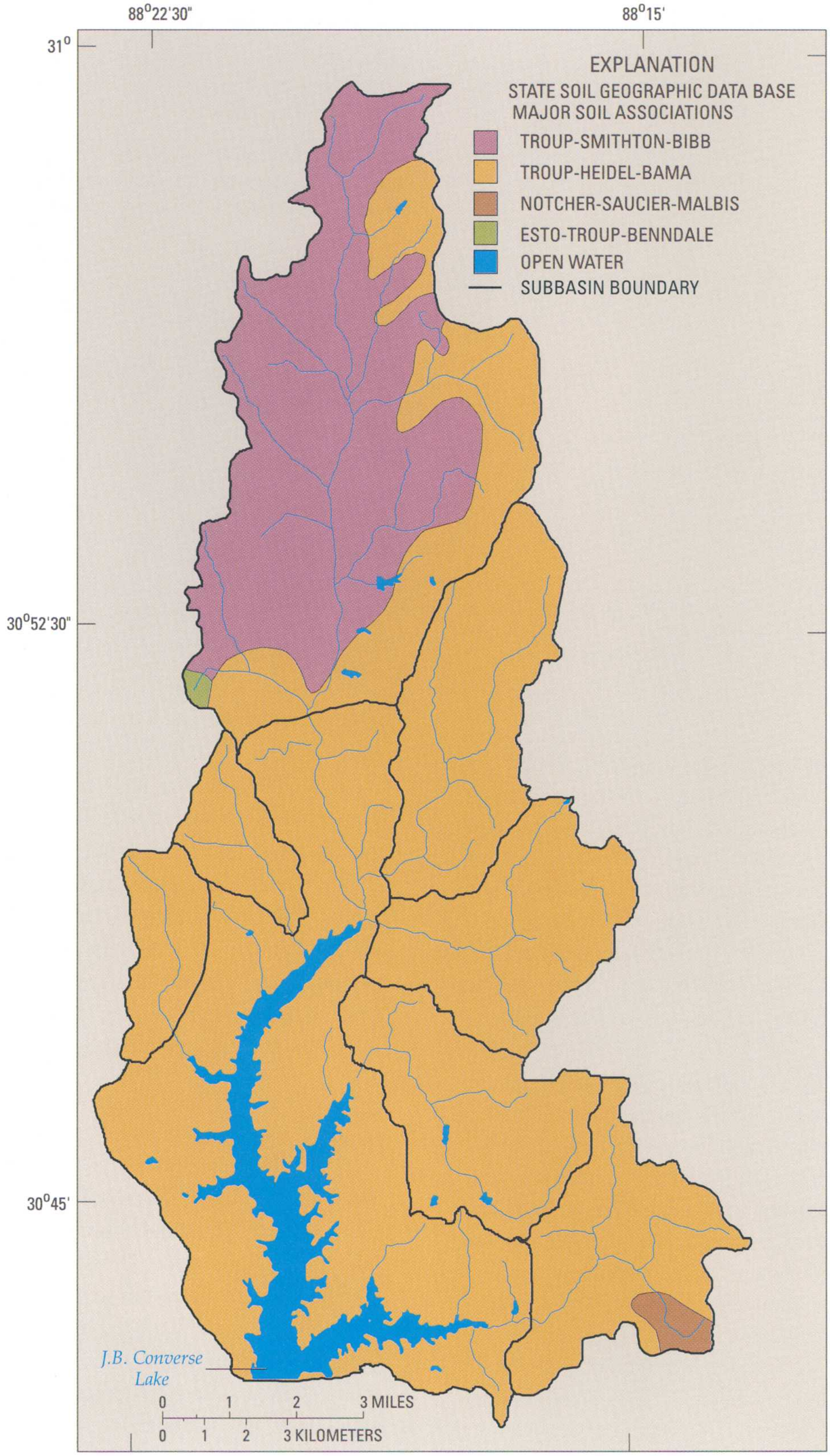


Figure 7. Major soil associations in the Converse Lake watershed, Alabama.

inflow to and outflow from the lake determines the residence time of the water in the lake.

Converse Lake receives inflow from seven major tributaries that drain about three-fourths of the total watershed (fig. 1; table 1). Big Creek is the largest subbasin and drains 31.5 mi^2 at the Big Creek gaging station (site BIG, fig. 1) near Wilmer, Ala. Adjoining subbasins in the eastern part of the watershed are Juniper Creek (site JUN), Collins Creek (site COL), Crooked Creek (site CRO), and Hamilton Creek (site HAM; fig. 1). These subbasins have drainage areas ranging from 8.08 to 9.22 mi^2. Long Branch (site LON) and Boggy Branch (site BOG; fig. 1), located in the western part of the watershed, have smaller subbasins that each drain about 3 mi^2 (table 1).

Streamflow data are critical in computing and interpreting nutrient loads and trends. A brief summary of streamflow conditions in the Converse Lake watershed for the study period, October 1990 to September 1998, is provided in table 3. Long and Boggy Branches (sites LON and BOG) had only 1 year of record; Collins and Juniper Creeks (sites COL and JUN) had 2 years of record. Big Creek, Crooked Creek, and Hamilton Creek (sites BIG, CRO, and HAM) had mean annual streamflows of 72.2, 19.4, and 25.0 (ft^3/s), respectively, for the study period.

Computation of annual yields was used to normalize streamflow for the tributary drainage areas to allow for comparisons of streamflow per square mile. Hamilton Creek subbasin had the greatest yield of 3.04 (ft^3/s)/mi^2; Crooked and Big Creeks had yields of 2.40 and 2.29 (ft^3/s)/mi^2, respectively.

Big Creek contributes about one-half of the gaged inflow to Converse Lake during average and above-average flow conditions, and Hamilton Creek contributes about 20 percent (Journey and others, 1995). Hamilton Creek, however, has more sustained flows, and the proportion of its contribution to the total inflow increases as overall flow decreases. Crooked, Collins, and Juniper Creeks also contribute substantial inflow to the lake, especially during low-flow periods. Long and Boggy Branches seldom contribute more than 10 percent of the total inflow to the lake under all flow conditions (table 3). Downstream from the dam, Big Creek continues to flow to the south-southwest to its confluence with the Escatawpa River in Mississippi.

Streamflow frequency can be estimated by constructing a flow-duration curve for the stream. By definition, the flow-duration curve is a cumulative-frequency curve that shows the percentage of time a specific streamflow is equaled or exceeded during a given period. The shape of the flow-duration curve is a

Table 3. Streamflow conditions in selected tributaries to Converse Lake, October 1990 to September 1998

[mi^2, square miles; ft^3/s, cubic feet per second; —, not applicable]

Site label (fig. 1)	Station number	Station name	Drainage area (mi^2)	Period of record	Streamflow characteristics, (ft^3/s)				
					Mean annual	1991 water year	10 percent exceeds	50 percent exceeds	90 percent exceeds
BIG	02479945	Big Creek at County Road 63 near Wilmer, Ala.	31.5	1991–98	72.2[a]	94.1	147[a]	40[a]	22[a]
JUN	02479948	Juniper Creek at Glenwood Road near Fairview, Ala.	9.22	1991–92	17.7[b]	20.1	28[b]	14[b]	10[b]
COL	02479950	Collins Creek at Glenwood Road near Fairview, Ala.	8.54	1991–92	15.7[b]	18.1	24[b]	13[b]	9.2[b]
LON	02479955	Long Branch near Wilmer, Ala.	2.85	1991	—	6.76[c]	—	—	—
BOG	02479960	Boggy Branch near Wilmer, Ala.	3.17	1991	—	9.43[c]	—	—	—
CRO	02479980	Crooked Creek near Fairview, Ala.	8.08	1991–98	19.4[a]	21.8	29[a]	12[a]	8.4[a]
HAM	02480002	Hamilton Creek at Snow Road near Semmes, Ala.	8.22	1991–98	25.0[a]	24.5	33[a]	18[a]	13[a]
		TOTAL	71.58	—	—	196	—	—	—

[a]Data published in Pearman, Stricklin, and Psinakis (1998).
[b]Data published in Pearman and others (1992).
[c]Data published in Pearman and others (1991).

reflection of the hydrologic and geologic characteristics of the stream's watershed (Searcy, 1959). A flow-duration curve that has a steep slope is indicative of a stream having highly variable flow derived largely from direct runoff (little or no ground-water contribution); a flat slope is indicative of sustained flow, a result of contributions from surface- or ground-water storage. During dry periods, when streamflow is at a minimum, water discharging to streams and lakes is considered to be derived almost solely from ground water.

Flow-duration curves were constructed from continuous streamflow record for the period October 1990 to September 1998 for three gaged sites in the Converse Lake watershed—Big Creek (site BIG), Crooked Creek (site CRO), and Hamilton Creek (site HAM, figs. 1, 8). Because the drainage areas of the selected streams vary, the computed values were normalized to obtain unit-area discharge in cubic feet per second per square mile. Hamilton Creek had the greatest sustained streamflow of the selected sites, but flow duration at all sites indicated that ground water is an important contributor of water to Converse Lake and its tributaries during periods of no rainfall.

For this investigation, mean annual inflow was estimated for October 1990 to September 1998 based on streamflow data for Big Creek, Crooked Creek, and Hamilton Creek (sites BIG, CRO, and HAM; fig. 1). Because of limited streamflow record at the remaining four sites (table 3), streamflow data for these sites were not used in the calculation. Based on the 1991 water year in which streamflow data were available for all seven sites, Big Creek, Crooked Creek, and Hamilton Creek contributed 72 percent of the total annual inflow to the reservoir. The mean annual inflow to the reservoir for the 1990–98 period was estimated by combining the mean annual streamflow for Big Creek, Crooked Creek, and Hamilton Creek (117 ft^3/s) and multiplying by 1.39 (the reciprocal of 72 percent). The product (163 ft^3/s) was converted to acre-ft by multiplying by 724 acre-ft per year to obtain a mean annual inflow to the reservoir of about 118,000 acre-ft. The residence time of water in a reservoir is calculated by dividing the volume of the reservoir (in the case of

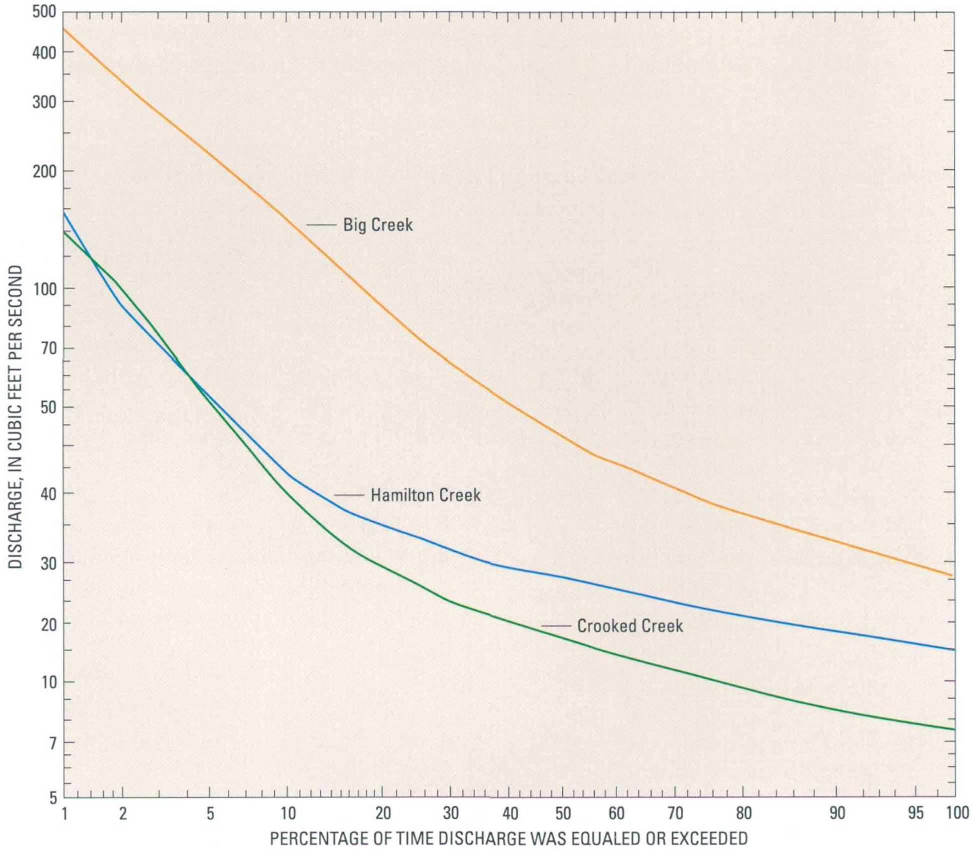


Figure 8. *Streamflow duration curves for Big Creek, Crooked Creek, and Hamilton Creek in the Converse Lake watershed, 1990–98.*

Converse Lake, 52,000 acre-ft) by the mean annual inflow to the reservoir. The residence time for water in Converse Lake was calculated to be 0.44 year or 160 days (table 2).

Cultural Factors

Other factors influencing the water quality of Converse Lake are cultural factors derived from human activities. Cultural factors in the watershed commonly are linked to natural factors, such as land use and land cover. For example, the degree to which agricultural activities within a given watershed will affect the water quality in the watershed depends on several natural factors, such as amount of precipitation, type and thickness of soils, land-surface slope, and the amount of vegetation left to form a buffer between the developed land and water bodies in the watershed.

The rural countryside of the Converse Lake watershed is covered mainly by forests of evergreen, deciduous, and mixed deciduous/evergreen trees (64 percent of the land use in the watershed) (figs. 9, 10). Timber is harvested usually by clear-cutting techniques, especially in the northern part of the watershed. Agriculture accounts for about 31 percent of the land use in the watershed and is separated into two categories—pasture land and hay (18 percent) and row crops or plant nurseries (13 percent). Residential and commercial development account for only 1 percent of the total land use in the watershed. Most of the residential land use in the watershed is categorized as low-intensity development, which means that impervious areas and construction materials account for 30–80 percent of the total area, and vegetation (trees, other grasses) accounts for the remaining 20–70 percent.

Land use varies within the tributary subbasins of the Converse Lake watershed (table 4). Nearly three-fourths of the Big Creek subbasin is covered by forested land. The remaining one-fourth is mainly agricultural land. The percentage of agricultural land use (row crops and pasture/hay) is greatest in the Crooked Creek subbasin, accounting for over 42 percent of the subbasin. Much of the land designated as row crops in the Crooked Creek subbasin actually is plant nurseries. The percentage of residential area (3.4 percent) in Crooked Creek is second only to Hamilton Creek (3.9 percent). The Hamilton Creek subbasin also has the greatest wetland coverage (5.3 percent) and relatively high agricultural land use (36.1 percent).

Previous work conducted by Auburn University relied on Landsat Thematic Mapper satellite images for 1984, 1992, and 1995 to identify changes in land use in the Converse Lake watershed over time (Reutebuch and others, 1997). The most dramatic change was a net regrowth of forest cover from 1984 to 1992, followed by a net loss of forest in 1995. Minimal change was observed in agricultural practices (grasslands and row crops). It should be noted, however, this method of land-use identification works best for large-scale changes in land use. Small-scale changes may be missed, as indicated by field verification that identified the presence of new homes and greenhouses in the Converse Lake watershed that were at a scale below the 30-m resolution of the satellite data.

Point-source discharges from industrial activity are monitored by State and Federal regulatory agencies. The USEPA Storage and Retrieval System (STORET) database contains all permitted point-source locations and descriptions in the United States. This database was queried to identify point sources in the Converse Lake watershed (fig. 11). No Toxic Release Inventory (TRI) or Superfund (CERCLA) sites were present in the watershed during 1990–98. Two hazardous- and solid-waste sites were identified—one in the Hamilton Creek subbasin and the other in the Juniper Creek subbasin (fig. 11). No contaminant releases (air, water, ground water) were reported from 1987 to 1995. Two permit compliance system (PCS) sites also were listed—one is permitted to discharge to the ground water near an unnamed tributary in the Collins Creek subbasin, and the other is permitted to discharge to the ground water near the headwaters of Hamilton Creek. No PCS discharges were reported between 1991 and 1995.

Plant nurseries ranging in size from less than an acre to over 300 acres increased in number and size in Crooked Creek and Hamilton Creek subbasins during the study period (fig. 11). The MRLC coverage does not distinguish nurseries from row crops and pastures. The Mobile County Extension Service of the Natural Resource Conservation Service (NRCS) provided location and acreage data for plant nurseries within the Converse Lake watershed that were used to develop a point coverage. The coverage shown in figure 11 demonstrates the concentration of plant nurseries in the Crooked Creek and, to a lesser extent, Hamilton Creek subbasins.

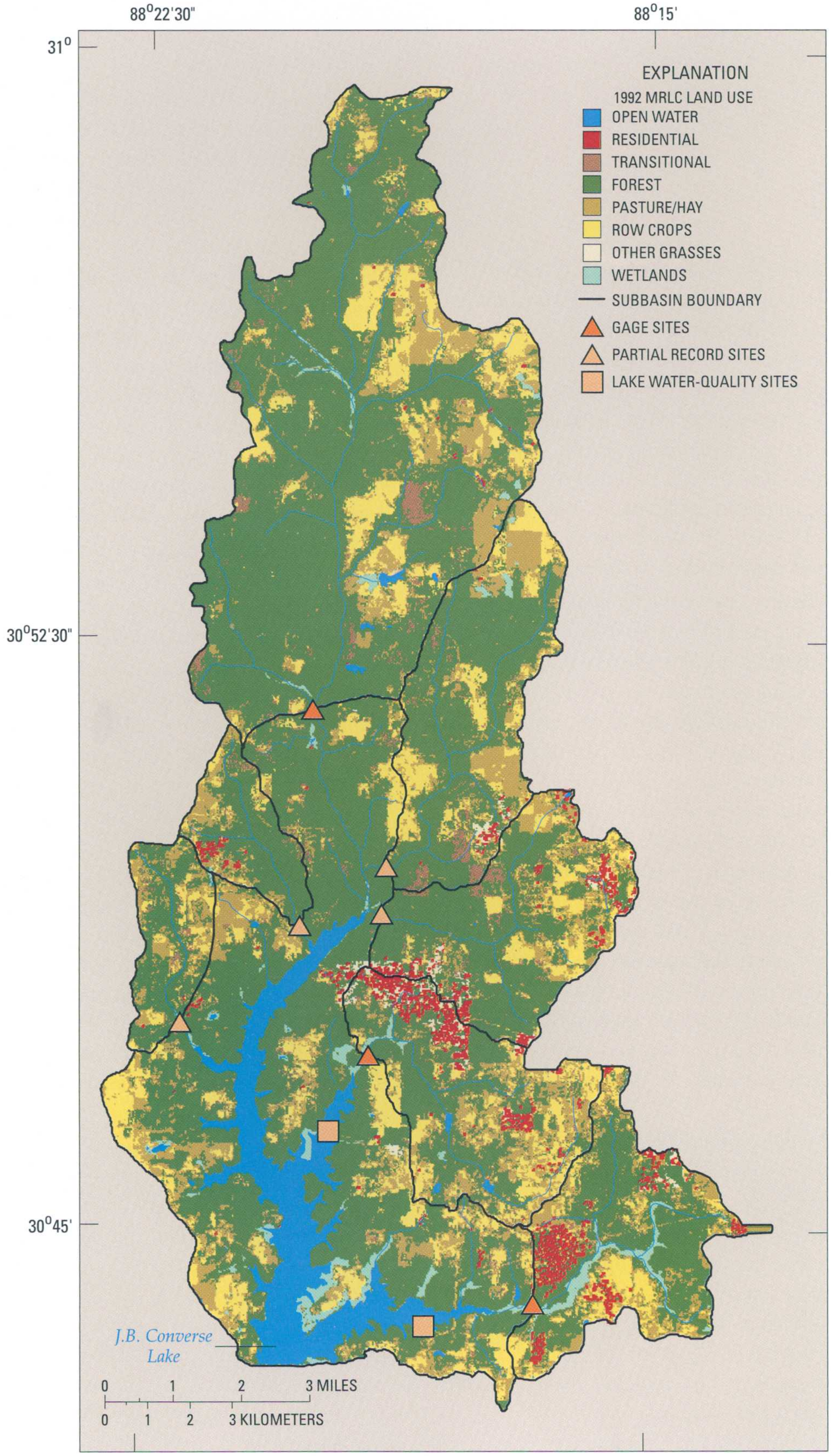


Figure 9. General land uses for the Converse Lake watershed, 1992.

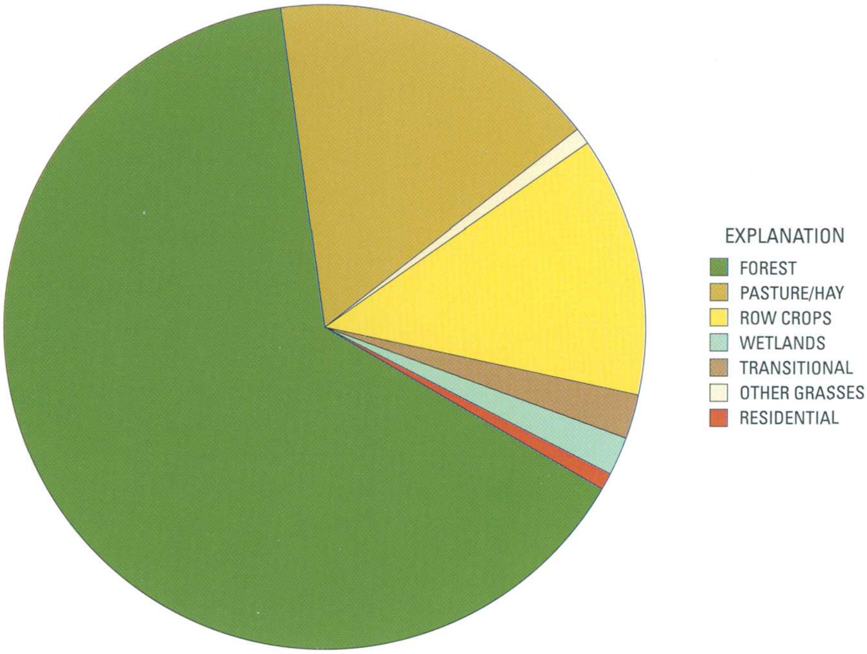
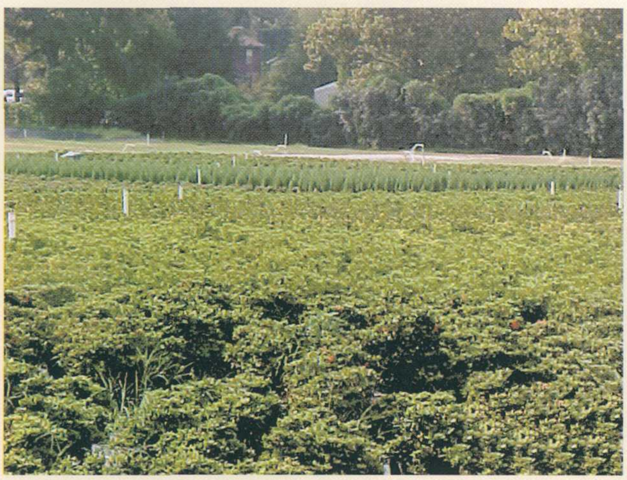


Figure 10. Land-use percentages in the Converse Lake watershed, 1992.



Croplands, wetlands, and a residential area in the Converse Lake watershed *(photographs by Will S. Mooty, U.S. Geological Survey).*

Table 4. Land use in selected subbasins of the Converse Lake watershed, in acres and percent acreage of subbasin, from 1992 Multi-Resolution Land Characteristics (MRLC) data

Subbasin	Woody wetlands	Emergent herbaceous wetlands	High-intensity residential/ industrial/ transportation	Low-intensity residential	High-intensity residential	Deciduous forest	Mixed forest	Evergreen forest	Pasture/ hay	Other grasses	Row crops	Transitional	Bare rock/sand/ clay
1992 MRLC land use, in acres													
Big Creek	154	7.6	6.8	0.7	0	1,335	6,744	6,387	2,540	0	2,230	431	2.9
Juniper Creek	42.0	5.1	2.8	8.9	0	362	1,613	1,750	1,181	60	823	205	0
Collins Creek	.0	0	41.4	69.1	5.8	372	1,278	1,576	927	207	757	203	0
Long Branch	3.0	0	7.1	12.2	.7	103	514	619	404	0	144	37	0
Boggy Branch	7.5	1.1	0.9	0	0	140	505	491	513	0	238	68	0
Unmonitored	559	64.7	7.6	16.4	1.0	727	3,241	7,972	2,668	60	2,323	221	.7
Hamilton Creek	260	17.1	8.5	178	15.5	222	1,121	1,400	1,081	62	814	70	0
Crooked Creek	56.0	2.7	34.7	141	9.9	215	1,048	1,227	1,309	277	967	101	0
1992 MRLC land use, in percent acreage of subbasin													
Big Creek	0.78	0.04	0.03	0	0	6.7	34	32	13	0	11	2.2	0.01
Juniper Creek	.69	.08	.05	.15	0	6.0	27	29	20	.99	14	3.4	0
Collins Creek	0	0	.76	1.3	.11	6.8	24	29	17	3.8	14	3.7	0
Long Branch	.16	0	.39	.66	.04	5.6	28	34	22	0	8	2.0	0
Boggy Branch	.38	.06	.04	0	0	7.1	26	25	26	0	12	3.4	0
Unmonitored	3.1	.36	.04	.09	.01	4.1	18	45	15	.34	13	1.2	0
Hamilton Creek	4.9	.33	.16	3.4	.30	4.2	21	27	21	1.2	16	1.3	0
Crooked Creek	1.0	.05	.64	2.6	.18	4.0	19	23	24	5.1	18	1.9	0

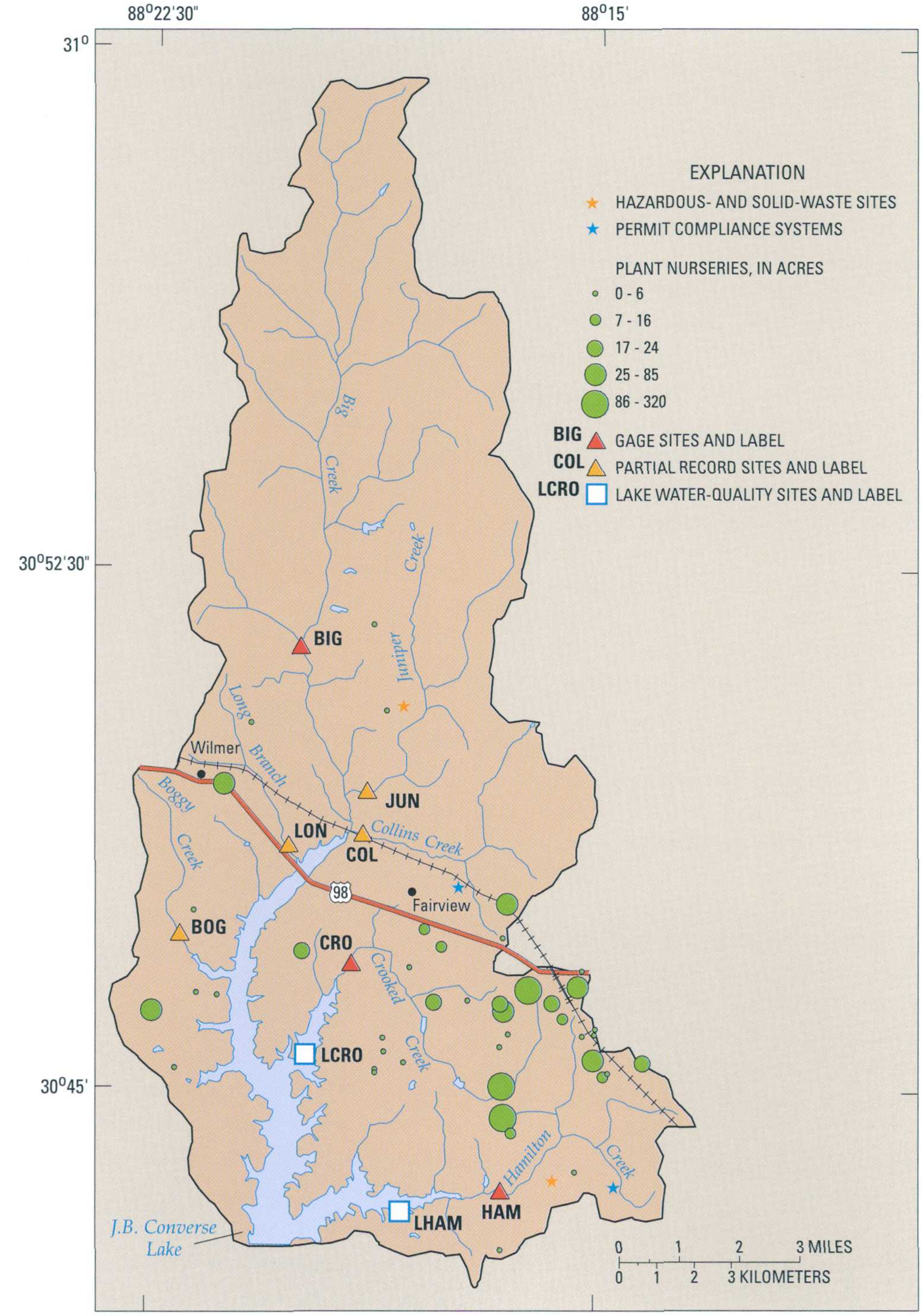


Figure 11. Locations of permitted point sources and plant nurseries in the Converse Lake watershed, 1997.

BASIC WATER CHEMISTRY

The major dissolved constituents that give water its characteristic chemistry are cations (positively charged ions) of calcium, magnesium, sodium, and potassium; and anions (negatively charged ions) of chloride, sulfate, and nitrate. Dissolved silica also is a major constituent of most waters, especially in sandstone bedrock and acidic, deeply weathered soils such as those in the Converse Lake watershed. Concentrations of major dissolved ions generally are measured in parts per million or milligrams per liter.

The chemistry of natural surface waters is the result of interactions between precipitation, ground water, rocks, and soils near the Earth's surface. Human activity, however, can alter naturally occurring water chemistry by contributing additional ions, most commonly sodium and chloride. While basic cations and anions are not considered contaminants, elevated ion concentrations occurring near human activities may provide a clue to potential sources of more problematic contaminants (nutrients, trace elements, synthetic organic compounds).

The term "trace elements" relates to constituents in water at levels that generally are measured in parts per billion or micrograms per liter. Trace elements include metals, such as beryllium, cadmium, chromium, copper, lead, mercury, and nickel; and nonmetals, such as arsenic. These listed trace elements are considered priority pollutants by the USEPA because of their potential harm to humans and aquatic health at elevated concentrations. Iron and manganese are commonly occurring trace elements that are nonpriority pollutants. All trace elements can be derived from natural sources, such as rocks, soils, and ground water, as well as anthropogenic sources.

Other measures of the physical and chemical nature of water provide further information to assess the quality of the water. Specific conductance, water temperature, dissolved-oxygen concentration, and pH are important physical and chemical factors when assessing water-quality conditions.

Water-Quality Analysis Methods and Approach

Water-quality samples have been collected quarterly since 1991 at the tributary sites (sites BIG, JUN, COL, LON, BOG, CRO, and HAM; fig. 1) and in the lake at the pump station (site LHAM, fig. 1). Water-quality samples were collected at the tributary sites using a multiple vertical technique; a DH-81 sampler was used in wadeable water and a weighted-bottle sampler was used in unwadeable water. The low-gradient, slow flowing tributaries prevented the collection of true isokinetic samples (Wilde and others, 1999a). Water-quality samples were processed in the field according to procedures described in Wilde and others (1999b), and shipped to the USGS Quality Water Service Unit Laboratory in Ocala, Florida, for analysis. The samples were analyzed for major ions (calcium, magnesium, sodium, potassium, nitrate, chloride, sulfate, silica), and for iron, manganese, and boron. The analytical results are stored in the USGS National Water Information System (NWIS) database. Streamflow gages provided continuous streamflow record at three tributary sites during the study period (sites BIG, CRO, and HAM; fig. 1). Instantaneous streamflow, water temperature, dissolved oxygen (concentration and percent saturation), pH, alkalinity, and specific conductance were measured in the field at the time of sampling, according to techniques described in Wilde and Radtke (1998).

The chemical data are summarized statistically for this report in appendix 1. Computed statistics include maximum, minimum, mean, and the 95th, 75th, 50th, 25th, and 5th percentiles. The *n*th percentile is a data value that exceeds no more than *n* percent of the data <u>and</u> is exceeded by no more than 100 minus *n* percent of the data (Helsel and Hirsch, 1992). These statistics were used to construct boxplots of concentration data for constituents of interest. A "boxplot is a concise graphical summary of the data distribution, displaying the median, interquartile range (75th–25th percentile), skewness, and extreme values" (Helsel, 1987). The median values (50th percentile of the measured values) were used to compare between tributary subbasins and between tributary sites and the lakes to identify major differences in water chemistry. The data were compared graphically by using radial plots of the major ion concentrations converted to milliequivalents per liter. The relation between pH levels and land use (1992 MRLC land-use categories) in the watershed was determined by computing Spearman rho correlation coefficients and probability values to identify significant relations between the median pH and the percentage of land-use category in the watershed.

Results of Water-Quality Analysis

The waters in Converse Lake and its tributaries have low pH and low specific conductance, which is typical of waters in humid climates that drain highly resistant sands and gravels (Hem, 1985; Drever, 1988; fig. 12). The basic chemistry of surface water in the Converse Lake watershed varies slightly among subbasins but basically is a calcium-sodium-chloride-dominated water.

The presence of electrically charged dissolved constituents in water makes the water conductive; therefore, specific conductivity provides an estimate of the total dissolved constituents in water. In natural freshwater systems, specific conductance values near 50 μS/cm are considered low and indicative of watersheds draining resistant rocks (Drever, 1988). In the Converse Lake watershed, median specific conductance values ranged from 23 (site COL) to 43 μS/cm (site LON) during the study period (fig. 12; appendix 1).

Water is considered saturated with oxygen when its concentration is exactly equal to the expected solubility concentration at a particular temperature and air pressure. Commonly, the dissolved-oxygen concentration in water is measured in milligrams per liter, but a saturation percentage—percent ratio of the dissolved-oxygen concentration measured in the water to the saturated dissolved-oxygen concentration based on oxygen solubility—also can be used. Photosynthesis from aquatic plants and reaeration from streamflow can raise the dissolved-oxygen concentration above saturated levels in natural waters, whereas respiration and bacterial decay of organic matter in these waters can reduce the dissolved-oxygen concentration below saturated levels. The degree of influence of these processes on dissolved-oxygen levels varies daily and seasonally. Photosynthesis dominates during the day because it requires sunlight; respiration dominates at night. Cooler temperatures in the winter allow for greater solubility of dissolved oxygen (solubility increases as temperature decreases), and increased streamflow during wet periods provides greater reaeration.

The ADEM criterion for minimum dissolved-oxygen concentration is 5 mg/L for the water-use classification in the Converse Lake watershed (Alabama Department of Environmental Management, 1994a). During this investigation, all tributary sites in the watershed had minimum dissolved-oxygen concentrations above 5 mg/L except for site BOG (fig. 1), which had a minimum dissolved-oxygen concentration of 3.7 mg/L. Median dissolved-oxygen concentrations at tributary sites ranged from 6.9 mg/L (site BOG) to 8.6 mg/L (sites JUN and LON), and median saturation percentages ranged from 74 to 94 percent.

Reservoirs, such as Converse Lake, stratify thermally during the late summer months. Stratification prevents mixing of the warmer, upper layer of water (epilimnion) with the cooler, denser, lower layer of water (hypolimnion). Because of the lack of mixing, solubility and photosynthetic processes in the upper layer, which produce dissolved oxygen, are unable to replenish the dissolved oxygen in the lower layer, resulting in a depletion of dissolved oxygen in the lower layer by respiration and decay of organic matter. Converse Lake typically becomes strongly stratified during August and September, and dissolved-oxygen concentrations generally fall below 1 mg/L at depths greater than 20 ft (Journey and others, 1995; Bayne and others, 1998).

Major Ions

Differences in the major ionic composition among subbasins were evaluated by constructing radial plots of median ion concentrations, in milliequivalents per liter, for the seven tributary sites and the two lake sites (fig. 13). These plots were used to illustrate variations in water composition by visually comparing the shape of the plots (sites with similar water compositions exhibit similar shapes) and the size of the plots (sites with the greater ionic concentrations exhibit larger sizes). The diagramming software plots a polygon that represents the major anion (sulfate, chloride, nitrate, and bicarbonate) and major cation (calcium, magnesium, sodium, and potassium) concentrations as a point on individual axes.

Big Creek had one of the most dilute and strongly sodium-chloride types of ionic compositions of all the sites (fig. 13). All other sites exhibited a greater calcium-bicarbonate component than Big Creek. Boggy Branch had a similar ionic composition to Collins Creek, except for a much greater chloride and magnesium component. Long Branch and Crooked Creek had ionic compositions with the greatest overall concentrations and strongest calcium-bicarbonate component. The ionic composition of Hamilton Creek was similar to Crooked Creek, but Hamilton Creek had a greater sodium-chloride component and less magnesium. The ionic composition at the lake sites

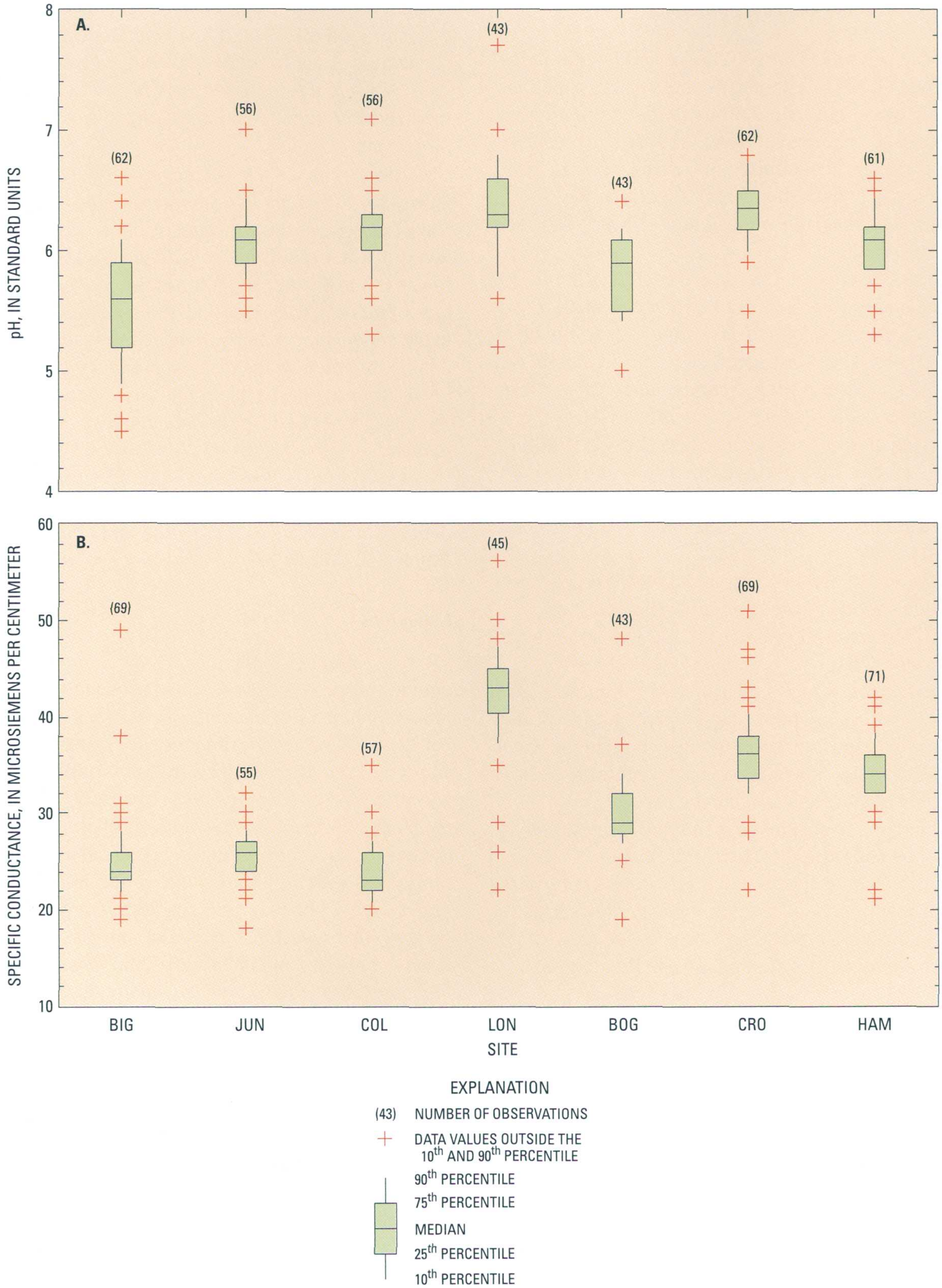


Figure 12. (A) pH and (B) specific conductance values at selected sites in the Converse Lake watershed, 1990–98.

Figure 13. Radial plots of median ion concentrations, in milliequivalents per liter, at (A) Hamilton Creek, (B) Crooked Creek, (C) Boggy Branch, (D) Converse Lake, (E) Long Branch, (F) Juniper Creek, (G) Collins Creek, and (H) Big Creek in the Converse Lake watershed, 1990–98.

appeared to be most like the composition of tributary waters in the central and southern parts of the watershed (Long Branch, Crooked Creek, and Hamilton Creek) and less similar to sites in the headwaters portion of the watershed. This similarity was especially evident in the proportion of cations (calcium, magnesium, sodium). The sulfate component of the overall ionic composition was minimal at all sites.

The chemistry of streamwater varies with flow conditions because of changes in the flow pathways in the watershed. During and immediately after a storm, the water in a stream is a mixture of surface runoff, shallow subsurface flow through the soil zone, and ground-water discharge. During base-flow conditions, streamwater is predominantly ground-water discharge. Ion concentrations during periods of base flow and high streamflow were plotted for Big Creek (site BIG, fig. 1), Hamilton Creek (site HAM), and Crooked Creek (site CRO) to identify changes in ionic composition with flow conditions (fig. 14). Big Creek exhibited effects of dilution during high streamflow conditions. The greatest nitrate and bicarbonate concentrations were during base flow at this site. Hamilton Creek exhibited slight dilution effects on silica and chloride, and an increase in the calcium-bicarbonate component during high streamflow conditions. Crooked Creek had a similar response—decreased nitrate and increased calcium-bicarbonate during high streamflow conditions as well as increased chloride.

In summary, no dramatic differences in ionic composition were observed among tributary and lake sites. The greatest difference was observed at Big Creek, which had proportionally lower calcium-bicarbonate component than the other sites. Bicarbonate and nitrate fractions of the ionic composition in Big Creek were highest during base-flow periods, suggesting a ground-water source. Runoff and shallow soil-zone flow during high streamflow conditions contributed more dilute waters, causing a decrease in ionic concentration at Big Creek. Median ion concentrations of calcium and bicarbonate in Crooked Creek and Hamilton Creek depicted an increase in overall ion concentrations compared to Big Creek. The calcium-bicarbonate component of these increased ion concentrations occurred during high streamflow periods, suggesting ion introduction to the streamwater from runoff and soil-zone flushing. Higher concentrations of nitrate were evident during base flow in both Crooked and Hamilton Creeks, suggesting a ground-water source.

pH and Alkalinity

Hydrogen ions contribute acidity in water. Although hydrogen-ion (H+) concentrations in water can be measured in milligrams per liter, the extremely low hydrogen-ion concentrations in natural aquatic systems require measurement and reporting in logarithmic units. The term "pH" represents the negative base-10 log of the hydrogen-ion concentration or, specifically, the activity. The pH of natural systems generally ranges from 6 to about 9, representing hydrogen-ion concentrations that range from 1×10^{-6} to 1×10^{-9} milligrams per liter (trace constituents). The ability or capacity of water to absorb hydrogen ions (neutralize acid) without a substantial change in pH is called the acid-neutralizing capacity (ANC) of the water. The ANC is a measure of the alkalinity of unfiltered water.

When the pH of aquatic systems falls below 4 or 5, the diversity of the endemic aquatic species (plants and animals) can be severely restricted. Some influences related to human activities that can have an adverse effect on the pH of surface water are commercial and industrial discharges, urban runoff, acidic drainage from mines, and acid rain. The ADEM established a pH range of 6 to 8.5 to prevent aquatic-species diversity restrictions in most natural water systems of the State (Alabama Department of Environmental Management, 2000). If, however, the pH range naturally falls below the criteria range, as in the case of waters draining resistant sandstone and granitic bedrocks or deeply weathered soils, the naturally occurring range is acceptable.

Although all sites in the Converse Lake watershed had pH levels that periodically fell below the ADEM lower level criterion of 6, only two streams had median pH levels below that level—sites BIG and BOG (fig. 1) had median pH values of 5.6 and 5.9, respectively. The remaining tributary and lake sites had median pH values that were within the criteria range (appendix 1; fig. 12). The highest median pH levels were recorded at tributary sites LON and CRO and at lake sites LCRO and LHAM, where the median pH levels were 6.3, 6.4, 6.2, and 6.2, respectively. Alkalinity and ANCs corresponded well with pH levels. Site BIG had the lowest median alkalinity (2 mg/L), and sites LON and CRO had the highest

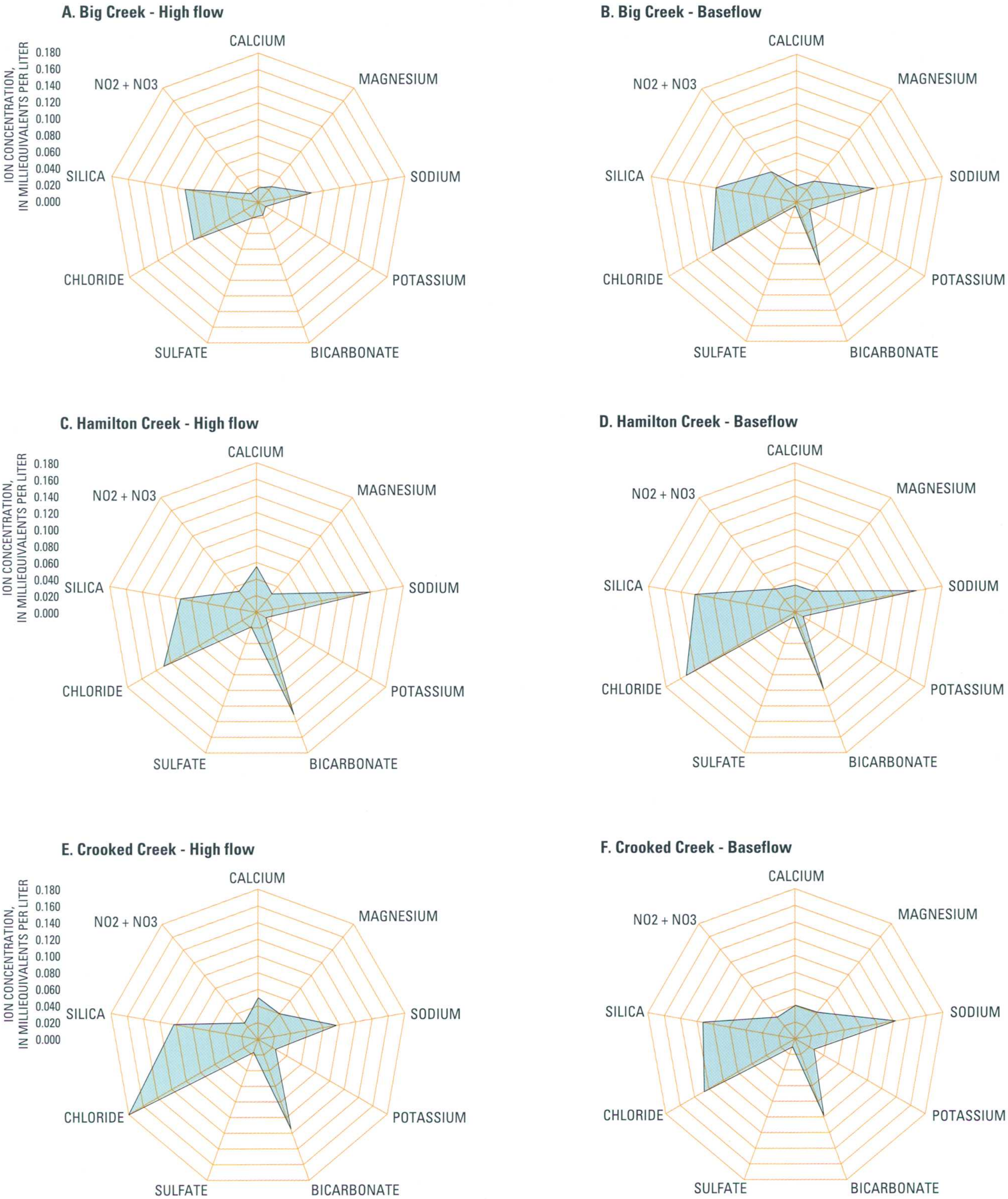


Figure 14. Radial plots of ionic concentrations, in milliequivalents per liter, at Big Creek, Hamilton Creek, and Crooked Creek during high streamflow conditions (A, C, and E, respectively) and base-flow conditions (B, D, and F, respectively) in the Converse Lake watershed, 1990–98.

alkalinity (7 mg/L). Median ANCs ranged from 3 (site BIG) to 8 mg/L (sites LON, CRO).

Percentages of land in each land-use category were computed for each subbasin in the 1992 MRLC coverage. The computed land-use percentages were correlated with median pH levels and ANCs for the tributary subbasins to determine if the more acidic pH levels were related to natural (forested) or anthropogenic (agricultural, residential) conditions in the watershed (table 5; fig. 15). Negative correlation coefficients indicate an inverse relation between land use and the median pH or ANC (when one increases,

Table 5. Spearman rho correlation coefficients for percentage of land use and median levels of pH, acid-neutralizing capacity, and specific conductance in the Converse Lake watershed

[MRLC, multi-resolution land characteristic. Coefficients that are statistically significant are bold (p-value < 0.05)]

MRLC land-use category	Water-quality constituent		
	pH	Acid-neutralizing capacity	Specific conductance
Evergreen forest	-0.1261	-0.2245	-0.7186
Deciduous forest	-0.6126	-0.7485	-0.6786
Mixed forest	-0.5225	-0.5052	-0.2143
Transitional	-0.2883	-0.6175	-0.7143
Row crops	0.3964	0.2994	0
Pasture and hay	0.3434	0.6175	0.7143
High-intensity residential	0.6171	0.6602	0.3706
Low-intensity residential	0.6727	0.6797	0.3604
Industrial/commercial/high-intensity residential	**0.8829**	0.6175	0.1786
Other grasses	0.6171	0.3690	-0.0371
Wetlands	-0.1261	0.1497	0.2857

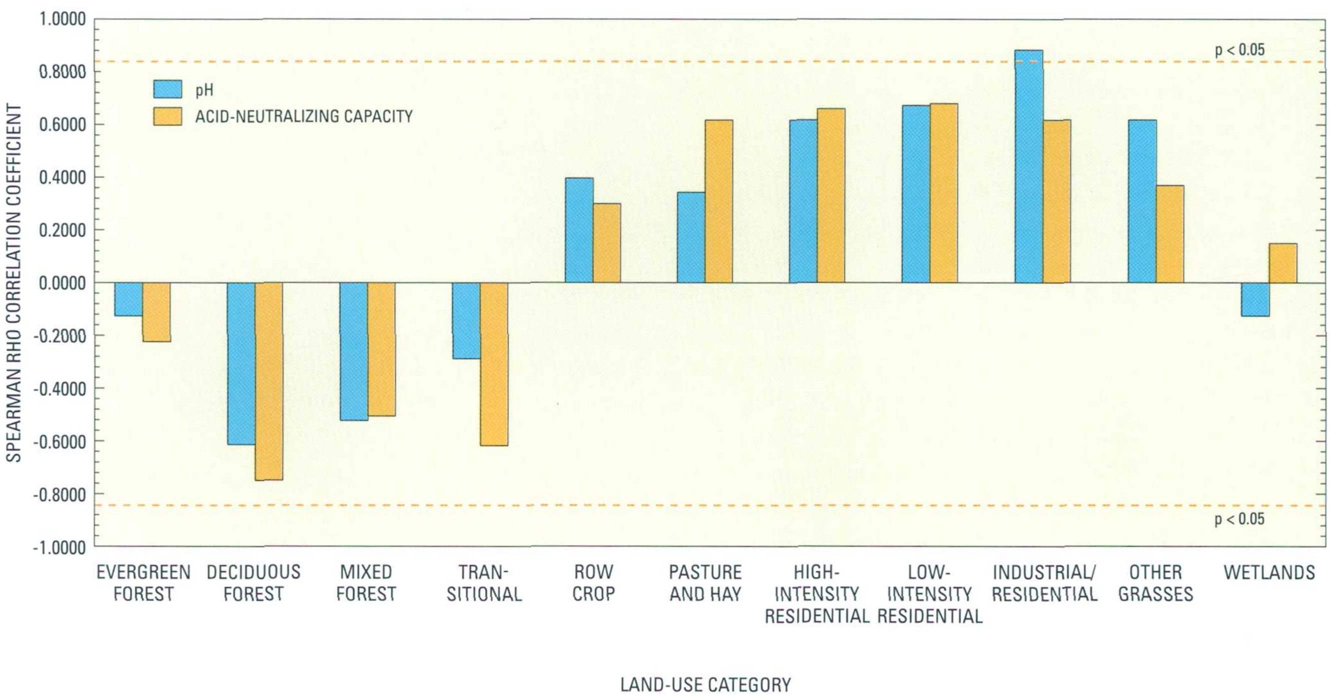


Figure 15. Correlation between land-use category and median pH and acid-neutralizing capacity in tributary subbasins in the Converse Lake watershed.

the other decreases); positive coefficients indicate direct relation (when one increases, the other also increases). No statistically significant relation was found among the agricultural land-use categories of row crops, pasture and hay, residential land use, other grasses (parks, fields), and forested land. The only significant relation (p-value < 0.05) was between pH and commercial, industrial, and residential land (table 5). This relation was positive, suggesting the greater the amount of developed land, the less acidic the pH.

In summary, Big Creek (site BIG) and Boggy Branch (site BOG) had median pH levels below the ADEM criterion of 6 and relatively low ANCs. Statistical correlations indicate that the greater the amount of commercial, industrial, and residential development (human influenced), the greater the tendency for the streamwater to have a more neutral median pH and a greater capacity to neutralize acid. This correlation, in conjunction with the environmental factors of resistant rock types and acidic soil in the watershed, provides a strong indication that low pH and low ANCs are of natural origin, not anthropogenic. In 1996, the ADEM 305(b) Water-Quality Report to Congress stated that Converse Lake, listed as Big Creek Lake, had pH values that fell below the criteria range of 6 to 8, but also stated that the "Low pH values measured in Big Creek...are determined to be of natural origin and are considered unlikely to cause adverse impacts" (Alabama Department of Environmental Management, 1999).

Trace Elements

Iron and manganese are two trace elements that were monitored quarterly in the Converse Lake watershed. Water samples were analyzed for both total and dissolved species. These elements adversely affect the taste and odor of water; therefore, the ADEM has set secondary standards for acceptable levels of less than 300 μg/L for total iron and 50 μg/L for total manganese in drinking water, after filtration and treatment (Alabama Department of Environmental Management, 2000).

Converse Lake and its tributaries had median total iron concentrations that exceeded the National secondary drinking-water standard of 300 μg/L (fig. 16; appendix 1). However, this raw water would be filtered and treated prior to distribution in the drinking-water system, resulting in iron concentrations below these limits. Median dissolved iron concentrations generally were one-half to one-third of the total iron value. The highest median concentrations of total iron were 940 and 725 μg/L in Boggy Branch (site BOG) and Crooked Creek (site CRO), respectively; the lowest median concentrations of 315 and 320 μg/L were in the lake sites LCRO and LHAM, respectively. Boggy Branch was the only site with a median total manganese concentration (79 μg/L) that exceeded the secondary standard of 50 μg/L. Collins Creek (site COL) and the lake site at the pump station (site LHAM) had the lowest median concentrations of total manganese (23 and 20 μg/L, respectively).

NUTRIENT LOADING AND TROPHIC RESPONSE

The amount of biologically available nutrients, mainly phosphorus and nitrogen compounds, contributes to the trophic state of a water body. Nutrient enrichment accelerates the process of eutrophication, which results in excessive growth of algae (algal blooms) and other aquatic plants. Nuisance algal production causes a variety of associated water-quality problems, including increased biochemical oxygen demand, extreme vertical changes in dissolved-oxygen concentrations (from oversaturated to depleted), high turbidity, unpleasant odors and tastes, and blockages of water-purification systems at treatment facilities. Globally, the process of eutrophication has increased rapidly as a result of human activities, including runoff (nonpoint) from agricultural areas and the discharge of industrial wastes and treated municipal sewage, that contribute excess nutrients to streams, rivers, lakes, and estuaries.

The relation between the annual input of nutrients and the in-lake phosphorus and nitrogen concentrations is central to understanding and managing eutrophication problems. This complex relation involves the interaction of physical and chemical processes and biological responses, requiring a distinction between trophic potential and trophic response. The trophic potential of a reservoir is the carrying or assimilating capacity of the ecosystem, and is a function of physical and chemical properties, such as nutrient concentrations, light penetration, climate, and hydraulic regime. The trophic response of a reservoir refers to the amount, type, and rate of biomass production and the water-quality variations that occur as a result of nutrient inputs. In order to predict or monitor the trophic response of a reservoir and its

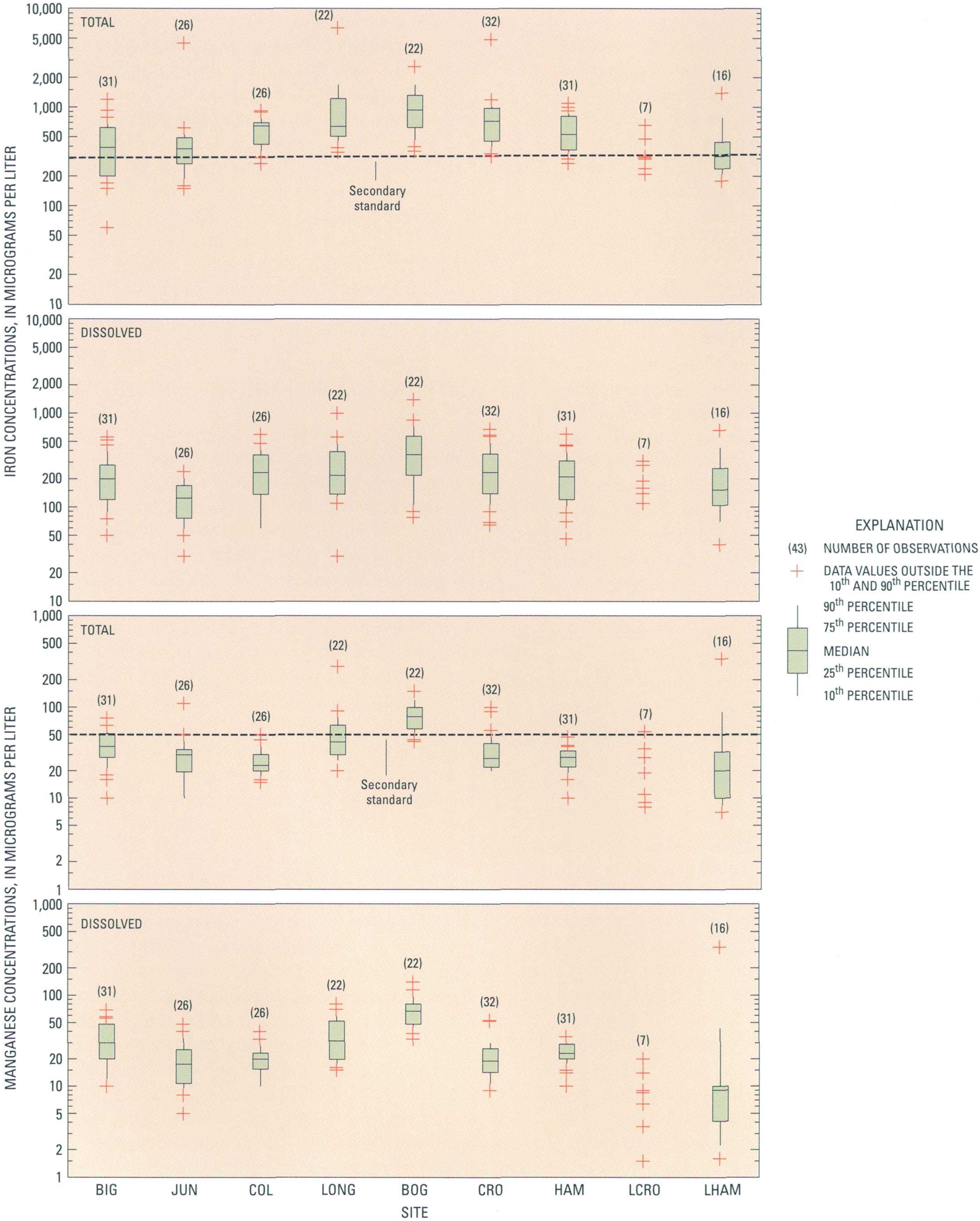


Figure 16. Boxplots of total and dissolved iron and manganese concentrations at selected sites in the Converse Lake watershed, 1990–98

associated water-quality changes, easily measured trophic potential factors (nutrient concentration, inflow) must be correlated with the trophic response variables (transparency, chlorophyll, hypolimnetic dissolved oxygen).

An index that estimates the trophic state can be computed from empirically derived equations determined from trophic response and trophic potential data from different lake systems. One of the most commonly used indices is Carlson's Trophic State Index (TSI), which is based on transparency, phosphorus concentrations, and chlorophyll *a* levels in a lake during the summer months (Carlson, 1977). Chlorophyll *a* is a pigment found in algae, and is considered an estimate of the amount of algae present in the water. Greater algal production generally is related to enrichment of lake water with plant nutrients, such as nitrogen and phosphorus. A TSI value of less than 40 is indicative of oligotrophic or nutrient-poor conditions (table 6). A TSI value of 40 to 50 is indicative of mesotrophic or nutrient-balanced conditions. A TSI value of 50 to 70 is indicative of eutrophic or nutrient-enriched conditions. Eutrophic conditions in a lake can lead to a variety of water-quality problems, including unpleasant tastes and odors, depletion of dissolved oxygen (anoxia), and nuisance algal blooms. A TSI value above 70 indicates hypertrophic or extremely nutrient-rich conditions. In hypertrophic conditions, eutrophic water-quality problems become more pronounced, algal blooms are more common, and fish communities become dominated by bottom dwellers.

The results of ADEM's Reservoir Water Quality Monitoring Program were reported in the Alabama 305(b) Water-Quality Reports to Congress (Alabama Department of Environmental Management, 1996, 1999). More than two-thirds of the lakes that were assessed in Alabama were classified as eutrophic. In

Table 6. Potential changes in lake characteristics related to trophic state (modified from Rast and Lee, 1978)

[<, less than; >, greater than]

Trophic state index[a]	Trophic state classification	Potential changes in lake characteristics
< 30	Oligotrophic	Clear water, oxygen in hypolimnion (deepest part of lake) year round. Sparse macrophyte (rooted aquatic plants) growth. Many algal species but low production.
30–40		Hypolimnion of shallower lakes becomes anoxic (lacking in oxygen).
40–50	Mesotrophic	Water moderately clear but increasing probability of anoxic hypolimnion during summer. Increased iron and manganese levels evident during the summer months.
50–60	Eutrophic	Anoxic hypolimnion. Greater potential for iron and manganese, taste and odor problems. Increase in macrophyte growth. Algal species become less diverse. Surface-dwelling warm-water fish dominate, such as perch and bass, but bottom-dwellers, such as catfish and carp, are present.
60–70		Dominant algal groups change from greens and diatoms to blue-greens; algal scums and macrophyte problems.
> 70	Hypertrophic	Light limited due to lack of transparency and high turbidity. Dense algae and macrophyte growth. Bottom-dwelling fish, such as catfish and carp, dominate.

[a]Carlson, 1977.

the 305(b) report, concern was expressed over the trophic state of Converse Lake, listed by its former name, Big Creek Lake. Although Converse Lake was considered stable and supportive of both its designated uses (aquatic life and water supply), a noticeable increase in the trophic state condition of Converse Lake was reported.

Defining the exact concentration of nitrogen or phosphorus that causes nutrient enrichment and an associated trophic response in a water body is difficult. The USEPA developed guidelines in 1975 for nutrient, chlorophyll *a*, and hypolimnetic dissolved-oxygen levels that can be used for trophic state determination as part of the National Eutrophication Survey (Gakstatter and others, 1975; table 7). The guidelines were developed from data collected at 96 lakes in the United States.

As part of a global effort by the Organization for Economic Cooperation and Development (OECD) project, data were collected and the relation between nutrient load and a lake's trophic response was quantified. The project consisted of four regional studies—Alpine, Nordic, Reservoir, and North American. The OECD index was developed based on the average value for each parameter for each trophic state. The results were summarized using a statistical approach to quantify the ranges of several parameters within the three trophic state conditions (Vollenweider and Kerekes, 1980; table 8). The results of the OECD study emphasized that lakes can have similar nutrient

Table 7. National Eutrophication Survey guidelines for trophic state determination (modified from Gakstatter and others, 1975)

[mg/L, milligram per liter; <, less than; >, greater than; µg/L, microgram per liter; m, meter]

Parameter	Oligotrophic	Mesotrophic	Eutrophic
Total phosphorus (mg/L)	< 0.01	0.01–0.02	> 0.02
Chlorophyll *a* (µg/L)	< 4	4–10	> 10
Secchi depth (m)	> 3.7	2.0–3.7	< 2.0
Hypolimnetic dissolved oxygen (percent saturation)	> 80	10–80	< 10

Table 8. Organization for Economic Cooperation and Development indices for trophic state determination based on scientific opinion (from Vollenweider and Kerekes, 1980)

[mg/L, milligram per liter; µg/L, microgram per liter; m, meter]

Parameter	Oligotrophic		Mesotrophic		Eutrophic	
	Geometric mean	Range	Geometric mean	Range	Geometric mean	Range
Total phosphorus (mg/L)	0.008	0.003–0.018	0.027	0.011–0.096	0.084	0.016–0.39
Total nitrogen (mg/L)	0.66	0.31–1.60	0.75	0.36–1.40	1.9	0.39–6.1
Chlorophyll *a* (µg/L)	1.7	0.3–4.5	4.7	3–11	14	2.7–78
Peak chlorophyll *a* (µg/L)	4.2[a]	1.3–11	16[a]	5–50	43[a]	10–280
Secchi depth (m)	9.9	5.4–28	4.2	1.5–8.1	2.4	0.8–7.0

[a]This value is an arithmetic mean, not a geometric mean.

and chlorophyll *a* concentrations, yet be placed in different trophic states.

Nitrogen occurs in natural waters in several different forms—dissolved molecular nitrogen (N_2), organic compounds (amino acids, amines, proteins, and refractory humic compounds of low nitrogen content), ammonia (NH_4^+), nitrite (NO_2^-), and nitrate (NO_3^+). Total Kjeldahl nitrogen (TKN) is the sum of total organic nitrogen and total ammonia species. For this report, total inorganic nitrogen (TIN) is the sum of total nitrate and nitrite species.

Nitrogen from specific sources enters the hydrologic cycle in characteristic forms. Sources of TKN include the decay of organic material, such as vegetation (algae), animal wastes, and urban sewage. Large amounts of ammonia and organic nitrogen are applied to cropland as fertilizers, but are relatively immobile in soils because of adsorption to soil surfaces. Under oxygen-rich conditions, however, TKN can be converted to the extremely mobile forms of nitrate and nitrite, which readily enter the ground- and surface-water systems.

A biologically catalyzed cycle converts one form of nitrogen into another. Bacteria and blue-green algae can transform atmospheric nitrogen into ammonia by the process called nitrogen fixation. Other bacteria catalyze the oxidation of ammonium to nitrite, then to nitrate by the process called nitrification; this process occurs rapidly in the oxygen-rich environment of most streams. Ammonia is the preferred form for algal uptake, followed by nitrate and nitrite, then dissolved molecular nitrogen (Wetzel, 1983). These nitrogen species can be taken up by organisms and incorporated into organic materials, which in turn decay and release nitrogen in the form of ammonia.

Like nitrogen, phosphorus exists in the aquatic environment in several forms, including inorganic and organic species. The most important form of inorganic phosphorus is orthophosphate (PO_4^{-3}) which is the form of phosphorus that is available for use by biota (Wetzel, 1983). Approximately 30 to 60 percent of the phosphorus in many natural waters is organically bound (Snoeyink and Jenkins, 1980). Phosphorus tends to adsorb strongly to particles in soils, suspended solids, and bed sediments.

Potential sources of nutrients in the Converse Lake watershed are from nonpoint contributions from atmospheric deposition, fertilizer applications on agricultural and residential land, livestock wastes, residential runoff, failing septic systems, contaminated ground water, and natural sources. No known point sources are located in the Converse Lake watershed.

Nutrient Analysis Methods and Approach

Trends in concentrations of total nitrogen and phosphorus, total inorganic nitrogen, total Kjeldahl nitrogen, and total orthophosphate (as phosphorus) were determined for one lake and seven tributary sites from water-quality data collected during the period October 1990 to June 1998. Trend analyses were performed on actual concentrations and concentrations adjusted for streamflow by using a statistical technique known as Locally Weighted Regression and Smoothing of Scatter Plots (LOWESS). This technique produces a continuous curvilinear line through the data points. Flow adjustment of concentration data eliminates variations in concentrations related to streamflow, allowing for a more accurate detection of trends in water quality over time. The actual concentrations and the residuals from the LOWESS relation were subjected to a trend analysis known as a seasonal Kendall trends test (Hirsch and others, 1982; Helsel and Hirsch, 1992), which accounts for seasonal variations in the constituent concentrations.

Annual and monthly in-stream loads of nitrogen, phosphorus, and silica were calculated as the product of the daily streamflow and estimated daily concentrations for the three continuous-record surface-water stations (Big Creek, Crooked Creek, and Hamilton Creek). Daily constituent concentration data were estimated by using Cohn's estimator model (Cohn and others, 1989; Gilroy and others, 1990; Cohn and others, 1992). This model includes a seven-constituent log-linear regression analysis of constituent concentrations against measured environmental variables.

$$\ln(C) = \beta_0 + \beta_1\langle \ln[Q - Q'] \rangle + \beta_2(\ln[Q - Q'])^2 + \beta_3[t - t'] + \beta_4[t - t']^2 + \beta_5 \sin[2\pi t] + \beta_6 \cos[2\pi t] + \varepsilon \,, \quad (1)$$

where

ln = natural logarithm function,
C = concentration (in milligrams per liter),
Q = instantaneous discharge (in cubic feet per second),
t = time (in decimal years),

$\sin$ = sine function,
$\cos$ = cosine function,
π = 3.14169,
β_0 to β_6 = coefficients of the regression model,
ε = model errors,
Q' = centering variable defined so that β_1 and β_2 are statistically independent, and
t' = centering variable defined so that β_3 and β_4 are statistically independent.

The regression analysis assumes that model errors (ε) are independent and normally distributed, with zero mean and variance. The Minimum Variance Unbiased Estimator (MVUE) (Bradu and Mundlak, 1970) was included in the model to correct for the retransformation bias associated with log-linear regression models; the model also employs the Adjusted Maximum Likelihood Estimator (Cohn, 1988), which statistically adjusts for censored data and multiple reporting limits.

Equation 1 results in an estimate of the daily logarithmic constituent concentrations. The estimated daily constituent concentrations are then multiplied by the daily mean discharge to produce a daily mean load by using the following equation.

$$\ln[L_i] = Q_i \times \ln[C_i] \times K , \qquad (2)$$

where
ln = the natural logarithm function,
L_i = the daily mean load (in kilograms per day),
i = any interval,
Q_i = the daily mean discharge for that interval (in cubic feet per second),
C_i = the mean concentration (in milligrams per liter), and
K = 2.447, the correction factor for unit conversion.

Yields allow easy comparison among sites with differing drainage areas; yields were computed by dividing the estimated load by the drainage area of the subbasin.

Results of Nutrient Analysis

Annual and monthly nutrient loads were estimated at three tributary sites in the Converse Lake watershed by using regression techniques. Nutrient yields also were computed from the estimated loads to allow for comparison among sites. Nutrient concentrations from October 1990 to June 1998 were analyzed to determine if any trends existed at the seven tributary sites and one lake site (site LHAM). The trophic response of the lake to the nutrient loads also was evaluated.

Nutrient Loads

Regression analyses were performed on seven species of nutrients—total inorganic nitrogen, ammonia, organic nitrogen, total Kjeldahl nitrogen, total nitrogen, total phosphorus, and orthophosphate. Regression summaries for the input data of nutrient concentrations are listed in table 9. Data used as input to the logarithmic-linear regression model are statistically summarized in appendix 1. Regression summaries include the variance (s) and the coefficient of determination (r^2) for each constituent, the model variables, and the coefficients used to determine the concentration for each variable.

The T value is the measure of the significance of the coefficients in the seven-parameter model. A model value with an absolute T value greater than 2 is considered to be significant, with the exception of the sine and cosine variables (β_5 and β_6, respectively). Because these variables together indicate seasonality, if either variable is significant, the other is considered significant. A significant variable indicates a relation to constituent concentration. For example, the statistical significance of variable β_1 indicates that streamflow, independent of other influences, is a good predictor of concentration. Temporal trends in nutrient concentrations are interpreted based on the statistical significance of β_3. Significant coefficients based on T values (not listed) are shown in bold in table 9.

The r^2, or coefficient of determination, is the percentage of the variation explained by the regression equation. For example, an r^2 of 74 indicates that approximately 74 percent of the variation in the actual data is explained by the equation. Because the data sets used to develop these equations cover only 1 year for Long and Boggy Branch and 2 years for Juniper and Collins Creek, the equations have relatively higher variance, as represented by the s values. Errors associated with predicted concentrations decrease as the number of samples collected increases.

The relative influence of nonpoint sources and point sources on water quality in the selected tributary subbasins can be examined by comparing the statistical significance of the streamflow regression coefficient,

Table 9. Regression summary for the seven-parameter, log-linear model used to estimate nutrient concentrations at selected sites in the Converse Lake watershed

[s, standard deviation of the residuals from ordinary least squares fit; r^2, coefficient of determination; n, number of observations used to fit the model; β_0, constant; β_1, coefficient of natural logarithm of streamflow; β_2, coefficient of natural logarithm of streamflow, squared; β_3, coefficient of time; β_4, coefficient of time, squared; β_5, coefficient of sine (time); β_6, coefficient of cosine (time); bold indicates coefficients with an absolute T value greater than 2, which indicates significance; —, no data]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

s	r^2	n	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Total nitrogen									
0.17462	0.952	36	**4.5788**	**0.9617**	0.0654	**-0.0381**	0.0128	**-0.1205**	**-0.0886**
Total Kjeldahl nitrogen									
0.25928	0.944	45	**3.8143**	**1.3822**	0.0548	**-0.0789**	-0.0059	**-0.1280**	**-0.2428**
Total organic nitrogen									
0.45647	0.619	45	1.3867	**0.5916**	-0.2125	**-0.0826**	-0.0036	0.1227	-0.0300
Total ammonia nitrogen									
0.23379	0.954	35	**3.8086**	**1.4066**	0.0416	-0.0087	0.0132	**-0.2075**	**-0.2683**
Total inorganic nitrogen									
0.65873	0.370	46	**3.4199**	**0.3984**	0.0886	**-0.1155**	0.0256	0.0654	0.0854
Total phosphorus									
0.79814	0.564	47	**0.8598**	**1.2094**	—	0.0384	—	-0.1885	0.0852
Total orthophosphorus									
0.00000	1.000	46	**0.3698**	1.0000	—	0.0000	—	0.0000	0.0000

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

s	r^2	n	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Total nitrogen									
0.21120	0.914	15	**3.6186**	**1.2182**	-0.2516	0.1828	0.3444	-0.0197	-0.0604
Total Kjeldahl nitrogen									
0.48771	0.780	22	**2.5123**	**1.9145**	-0.3111	0.0472	0.5640	-0.0030	-0.1662
Total organic nitrogen									
0.50111	0.736	21	-0.2969	**1.8449**	-0.3239	0.2984	0.4448	-0.1841	0.2092
Total ammonia nitrogen									
0.35746	0.902	14	**2.6389**	**1.7567**	-0.9557	0.0969	**1.7190**	-0.2388	-0.1634
Total inorganic nitrogen									
0.14268	0.865	22	**2.9863**	**0.5089**	-0.0527	0.1211	**-0.3242**	0.0556	0.0087
Total phosphorus									
1.6806	0.559	22	-0.0208	**3.0008**	—	1.1154	—	-0.5257	0.5632
Total orthophosphorus									
—	—	—	—	—	—	—	—	—	—

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

s	r^2	n	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Total nitrogen									
0.18147	0.947	15	**3.0989**	**1.2212**	0.2776	-0.0434	-0.1851	-0.0271	-0.0545
Total Kjeldahl nitrogen									
0.27668	0.889	22	**2.5112**	**1.5333**	0.4112	-0.0011	-0.1261	**-0.0030**	**-0.1979**
Total organic nitrogen									
0.35532	0.842	22	-0.1938	**1.8439**	-0.7371	0.2604	0.3858	**-0.2329**	**-0.3952**
Total ammonia nitrogen									
0.22210	0.945	15	**2.5664**	**1.3756**	0.5555	-0.0960	-0.2207	0.0444	-0.1052
Total inorganic nitrogen									
0.17477	0.839	23	**1.9871**	**0.8225**	-0.3740	0.0536	-0.1092	-0.0998	0.0874
Total phosphorus									
0.69307	0.504	24	-0.3192	**1.5228**	0.3541	0.4934	-0.0690	0.0052	0.2477
Total orthophosphorus									
—	—	—	—	—	—	—	—	—	—

Table 9. Regression summary for the seven-parameter, log-linear model used to estimate nutrient concentrations at selected sites in the Converse Lake watershed—Continued

[s, standard deviation of the residuals from ordinary least squares fit; r^2, coefficient of determination; n, number of observations used to fit the model; β_0, constant; β_1, coefficient of natural logarithm of streamflow; β_2, coefficient of natural logarithm of streamflow, squared; β_3, coefficient of time; β_4, coefficient of time, squared; β_5, coefficient of sine (time); β_6, coefficient of cosine (time); bold indicates coefficients with an absolute T value greater than 2, which indicates significance; —, no data]

Long Branch near Wilmer, 02479955 (site LON)

s	r^2	n	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Total nitrogen									
0.32975	0.915	10	**4.0791**	1.1099	-0.0016	0.8848	-16.9089	-1.4540	0.2904
Total Kjeldahl nitrogen									
0.61057	0.694	12	**1.5759**	**1.5055**	—	0.8309	—	-0.2587	-0.1209
Total organic nitrogen									
0.51128	0.715	11	-0.3187	**1.7021**	—	1.0415	—	-0.3502	0.5939
Total ammonia nitrogen									
0.64878	0.583	10	**1.6432**	1.2254	—	-0.0024	—	-0.1950	-0.4100
Total inorganic nitrogen									
0.20918	0.948	12	**2.1060**	**1.4223**	—	0.2951	—	0.1310	0.2797
Total phosphorus									
0.87464	0.303	12	**-1.6383**	0.7019	—	1.2450	—	-0.2464	0.1349
Total orthophosphorus									
—	—	—	—	—	—	—	—	—	—

Boggy Branch near Wilmer, 02479960 (site BOG)

s	r^2	n	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Total nitrogen									
0.33084	0.949	12	**1.4754**	**1.2912**	0.3733	-0.0992	-1.3389	-0.2691	-0.2252
Total Kjeldahl nitrogen									
0.38391	0.912	12	**1.2347**	**1.3736**	—	-1.1838	—	**-0.1122**	**-0.6940**
Total organic nitrogen									
0.58766	0.720	11	**-1.7646**	0.8351	—	1.0541	—	0.0528	-0.1367
Total ammonia nitrogen									
0.41959	0.929	11	1.9234	**1.1463**	0.7731	0.0081	-11.8689	-1.0106	-0.1948
Total inorganic nitrogen									
0.30845	0.921	12	0.1871	**1.3184**	—	0.3513	—	-0.3106	0.2623
Total phosphorus									
0.35835	0.461	12	**-1.6876**	0.2324	—	0.4350	—	0.0446	0.0386
Total orthophosphorus									
—	—	—	—	—	—	—	—	—	—

Crooked Creek near Fairview, 02479980 (site CRO)

s	r^2	n	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Total nitrogen									
0.27019	0.831	33	**3.6626**	**1.2274**	-0.0626	-0.0019	-0.0078	-0.1549	-0.0960
Total Kjeldahl nitrogen									
0.49310	0.697	48	**2.5244**	**1.5384**	0.0311	**-0.0803**	-0.0009	**-0.0303**	**-0.3407**
Total organic nitrogen									
0.46168	0.715	47	0.0032	**1.4031**	-0.0448	0.0501	-0.0225	0.2067	-0.1162
Total ammonia nitrogen									
0.44554	0.753	31	**2.9074**	**1.5571**	-0.0208	-0.0181	-0.0033	**-0.2773**	**-0.2374**
Total inorganic nitrogen									
0.47087	0.374	48	**2.4798**	**0.7253**	0.0558	-0.0406	0.0168	0.0326	-0.0527
Total phosphorus									
0.71127	0.560	48	0.0566	**1.7386**	—	-0.0052	—	0.1320	0.0004
Total orthophosphorus									
0.37663	0.683	45	**-0.7975**	**1.2952**	—	-0.0546	—	-0.0929	0.0463

Table 9. Regression summary for the seven-parameter, log-linear model used to estimate nutrient concentrations at selected sites in the Converse Lake watershed—Continued

[s, standard deviation of the residuals from ordinary least squares fit; r^2, coefficient of determination; n, number of observations used to fit the model; β_0, constant; β_1, coefficient of natural logarithm of streamflow; β_2, coefficient of natural logarithm of streamflow, squared; β_3, coefficient of time; β_4, coefficient of time, squared; β_5, coefficient of sine (time); β_6, coefficient of cosine (time); bold indicates coefficients with an absolute T value greater than 2, which indicates significance; —, no data]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

s	r^2	n	β_0	β_1	β_2	β_3	β_4	β_5	β_6
				Total nitrogen					
0.12143	0.930	28	**4.0483**	**0.8320**	0.0846	**-0.0389**	-0.0025	-0.0174	-0.0070
				Total Kjeldahl nitrogen					
0.34478	0.789	47	3.0790	1.5212	-0.0292	**-0.0974**	-0.0051	**-0.0541**	**-0.1981**
				Total organic nitrogen					
0.44160	0.706	46	**1.0568**	**1.5513**	**-0.4915**	0.0022	-0.0314	0.0870	-0.0826
				Total ammonia nitrogen					
0.30069	0.849	28	**3.2374**	**1.3453**	0.0341	**-0.0828**	-0.0018	-0.0766	-0.0766
				Total inorganic nitrogen					
0.09986	0.723	47	**3.3101**	**0.2486**	**-0.2291**	-0.0030	0.0021	**0.0308**	**0.0992**
				Total phosphorus					
0.77744	0.456	47	**0.5527**	**1.6829**	—	-0.0443	—	-0.0346	-0.2391
				Total orthophosphorus					
0.24929	0.788	45	**-0.3123**	**1.0960**	—	-0.0172	—	0.0790	-0.0700

β_1 (table 9). A significant, positive relation between streamflow and nutrient concentration indicates that nonpoint sources are the dominant source of input. If the relation is significantly negative, the primary source of nutrients is point sources. Total nitrogen (except at site LON), total Kjeldahl nitrogen (except at site HAM), total organic nitrogen (except at site BOG), ammonia (except at site LON), total inorganic nitrogen, and total phosphorus (except at sites LON and BOG) exhibited a significant, positive relation with streamflow, indicating that the dominant source of nutrient input to the watershed is from nonpoint sources.

The seasonal variation of nutrient concentrations has been attributed to several natural and cultural factors, including seasonal changes in algal or aquatic macrophyte uptake, fertilizer applications, or temperature-driven nitrification processes. A significant seasonal pattern, independent of flow variation, was observed for total nitrogen, total Kjeldahl nitrogen, and ammonia at sites BIG and CRO; for total Kjeldahl nitrogen and total organic nitrogen at site COL; and for total Kjeldahl and inorganic nitrogen at site HAM.

Different land-use practices contribute different levels of nutrients by nonpoint sources. A study by Reckhow and others (1980) summarized literature values of nutrient export from a variety of nonpoint sources (table 10). The range in nutrient yields is due to differences in climate, soils, and land-management practices for each category.

Annual yields at all monitored sites in the Converse Lake watershed were computed for total phosphorus, total inorganic nitrogen, total Kjeldahl nitrogen, and total nitrogen for the 1991 water year when all sites had continuous streamflow record (table 11). The total phosphorus yields ranged from 0.10 (site LON) to 0.52 (site CRO) (kg/ha)/yr, and total nitrogen yields ranged from 3.83 (site COL) to 8.45 (site BIG) (kg/ha)/yr (table 11). When compared to table 10, the computed total phosphorus yields for Big Creek, Collins Creek, Long Branch, and Boggy Branch are within the expected range for forested land with minor agriculture (pasture, crops, mixed agriculture). Crooked Creek (site CRO) and Hamilton Creek (site HAM) subbasins had higher residential and nonrow crop (plant nurseries) land use (table 4) and higher total phosphorus yields (0.52 and 0.40 [kg/ha]/yr, respectively) than the other tributary subbasins. Juniper Creek (site JUN) subbasin had a total phosphorus yield of 0.45 (kg/ha)/yr, which was within the range observed at Crooked and Hamilton Creek; however, little to no residential influence is present in Juniper Creek (table 4). The total nitrogen

Table 10. Range in nutrient yields from nonpoint sources (modified from Reckhow and others, 1980)

Dominant land use	Nutrient yields, in kilograms per hectare per year			
	Mean	Minimum	Median	Maximum
	Total phosphorus export			
Forest	0.24	0.02	0.21	0.83
Row crops	4.46	0.26	2.24	18.6
Nonrow crops	1.08	0.10	0.76	2.90
Pasture	1.50	0.14	0.81	4.90
Feedlots	301	21.3	224	795
Mixed agriculture	1.13	0.08	0.91	3.25
Urban	1.91	0.19	1.10	6.23
	Total nitrogen export			
Forest	2.86	1.38	2.46	6.26
Row crops	16.1	2.10	9.00	79.6
Nonrow crops	5.19	0.97	6.08	7.82
Pasture	8.65	1.48	5.19	30.9
Feedlot	3,110	681	2,920	7,980
Mixed agriculture	16.5	2.82	14.3	41.5
Urban	9.97	1.48	5.50	38.5

Table 11. Annual nutrient loads and yields for selected tributary sites in the Converse Lake watershed for water year 1991

[—, no data]

Site label (fig. 1)	Station name	Annual nutrient loads, in kilograms				Annual nutrient yields, in kilograms per hectare per year			
		Total phosphorus	Total inorganic nitrogen	Total Kjeldahl nitrogen	Total nitrogen	Total phosphorus	Total inorganic nitrogen	Total Kjeldahl nitrogen	Total nitrogen
BIG	Big Creek	1,880	27,300	58,800	69,000	0.23	3.35	7.19	8.45
JUN	Juniper Creek	1,080	6,360	6,390	2,410	0.45	2.66	2.68	5.59
COL	Collins Creek	270	2,260	6,360	8,510	0.12	1.02	2.88	3.83
LON	Long Branch	87.7	4,640	2,710	5,440	0.10	5.62	3.30	6.61
BOG	Boggy Branch	76.7	1,580	5,520	—	0.11	2.14	7.45	—
CRO	Crooked Creek	1,080	6,900	10,800	15,200	0.52	3.29	5.16	7.24
HAM	Hamilton Creek	847	8,620	8,840	17,400	0.40	4.04	4.14	8.16
	TOTAL	5,245	57,660	99,420	118,000	—	—	—	—

yields at the tributary sites fell within the published range of forested, agricultural (pasture, nonrow crops), and urban land use.

The total annual nutrient loads to Converse Lake for the 1991 water year were 5,245 kg for total phosphorus, 57,660 kg for total inorganic nitrogen, 99,420 kg for total Kjeldahl nitrogen, and 118,000 kg for total nitrogen (table 11). The nutrient loads at Big Creek, Crooked Creek, and Hamilton Creek accounted for over 70 percent of the total load in the watershed. Big Creek had the highest nutrient loads, accounting for almost 60 percent of the total nitrogen and total Kjeldahl nitrogen, 47 percent of the total inorganic nitrogen, and 36 percent of total phosphorus loads. Crooked and Juniper Creeks each contributed 21 percent of the total phosphorus load in 1991, and Hamilton Creek contributed about 16 percent. Total phosphorus yields from the Crooked, Juniper, and Hamilton Creek subbasins are 2 to 5 times those of the other tributary subbasins.

Annual loads were computed for the 1991 to 1998 water years at the three gaged sites—Big Creek (table 12), Crooked Creek (table 13), and Hamilton Creek (table 14). During the study period, nutrient loads and yields at all three sites were highest in the 1991 and 1998 water years; nutrient loads and yields were lowest in the 1992 and 1994 water years, except for total inorganic nitrogen in 1995. The mean annual loads and yields represent the average annual contribution of nutrients to Converse Lake for the study

Table 12. Annual and mean annual nutrient loads and yields for Big Creek (site BIG), Converse Lake watershed, water years 1991–98

[kg/d, kilogram per day; g/d, gram per day; (kg/ha)/yr, kilogram per hectare per year]

Water year	Orthophosphate (kg/d)	Total phosphorus (kg/d)	Total inorganic nitrogen (kg/d)	Total ammonia (g/d)	Total Kjeldahl nitrogen (kg/d)	Total nitrogen (kg/d)
Annual loads						
1991	840	1,880	27,300	49.7	58,700	69,000
1992	472	1,050	18,000	16.7	19,700	33,800
1993	748	1,850	17,400	34.3	39,200	51,500
1994	442	1,020	12,400	15.5	16,300	29,100
1995	550	1,340	12,000	23.6	22,900	36,000
1996	747	2,060	13,100	34.6	29,800	49,200
1997	543	1,380	12,000	23.6	16,200	37,000
1998	816	2,530	13,400	64.5	35,800	66,300
Mean annual	645	1,640	15,700	32.8	29,800	46,500
Annual yields ([kg/ha]/yr)						
Water year	Orthophosphate	Total phosphorus	Total inorganic nitrogen	Total ammonia	Total Kjeldahl nitrogen	Total nitrogen
1991	0.103	0.230	3.35	0.0061	7.19	8.45
1992	0.058	0.129	2.20	0.0020	2.42	4.15
1993	0.092	0.226	2.13	0.0042	4.81	6.31
1994	0.054	0.125	1.52	0.0019	2.00	3.56
1995	0.067	0.164	1.48	0.0029	2.80	4.41
1996	0.092	0.252	1.60	0.0042	3.65	6.03
1997	0.067	0.169	1.48	0.0029	1.99	4.52
1998	0.100	0.311	1.64	0.0079	4.38	8.13
Mean annual	0.079	0.201	1.93	0.0040	3.66	5.70

Table 13. Annual and mean annual nutrient loads and yields for Crooked Creek (site CRO), Converse Lake watershed, water years 1991–98

[kg/d, kilogram per day; g/d, gram per day; (kg/ha)/yr, kilogram per hectare per year]

Water year	Orthophosphate (kg/d)	Total phosphorus (kg/d)	Total inorganic nitrogen (kg/d)	Total ammonia (g/d)	Total Kjeldahl nitrogen (kg/d)	Total nitrogen (kg/d)
Annual loads						
1991	283	1,080	6,890	9.49	10,800	15,200
1992	154	480	4,620	4.93	4,820	9,580
1993	210	850	4,860	7.12	6,630	13,300
1994	115	366	3,600	4.62	3,970	8,800
1995	173	913	3,970	6.34	5,420	11,600
1996	212	1,030	4,570	7.79	5,820	14,200
1997	215	1,130	5,150	10.5	7,890	16,300
1998	306	1,890	5,880	10.0	6,690	17,570
Mean annual	208	967	4,940	7.59	6,510	13,300
Annual yields ([kg/ha]/yr)						
Water year	Orthophosphate	Total phosphorus	Total inorganic nitrogen	Total ammonia	Total Kjeldahl nitrogen	Total nitrogen
1991	0.135	0.517	3.29	0.0045	5.16	7.24
1992	0.0733	0.229	2.21	0.0024	2.30	4.58
1993	0.100	0.406	2.32	0.0034	3.17	6.34
1994	0.0549	0.179	1.72	0.0022	1.90	4.21
1995	0.0826	0.436	1.89	0.0030	2.59	5.54
1996	0.101	0.492	2.18	0.0037	2.78	6.80
1997	0.103	0.540	2.46	0.0050	3.77	7.79
1998	0.146	0.903	2.81	0.0048	3.19	8.40
Mean annual	0.100	0.462	2.36	0.0036	3.11	6.36

Table 14. Annual and mean annual nutrient loads and yields for Hamilton Creek (site HAM), Converse Lake watershed, water years 1991–98

[kg/d, kilogram per day; g/d, gram per day; (kg/ha)/yr, kilogram per hectare per year]

Water year	Orthophosphate (kg/d)	Total phosphorus (kg/d)	Total inorganic nitrogen (kg/d)	Total ammonia (g/d)	Total Kjeldahl nitrogen (kg/d)	Total nitrogen (kg/d)
Annual loads						
1991	225	857	8,610	8.41	8,820	17,400
1992	171	469	8,120	5.44	5,300	14,100
1993	196	686	8,080	6.22	6,230	15,300
1994	142	405	7,470	4.08	3,990	12,150
1995	191	795	7,700	5.51	5,630	14,300
1996	237	960	8,450	6.56	6,350	16,300
1997	211	901	8,400	5.64	5,720	14,700
1998	342	1,950	9,010	6.93	6,340	20,300
Mean annual	214	876	8,230	6.09	6,050	15,600

Water year	Orthophosphate	Total phosphorus	Total inorganic nitrogen	Total ammonia	Total Kjeldahl nitrogen	Total nitrogen
Annual yields ([kg/ha]/yr)						
1991	0.106	0.398	4.04	0.0039	4.14	8.16
1992	0.0801	0.221	3.81	0.0026	2.49	6.64
1993	0.0920	0.322	3.79	0.0029	2.93	7.17
1994	0.0667	0.190	3.51	0.0019	1.87	5.71
1995	0.0896	0.374	3.62	0.0026	2.64	6.73
1996	0.111	0.451	3.97	0.0030	2.98	7.67
1997	0.0993	0.423	3.95	0.0027	2.69	6.91
1998	0.161	0.914	4.23	0.0033	2.98	9.54
Mean annual	0.101	0.412	3.87	0.0029	2.84	7.32

period. A combined mean annual load of 75,400 kg of total nitrogen, 36,950 kg of total Kjeldahl nitrogen, 28,870 kg of total inorganic nitrogen, and 3,480 kg of total phosphorus was contributed to the lake by these sites during the 1991 to 1998 water years. Of the combined loads, 62 percent of the total nitrogen, 70 percent of the total Kjeldahl nitrogen, 54 percent of the total inorganic nitrogen, and 47 percent of the total phosphorus originated from the forested subbasin of Big Creek. The more residential and agricultural subbasins of Crooked Creek and Hamilton Creek, however, yielded over twice the total phosphorus per hectare of land use (fig. 17). Crooked and Hamilton Creek subbasins also had higher total inorganic nitrogen yields. The mean annual nutrient yields for the three sites were averaged to obtain a watershed yield for each nutrient species—0.0933 (kg/ha)/yr for orthophosphate, 0.358 (kg/ha)/yr for total phosphorus, 2.72 (kg/ha)/yr for total inorganic nitrogen, 0.0035 (kg/ha)/yr for total ammonia, 3.20 (kg/ha)/yr for total Kjeldahl nitrogen, and 6.46 (kg/ha)/yr for total nitrogen (fig. 17). The 103-mi^2 drainage area of the Converse Lake watershed is equivalent to 26,677 hectares. These estimated values were used to compute a mean annual nutrient contribution to Converse Lake (table 15).

Table 15. Estimated mean annual nutrient contributions to Converse Lake

[(kg/ha)/yr, kilogram per hectare per year; kg/yr, kilogram per year]

Nutrient	Nutrient contributions to the watershed: Yield[a] ([kg/ha]/yr)	Load[b] (kg/yr)
Orthophosphate	0.0933	2,490
Total phosphorus	0.358	9,550
Total inorganic nitrogen	2.72	72,600
Total ammonia	0.0035	93
Total Kjeldahl nitrogen	3.20	85,400
Total nitrogen	6.46	172,000

[a]Estimated by averaging the mean annual yields of the selected nutrients listed in tables 12, 13, and 14.

[b]Estimated by multiplying yield by 26,677 hectares (drainage area of watershed).

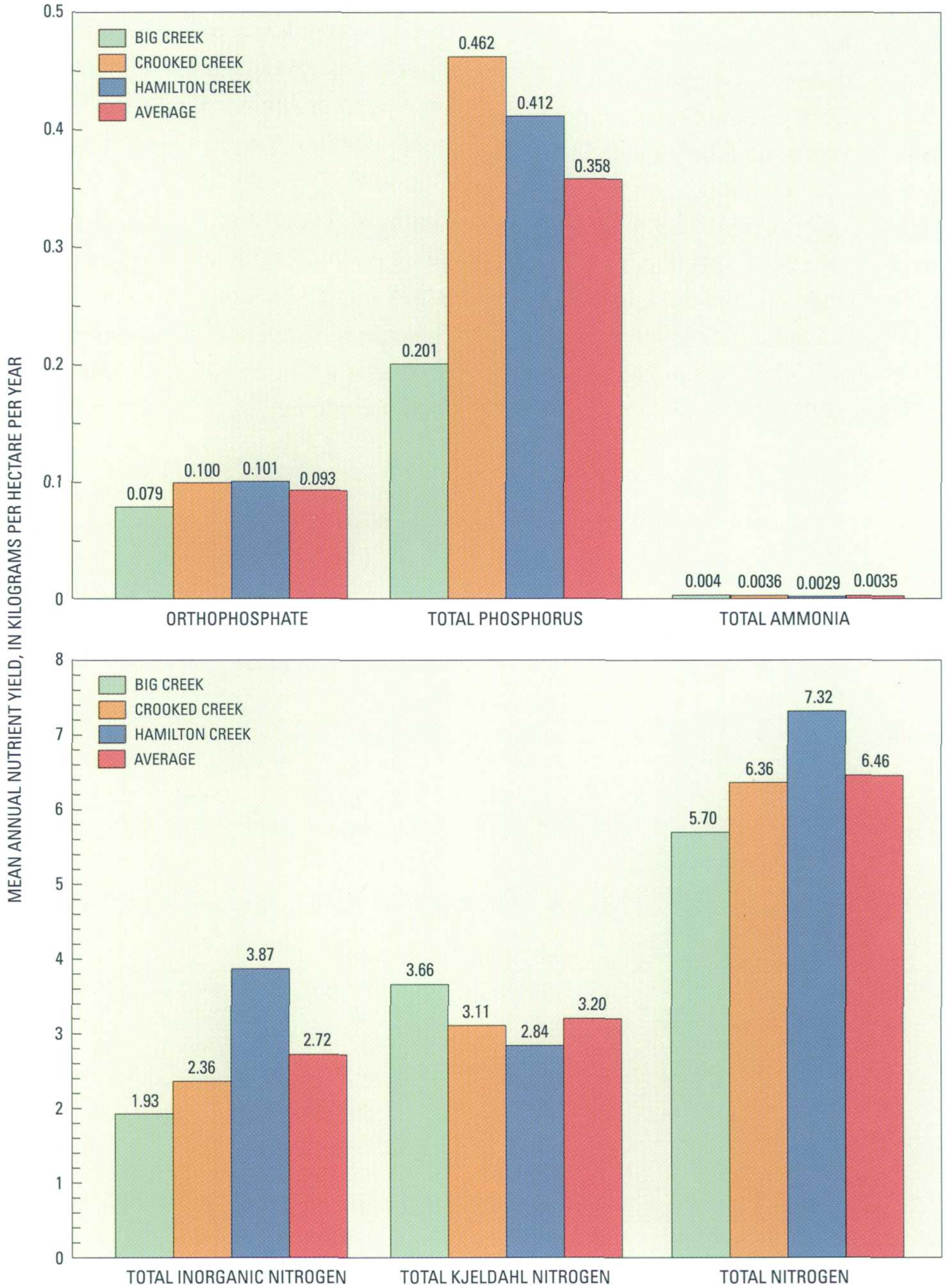


Figure 17. Mean annual nutrient yields for three sites in the Converse Lake watershed, 1990–98.

Eight-Year Trend Analysis

Statistical significance levels were determined for each variable by the Kendall tau trend test, which accounts for seasonal variations in the constituent concentrations. The unadjusted trends were computed by using actual concentrations, and the adjusted trends were computed by using the residuals from the LOWESS relation (table 16). A two-sided probability or *p*-value was used to describe the attained significance level. Trend analysis was considered significant at a 95-percent confidence level when the trend test detected an actual or real trend and the estimate had a *p*-value less than 0.05.

The trend analysis indicated little or no change in nutrient concentrations at the tributary and lake sites in the Converse Lake watershed from 1990 to 1998. Minimal decreases in total organic nitrogen were observed for Juniper Creek (0.005 [mg/L]/yr—unadjusted), Crooked Creek (0.007 [mg/L]/yr), and Hamilton Creek (0.003 [mg/L]/yr). Collins Creek and Hamilton Creek also had small, but significant, decreases in total Kjeldahl nitrogen (0.011 and 0.005 [mg/L]/yr, respectively). The only significant increase in nutrient concentrations was for total phosphorus at Long Branch, which was less than 0.001 (mg/L)/yr.

Table 16. Results of the seasonal Kendall tau test for trends in unadjusted and flow-adjusted nutrient concentrations at selected sites in the Converse Lake watershed, 1990–98

[Trends reported in units of milligrams per liter per year; bold values represent significant trends with *p*-value less than or equal to 0.05; <, less than; —, not applicable]

Constituent	Unadjusted			Adjusted		
	Trend	tau value	*p*-value	Trend	tau value	*p*-value
BIG CREEK (SITE BIG)						
Total inorganic nitrogen	0.010	0.22	0.180	-0.004	-0.13	0.431
Dissolved inorganic nitrogen	0.010	0.24	0.158	-0.002	-0.09	0.603
Total ammonia	0	-0.15	0.358	-0.001	-0.16	0.347
Total organic nitrogen	-0.007	-0.19	0.363	-0.003	-0.05	0.856
Total nitrogen	-0.005	-0.10	0.692	-0.038	-0.15	0.497
Total Kjeldahl nitrogen	-0.009	-0.13	0.530	-0.008	-0.21	0.287
Total phosphorus	0	0.22	0.303	0.0011	0.28	0.240
JUNIPER CREEK (SITE JUN)						
Total inorganic nitrogen	0.006	0.13	0.506	-0.001	-0.03	0.933
Dissolved inorganic nitrogen	0.005	0.13	0.506	0.002	0.04	0.868
Total ammonia	0	0.18	0.278	0.0001	0.03	0.933
Total organic nitrogen	**-0.005**	**-0.39**	**0.022**	-0.004	-0.17	0.362
Total nitrogen	-0.004	-0.11	0.559	0.004	0.14	0.455
Total Kjeldahl nitrogen	0	-0.25	0.113	-0.004	-0.21	0.244
Total phosphorus	0	0.29	0.052	0.00004	0.28	0.107
COLLINS CREEK (SITE COL)						
Total inorganic nitrogen	0.005	0.24	0.180	0.005	0.19	0.278
Dissolved inorganic nitrogen	0.005	0.31	0.079	0.006	0.25	0.156
Total ammonia	0	-0.03	0.925	0	0	1.000
Total organic nitrogen	0.001	0.04	1.000	-0.030	-0.42	0.151
Total nitrogen	-0.023	-0.16	0.704	-0.015	-0.21	0.561
Total Kjeldahl nitrogen	-0.008	-0.28	0.092	**-0.011**	**-0.43**	**0.013**
Total phosphorus	0	0	1.000	0.0002	0.14	0.452
LONG BRANCH (SITE LON)						
Total inorganic nitrogen	-0.013	-0.04	0.911	-0.029	-0.20	0.374
Dissolved inorganic nitrogen	-0.013	-0.04	0.911	-0.035	-0.20	0.374
Total ammonia	0.0007	0.11	0.649	-0.003	0.20	0.374
Total organic nitrogen	-0.009	-0.13	0.581	-0.008	-0.15	0.505
Total nitrogen	-0.016	-0.02	1.000	-0.021	-0.17	0.440
Total Kjeldahl nitrogen	-0.002	-0.09	0.733	-0.003	-0.13	0.581
Total phosphorus	**0.002**	**0.41**	**0.023**	**0.0009**	**0.54**	**0.008**

Table 16. Results of the seasonal Kendall tau test for trends in unadjusted and flow-adjusted nutrient concentrations at selected sites in the Converse Lake watershed, 1990–98—Continued

[Trends reported in units of milligrams per liter per year; bold values represent significant trends with *p*-value less than or equal to 0.05; <, less than; —, not applicable]

Constituent	Unadjusted			Adjusted		
	Trend	tau value	*p*-value	Trend	tau value	*p*-value
BOGGY BRANCH (SITE BOG)						
Total inorganic nitrogen	0.001	0.12	0.644	0.001	0.13	0.618
Dissolved inorganic nitrogen	0.002	0.11	0.653	-0.001	-0.07	0.812
Total ammonia	0	-0.02	1.000	0	0	1.000
Total organic nitrogen	0.005	0.07	0.877	0.018	0.30	0.311
Total nitrogen	0.002	0.07	0.881	0.004	0.20	0.515
Total Kjeldahl nitrogen	-0.003	-0.08	0.880	0.005	0.04	1.000
Total phosphorus	0.003	0.60	0.149	0.0004	0.25	0.743
CROOKED CREEK (SITE CRO)						
Total inorganic nitrogen	-0.006	-0.23	0.133	-0.009	-0.21	0.176
Dissolved inorganic nitrogen	**-0.010**	**-0.31**	**0.048**	**-0.011**	**-0.31**	**0.050**
Total ammonia	0	0.17	0.221	0.001	0.30	0.055
Total organic nitrogen	-0.005	-0.21	0.1655	**-0.007**	**-0.32**	**0.042**
Total nitrogen	-0.011	-0.17	0.274	-0.017	-0.28	0.079
Total Kjeldahl nitrogen	-0.001	-0.12	0.441	-0.006	-0.27	0.091
Total phosphorus	0	0.18	0.195	0.0003	0.15	0.343
HAMILTON CREEK (SITE HAM)						
Total inorganic nitrogen	0.004	0.11	0.524	0.003	0.15	0.362
Dissolved inorganic nitrogen	0.001	0.04	0.832	0.003	0.09	0.624
Total ammonia	0	0.03	0.880	-0.001	-0.15	0.360
Total organic nitrogen	**-0.008**	**-0.041**	**0.008**	**-0.003**	**-0.33**	**0.041**
Total nitrogen	-0.010	-0.24	0.137	-0.008	-0.22	0.183
Total Kjeldahl nitrogen	-0.008	-0.40	0.195	**-0.005**	**-0.40**	**0.011**
Total phosphorus	0	0.15	0.195	0	0.18	0.131
J.B. CONVERSE LAKE AT THE PUMP STATION (SITE LHAM)						
Total inorganic nitrogen	0.007	0.41	0.155	—	—	—
Dissolved inorganic nitrogen	0.006	0.50	0.063	—	—	—
Total ammonia	0.002	0.27	0.350	—	—	—
Total organic nitrogen	-0.012	-0.45	0.115	—	—	—
Total nitrogen	0	0	1.000	—	—	—
Total Kjeldahl nitrogen	-0.010	-0.27	0.367	—	—	—
Total phosphorus	0.002	0.32	0.248	—	—	—

Trend analysis results suggest nutrient contributions from land-use activities have little effect on the reported increase in the trophic state of Converse Lake from 1984 to 1995. Evidence for this is the decreasing or insignificant change in nutrient concentrations from 1990 to 1998 identified in the trend analysis in conjunction with little or no substantial change in land use in the watershed from 1985 to 1995 (Reutebuch and others, 1997).

Spatial and Temporal Distribution

Nutrient concentrations at the tributary sites in the Converse Lake watershed showed only minor spatial variations (fig. 18). Long Branch had the greatest range in and median concentrations of total inorganic nitrogen (0.57 mg/L) and total nitrogen (0.93 mg/L) in the Converse Lake watershed. Collins Creek and the lake at the pump station (site LHAM) had the lowest median concentration of total nitrogen (0.43 mg/L). The lowest median concentrations of total inorganic nitrogen were at Boggy Branch (0.12 mg/L) and Converse Lake at the pump station (0.09 mg/L). Median concentrations of total Kjeldahl nitrogen were highest at Boggy Branch, Long Branch, and Big Creek (0.30 mg/L). Hamilton Creek, Juniper Creek, and Collins Creek had the lowest median concentrations of

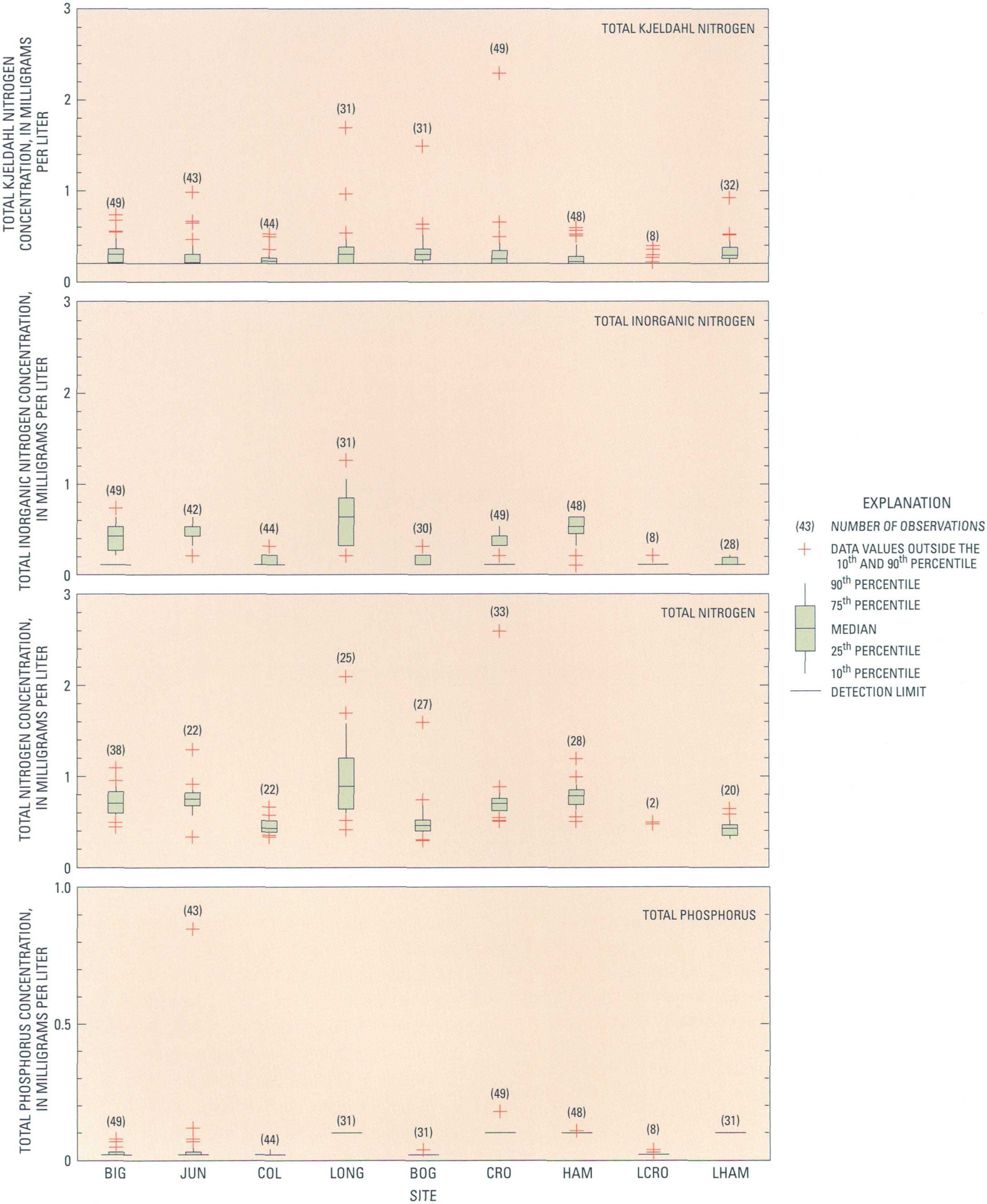


Figure 18. Boxplots of total Kjeldahl nitrogen, total inorganic nitrogen, total nitrogen, and total phosphorus concentrations at selected sites in the Converse Lake watershed, 1990–98.

total Kjeldahl nitrogen (0.22 mg/L). Hamilton and Crooked Creeks had the highest median concentrations of total phosphorus (0.02 mg/L). The lake site at the pump station had similar median concentrations of total phosphorus (0.012).

Seasonal changes in nutrient concentrations related to biological uptake were not strongly evident at the tributary sites because of the added influence of streamflow. Within the lake, however, nutrient concentrations demonstrated seasonal patterns related to algal production (fig. 19). From 1996 to 1998, chlorophyll *a* levels in Converse Lake at the pump station increased from below 2 µg/L in February and March 1997 to a maximum of 9.7 µg/L in June 1997, indicating the period of greatest algal production. Beginning in August 1997, chlorophyll *a* levels gradually decreased to a minimum of below 0.1 µg/L in January and February 1998. A second peak also was noted in October 1997 when chlorophyll *a* levels increased to more than 6 µg/L. During the summer and

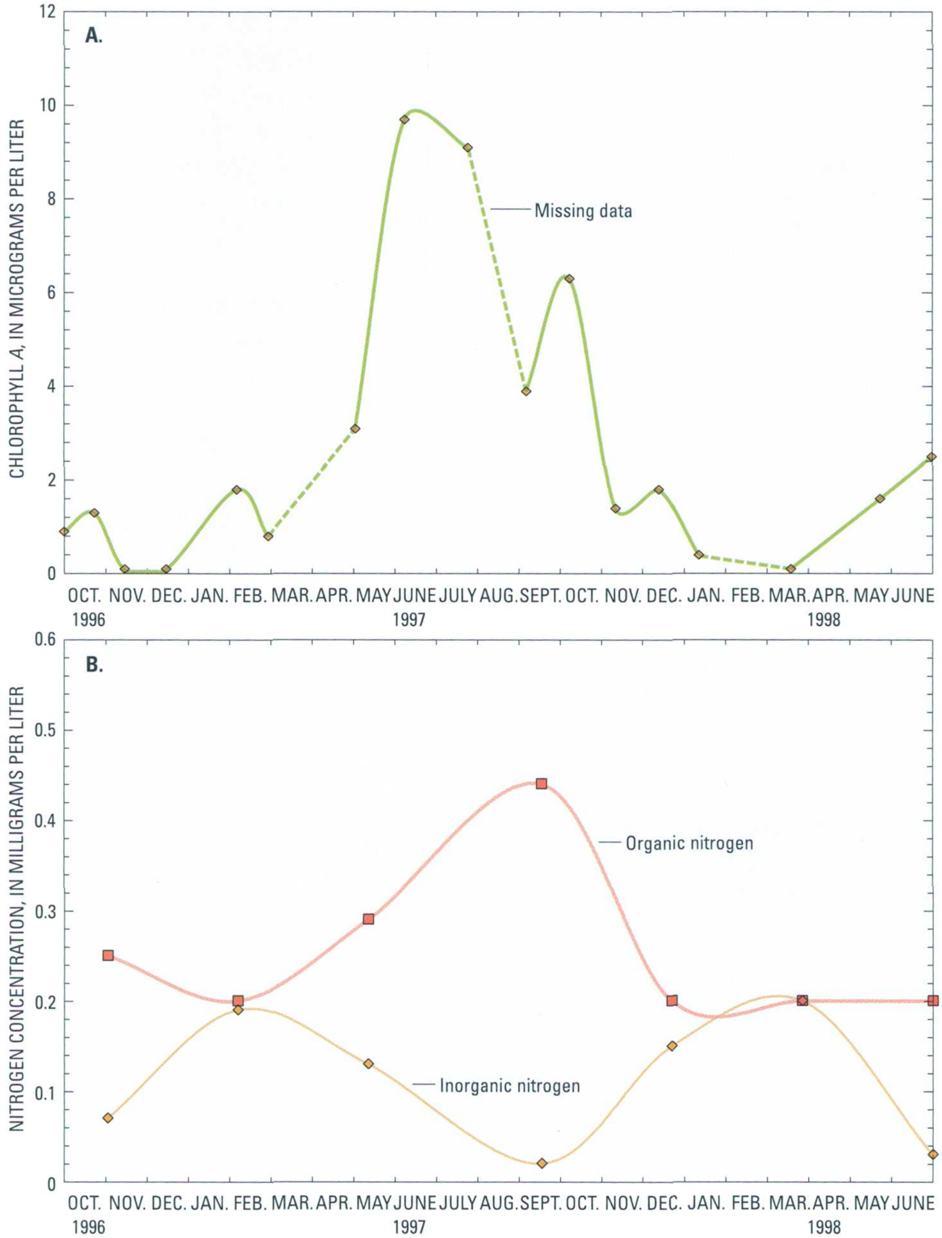


Figure 19. Seasonal variations in (A) chlorophyll *a*, and (B) organic and inorganic nitrogen concentrations in the Converse Lake watershed, 1996–98.

fall of 1997 when algal production was greatest, total inorganic nitrogen concentration decreased to a minimum of less than 0.1 mg/L at the same time total organic nitrogen increased to a maximum of 0.44 mg/L. This pattern suggests that during the peak of chlorophyll *a* production, inorganic forms of nitrogen were assimilated by photoplankton and converted to the organic form (fig. 19).

Comparison of Nutrient Loads with Trophic State of Lake

The results of ADEM's Reservoir Water Quality Monitoring Program indicated that the trophic state of Converse Lake apparently increased from a TSI value of 37 (oligotrophic) in 1985 to a TSI value of 62 (eutrophic) in 1995 (table 17). The mean TSI for 1985 to 1995 was 50, which placed the average trophic state of Converse Lake between eutrophic and mesotrophic conditions. In 1997, the TSI for the lake decreased to 51 (Alabama Department of Environmental Management, 1999; table 17).

A simple trophic response of the lake to the nutrient loadings from the tributary subbasins was not evident during the study period. A surface phosphorus concentration of more than 0.024 mg/L in a lake is considered to indicate eutrophic conditions (Vollendweider, 1976), and would produce a Carlson's TSI of over 50. To obtain a TSI of over 60, the total phosphorus and nitrogen concentrations must be greater than 0.048 and 0.333 mg/L, respectively, according to Carlson's TSI (Carlson, 1977) and the Lake Evaluation Index (Porcella and others, 1980). Converse Lake at the pump station (site LHAM) had a mean total phosphorus concentration of 0.02 mg/L and a mean total nitrogen concentration of 0.43 mg/L, which categorizes the trophic state as mesotrophic during the study period 1990–98. These mean nutrient concentrations, however, do not include 1995 data

Table 17. Seasonal and annual change in trophic potential and response variables in Converse Lake, 1992–97

[—, no data; µg/L, microgram per liter; mL, milliliter; mg/L, milligram per liter; kg/d, kilogram per day]

Trophic potential or response variable	1992		1995		1997	
	Spring	Summer	Spring	Summer	Spring	Summer
Carlson's Trophic State Index	—	51[a]	—	62[a]	—	51[b]
Chlorophyll *a* (µg/L)	—	—	—	—	1.4[c] 2.9[d]	7.1[c] 8.0[d]
Phytoplankton density (organisms/mL)	—	—	—	—	1,886[d]	1,485[d]
In-lake total phosphorus (mg/L)	0.013[c]	0.020[c]	—	—	—[c] 0.009[d]	0.010[c] 0.013[d]
In-lake total orthophosphorus (mg/L)	0.007[c]	0.007[c]	—	—	0.005[c] 0.008[d]	0.005[c] 0.006[d]
In-lake total nitrogen (mg/L)	0.45[c]	0.42[c]	—	—	0.42[c] 0.39[d]	0.45[c] 0.37[d]
In-lake total inorganic nitrogen (mg/L)	0.15[c]	0.03[c]	—	—	0.13[c] 0.16[d]	0.01[c] 0.03[d]
Mean monthly total nitrogen loading[e] (kg/d)	107	101	259	176	156	314
Mean monthly total phosphorus loading[e] (kg/d)	3.99	3.41	17.5	7.05	7.39	19.3
Mean monthly total inorganic nitrogen loading[e] (kg/d)	82.9	66.6	78.2	60.8	67.8	79.0
Land-use changes[f]	Forest re-growth		Net loss of forest		Forest re-growth	

[a]From Alabama Department of Environmental Management (1996).
[b]From Alabama Department of Environmental Management (1999).
[c]Average seasonal concentration at the lake for the pump station (USGS site LHAM).
[d]Computed as an average of three sites in the Hamilton Creek embayment in Bayne and others (1998).
[e]From appendix 2; spring is the average of the monthly load rates for March, April, and May at Big, Hamilton, and Crooked Creeks; these averages are summed to get the mean monthly load. Summer is the average of the monthly load rates for June, July, and August.
[f]From Reutebuch and others (1997).

when the TSI was over 60 because no data were collected in the lake from 1993 to 1995.

Nutrient concentrations and trophic response in the lake varied seasonally as well as annually (table 17). Trophic response variables and nutrient concentrations in the lake during the growing season were compared to the average monthly loading rates to the lake for spring and summer (computed from appendix 2 for Big, Crooked, and Hamilton Creeks) for 1992, 1995, and 1997. In general, nutrient loads were least in the fall, and greatest in the winter and spring. Monthly total nitrogen and total phosphorus loading rates to the lake from the tributaries for 1997 were much higher than for 1992; however, the higher rates appeared to have minimal influence on the in-lake concentrations and trophic response (fig. 20; table 17). The only differences between the TSI in 1995, when a value of 62 was well within eutrophic conditions, and the other 2 years when the TSI was 51, are relatively high total phosphorus and total nitrogen loading rates of 17.5 and 259 kg/d, respectively, in the spring of 1995. Although the rates of monthly loadings of total phosphorus and nitrogen were actually higher in the summer of 1997 (19.3 and 314 kg/d, respectively) than in the spring of 1995, the lake did not display a similar trophic response to the 1997 loadings.

Although the relation between the annual input of nutrients and the in-lake phosphorus and nitrogen concentrations can be complex, an attempt was made to identify a relation between these two conditions. The annual in-lake phosphorus concentrations can be estimated by empirical models developed from information collected by several researchers for a variety of lake types in a variety of geographic and climatic regions (Kirchner and Dillon, 1975; Vollenweider, 1975; Larsen and Mercier, 1976; Reckhow and Clements, 1984). Vollenweider (1968, 1969) developed an input-output (black box) model based on data from 20 natural lakes that established a correlation between annual areal nutrient loading and the mean lake depth for a given trophic state of the lake. Vollenweider (1975) modified the model to provide a measure of the phosphorus sedimentation or the amount of total phosphorus entering the lake that is

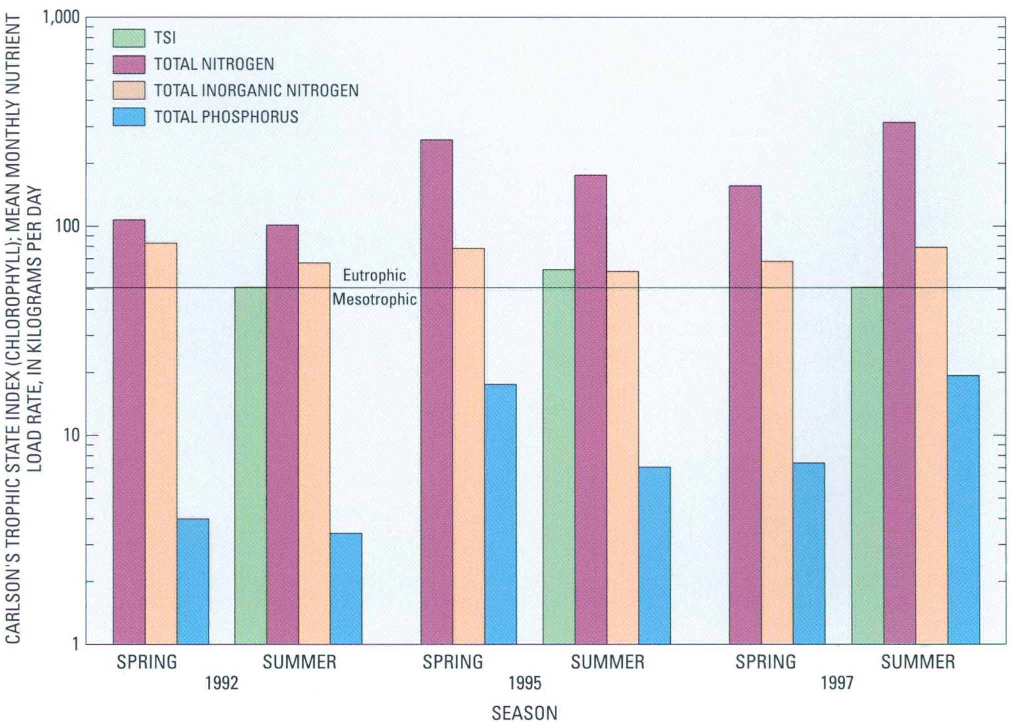


Figure 20. Temporal variations in nutrient loadings to the lake during the growing season and the lake response to these loadings.

retained. This model computes the lake phosphorus concentration (P), in milligrams per liter, by the formula

$$P = \frac{L}{v_s + z/\tau}, \qquad (3)$$

where
- L is the areal phosphorus loading (in grams per square meter per year),
- v_s is the apparent settling velocity (in meters per year),
- z is the mean lake depth (in meters), and
- τ is the hydraulic residence time (in years).

The areal phosphorus loading (L) is computed by the annual mass rate of phosphorus inflow (M; mean annual phosphorus load), in grams per year divided by the lake surface area (A), in square meters. The model assumes immediate and complete mixing of the input phosphorus in the lake, outflow concentrations equal to lake concentrations, phosphorus sedimentation rate proportional to its concentration, and negligible seasonal fluctuations in loading.

Additional studies showed that the retention coefficient (R) could be described as

$$R = \frac{v_s}{(v_s + q_s)} \qquad (4)$$

where q_s is the areal water loading, in meters per year (Chapra, 1975; Dillon and Kirchner, 1975). The areal water loading can be defined as the mean lake depth (z), in meters, divided by the hydraulic residence time (τ), in years (Reckhow, 1979). The general model then becomes:

$$P = \frac{L\tau}{z}(1 - R). \qquad (5)$$

Vollenweider (1975) estimated the apparent settling velocity (v_s) as 10 m/yr.

The mean annual total phosphorus load to Converse Lake was estimated to be 9,600 kg/yr (table 15) or 9,600,000 g/yr. The areal water loading (q_s) is 9.98 m/yr (a mean depth of 14.4 ft is equivalent to 4.39 m; hydraulic residence time is 0.44 years). The lake surface area of 3,600 acres was converted to 14,569,200 m^2. The areal water loading and apparent settling velocity were used as input to equation 4 to get a retention coefficient of 0.50. The mean annual total phosphorus load was used in equation 5 to provide an estimated annual in-lake phosphorus concentration of 0.034 mg/L, which was about twice as high as the observed mean concentration of 0.020 mg/L (appendix 1).

In summary, the lack-of-fit of the estimated in-lake phosphorus concentration from a simple input-output empirical model to the observed value in Converse Lake accentuates the need for a more robust model of lake water quality and trophic response. A more robust model would better explain the relation between annual nutrient contributions to Converse Lake from the tributaries and the lake's ability to assimilate these contributions by biomass uptake, sedimentation, and outflow.

MICROBIOLOGICAL ASSESSMENT

Fecal indicator bacteria are useful in assessing water quality because they are strongly correlated to the presence of waterborne pathogens (Myers and Wilde, 1999). Simple field methods are available to culture and enumerate fecal indicator bacteria; therefore, areas of possible fecal contamination can be readily identified. Two groups of bacteria commonly used as indicators are the fecal coliforms and fecal streptococci. These groups usually occur in the intestines of warm-blooded animals, but they also are able to live in other environments. *Escherichia coli (E. coli)*, a subgroup of the fecal coliforms, is enteric in origin. The presence of *E. coli* in water is direct evidence of fecal contamination from warm-blooded animals and the possible presence of pathogens (Dufour, 1977).

Giardia and *Cryptosporidium* are protozoan parasites that infect the digestive tracts of human beings and other animals. Excretion of infected animals may contain resistant cysts (*Giardia*) or oocysts (*Cryptosporidium*) that can persist in the environment and remain infective after leaving the host (Rose, 1990).

Giardia is the cause of giardiasis, currently the most common waterborne disease in human beings (Hibler and Hancock, 1990). *Cryptosporidium* was first identified as a cause of disease in human beings in 1980 (Rose, 1990). Symptoms of infection by these protozoans are diarrhea and abdominal discomfort (U.S. Environmental Protection Agency, 1993).

Documented waterborne occurrences include a 1987 outbreak in Carrollton, Ga., from a conventionally treated water supply (Rose, 1990), and another in Milwaukee, Wis., in 1993, which sickened 400,000 people and killed more than 100 people (Conrad, 1998). Because of the possibility of other outbreaks, the USEPA included testing of drinking water throughout the treatment and distribution process for *Giardia* cysts and *Cryptosporidium* oocysts in requirements for the Information Collection Rule (ICR; U.S. Environmental Protection Agency, 1999).

Microbiological Analysis Methods and Approach

Water samples were analyzed for fecal coliform and fecal streptococci bacteria quarterly from 1990 to 1996 and monthly from October 1996 to June 1998. Monthly analysis for *E. coli* was added in October 1996. All bacteria were cultured and enumerated using membrane filtration techniques described in chapter 7.1 of the USGS National Field Manual (Myers and Wilde, 1999). The following media were used for culturing: m-FC for fecal coliforms, KF for fecal streptococci, and m-TEC for *E. coli.* Results were reported in colonies per 100 milliliters of water.

Basic summary statistics of fecal bacteria concentrations at each of the sites in the Converse Lake watershed were calculated (appendix 1). Boxplots of bacteria concentrations illustrate the range in concentrations found at each site. To further compare bacteria data to existing standards, the geometric mean concentration of each bacteria type was calculated. The geometric mean (G) of a series of numbers (x_1, x_2, x_3...x_n) is defined as follows:

$$G = (x_1 x_2 x_3 \ldots x_n)^{1/n} . \qquad (6)$$

Geometric means are used in many water-quality standards and criteria for concentrations of bacteria because the effects of outlier values on the mean are reduced.

The trends in concentrations of fecal coliform and fecal streptococcus were determined at one lake and seven tributary sites from bacteria data collected during the period October 1990 to June 1998. Trend analysis was performed by using the same LOWESS statistical technique described in the previous section. Statistical significance was set for trend estimates with a *p*-value of less than 0.05.

The Converse Lake water-quality monitoring program included quarterly sampling for *Giardia* and *Cryptosporidium* at sites in the lake and in the water-supply system. *Giardia* sampling began in November 1990, and *Cryptosporidium* sampling began in June 1993. Water samples were shipped to BioVir Laboratories in Benicia, California, for analysis. Most of the samples collected during the study were analyzed for *Giardia lamblia*, the species of *Giardia* known to infect human beings, and for *Cryptosporidium* by using Standard Method 9711B; FA (Greenberg and others, 1992b). The Information Collection Rule (ICR) method, EPA 600/R-95/178, was used to detect *Giardia sp.* and *Cryptosporidium* in samples collected during May 1998. ICR results are reported as cysts per 100 liters of raw water, rather than a direct count of cysts observed. Methods information and analytical data for June 1993 to May 1998 are presented in appendix 3.

Results of Microbiological Analysis

The USEPA and the ADEM established standards and criteria for concentrations of fecal coliform bacteria for waters of varying uses (table 18). The ADEM established a use-classification system for State waters. Tributaries to Converse Lake are designated as suitable for fish and wildlife habitats, and the lake is classified as a public water supply.

The drinking-water standards are the maximum allowable levels of fecal bacteria in finished water, and are enforceable. The ADEM and USEPA criteria values are suggested limits or goals for fecal bacteria. All water-use classifications have criteria based on the maximum geometric mean bacterial density of five or more samples collected over 30 days at intervals of not less than 24 hours. Seasonal geometric mean criteria, which are effective June through September, apply to fish and wildlife and public water-supply uses. Even though geometric mean criteria were developed for use with several samples per month, the levels can provide a benchmark to assess the water quality of the Converse Lake watershed. Public water-supply, fish and wildlife, and agricultural and industrial water-supply water-use classifications also have maximum single-sample fecal coliform concentrations.

The USEPA-suggested criteria for *E. coli* for areas where swimming and whole-body contact sports occur are included in table 18. The USEPA suggests that the geometric mean of samples collected at a site

Table 18. Standards and criteria for concentrations of fecal bacteria set by the Alabama Department of Environmental Management and the U.S. Environmental Protection Agency for various water-use classifications (U.S. Environmental Protection Agency, 1986; Alabama Department of Environmental Management, 2000)

[—, not applicable]

Type of bacteria	Drinking-water standard	Fecal bacterial concentrations by water-use classifications, in colonies per 100 milliliters				
		Outstanding Alabama water	Public water supply	Swimming and other whole-body water contact sports	Fish and wildlife	Agricultural and industrial water supply
Fecal coliform	0	200[a]	1,000[a] (200)[b] 2,000[c]	200[a]	1,000[a] (200)[b] 2,000[c]	2,000[a] 4,000[c]
Escherichia coli	0	—	—	126[a] 235 to 576[d]	—	—

[a]Bacterial concentrations shall not exceed a geometric mean of this value. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours.

[b]Values in parentheses are seasonal geometric mean limits effective during June through September to account for incidental water contact and recreational uses.

[c]Maximum bacterial concentration not to be exceeded in any sample.

[d]Range in U.S. Environmental Protection Agency recommended single-sample maximum allowable density for whole-body contact recreation for different frequencies of use, from designated beach areas to infrequently used whole-body contact recreational areas.

should not exceed 126 col/100 mL, and that single-sample concentrations should not exceed 235 col/100 mL in designated beach areas, or 576 col/100 mL in areas where waters are infrequently used for whole-body contact recreation (U.S. Environmental Protection Agency, 1986).

Summary statistics were calculated for each bacteria type at each site (appendix 1). Boxplots of the concentration data for each bacteria type, sorted by site, represent the data distribution graphically (fig. 21). Percentile values of bacterial concentrations were used to describe how often individual measurements exceeded criteria levels. Seventy-five percent of all measured fecal coliform concentrations at each of the sites were less than 1,000 col/100 mL, the geometric mean criterion for public water supply and fish and wildlife water uses (red line, fig. 21A). Fifty percent of all measured fecal coliform concentrations at all sites except JUN and CRO were less than 200 col/100 mL, the geometric mean criterion for swimming and whole-body contact water uses (blue line, fig. 21A). Maximum fecal coliform levels at the two lake sites were below public water-supply criteria, but the maximum at site LHAM was above the criterion for swimming. At each of the tributary sites, at least 50 percent of all measured *E. coli* concentrations exceeded 126 col/100 mL, the geometric mean criterion for swimmable waters (blue line, fig. 21C). At sites COL, CRO, HAM, and JUN, at least 50 percent of all measured *E. coli* concentrations exceeded 235 col/100 mL, the single-sample criterion for designated beach areas (brown line, fig. 21C). At site JUN, 50 percent of all measured concentrations of *E. coli* exceeded 576 col/100 mL, the single-sample limit for infrequent body contact (green line, fig. 21C). Concentrations of all bacteria types were lower at the two lake sites (LCRO and LHAM) than at the tributary sites (fig. 21). Also, the concentration range of *E. coli* appears to be higher at Juniper Creek (site JUN) than at other sites in the watershed.

Boxplots illustrate the seasonal concentrations of each bacteria type for all sites (fig. 22). Fecal coliform and *E. coli* had only minor variations in concentrations between seasons, whereas fecal streptococcus concentrations were somewhat greater during spring and summer. The difference in concentrations between seasons is probably due to temperature changes, which affect the survival rates of the fecal streptococci.

Median concentrations of each bacteria type were calculated by season for each site to examine seasonal effects on bacteria concentrations (table 19). At the majority of the sites, fecal coliform bacteria seem to be more abundant in summer than during the other seasons. Fecal streptococci were more abundant during spring and summer at individual sites.

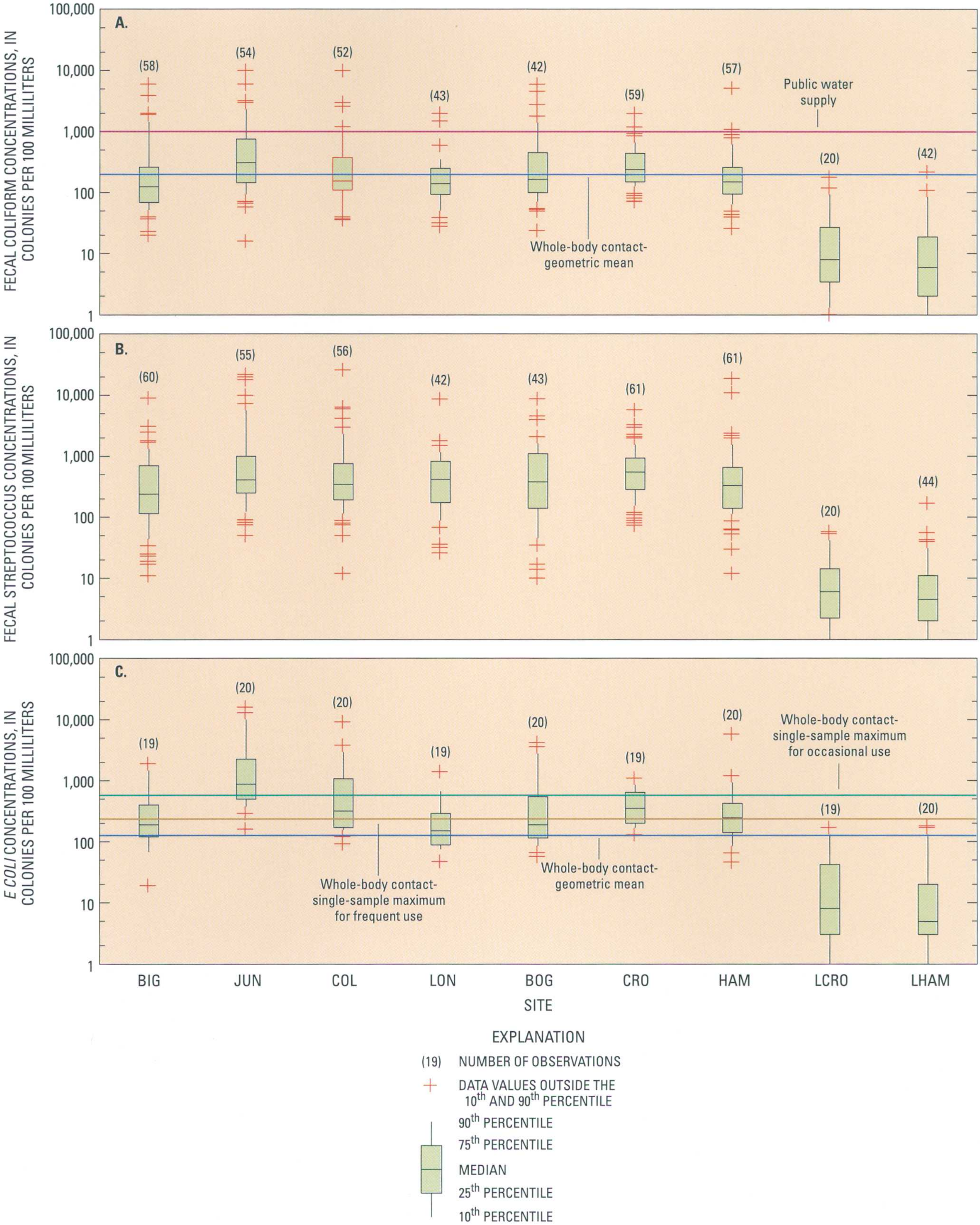


Figure 21. Boxplots showing ranges of (A) fecal coliform, (B) fecal streptococcus, and (C) *E. coli* concentrations at selected sites in the Converse Lake watershed, 1990–98.

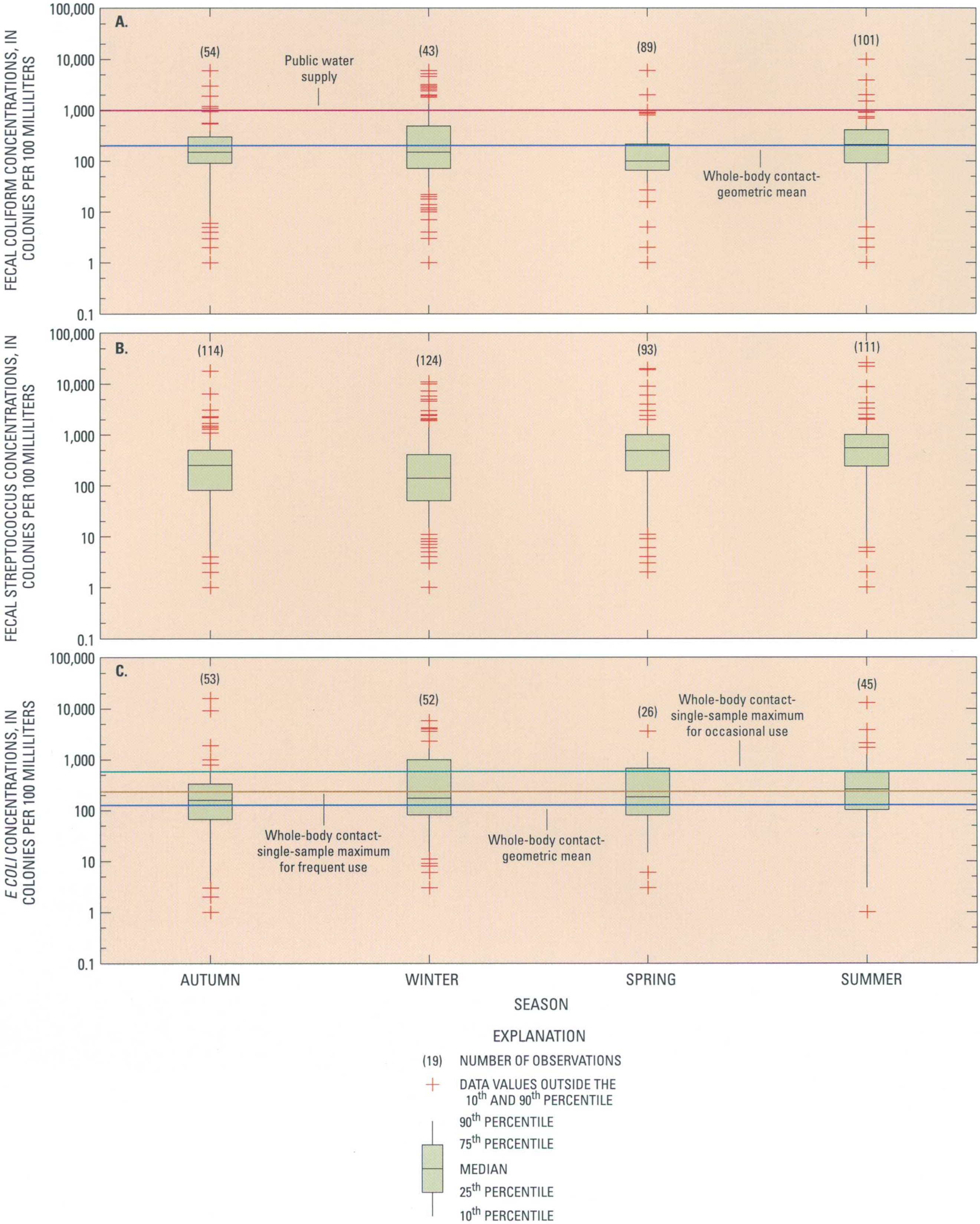


Figure 22. Boxplots showing seasonal (A) fecal coliform, (B) fecal streptococcus, and (C) *E. coli* concentrations at selected sites in the Converse Lake watershed, 1990–98.

Table 19. Seasonal median bacterial concentrations for selected sites in the Converse Lake watershed, 1990–98

[col/100 mL, colonies per 100 milliliters]

Site label (fig. 1)	Spring		Summer		Autumn		Winter	
	Number of observations	Median	Number of observations	Median	Number of observations	Median	Number of observations	Median
				Fecal coliforms (col/100mL)				
BIG	13	69	14	200	15	130	16	145
JUN	11	190	13	340	14	300	16	460
COL	10	120	12	240	14	180	16	145
LON	10	105	10	250	10	145	13	110
BOG	9	150	10	205	10	160	13	170
CRO	13	120	14	360	15	310	17	180
LCRO	3	27	5	2	6	7	6	24
HAM	12	140	13	160	15	140	17	160
LHAM	8	2	10	6	12	5	12	13
				Fecal streptococci (col/100 mL)				
BIG	13	260	15	520	16	235	16	86
JUN	12	670	14	935	13	250	16	295
COL	12	630	14	370	14	260	16	245
LON	9	660	11	700	10	295	12	102
BOG	9	540	11	500	10	375	13	140
CRO	13	700	15	740	16	530	17	220
LCRO	3	9	5	1	6	6	6	13
HAM	13	490	15	550	16	170	17	190
LHAM	9	6	11	2	13	3	11	6
				Escherichia coli (col/100 mL)				
BIG	3	140	5	200	6	160	5	160
JUN	3	790	5	1,600	6	485	6	2,150
COL	3	170	5	1,500	6	210	6	620
LON	3	83	5	290	5	120	6	140
BOG	3	130	5	210	6	240	6	190
CRO	3	350	5	540	6	370	5	300
LCRO	2	24	5	3	6	7	6	48
HAM	3	480	5	280	6	195	6	500
LHAM	3	22	5	3	3	4	3	12

Seasonal median values also can be compared to criteria to help determine when exceedances occur. At all sites in the watershed, median fecal coliform concentrations measured in spring were less than 200 col/100 mL, the geometric mean criterion for swimmable waters. Median fecal coliform concentrations measured in summer were greater than or equal to 200 col/100 mL at sites BIG, JUN, COL, LON, BOG, and CRO. Median fecal coliform concentrations in autumn were greater than 200 col/100 mL at sites JUN and CRO. In winter, only site JUN had a median fecal coliform concentration above 200 col/100 mL. None of the seasonal median fecal coliform concentrations was greater than 1,000 col/100 mL, the public water-supply and fish and wildlife geometric mean criterion. Median values of fecal coliform concentrations in the lake sites were below all criteria throughout the year.

Median *E. coli* concentrations exceeded the geometric mean criterion of 126 col/100 mL at sites BIG, JUN, COL, BOG, CRO, and HAM during all seasons, and at site LON during summer and winter. Median *E. coli* concentrations exceeded the designated beach single-sample criterion of 235 col/100 mL at sites JUN and CRO during all seasons, at site HAM during spring, summer, and winter, at site COL during summer and winter, at site LON during summer, and at site BOG during autumn (table 19). Median concentrations exceeded the single-sample maximum of 576 col/100 mL for infrequently used whole-body contact recreation areas at site JUN during spring, summer, and winter and at site COL during summer. For all seasons, median *E. coli* concentrations at lake sites LCRO and LHAM were below all criteria. Median concentrations of *E. coli* were lower at the lake sites in summer and autumn than during winter and spring, possibly because low flows in the tributaries prevented the bacteria from being transported to the lake before they naturally died off.

For comparison to criteria, geometric means of the measured concentrations of each bacteria type were calculated. Geometric means are summarized in table 20, and geometric mean bacterial density is shown in figure 23.

Geometric mean concentrations of fecal coliform for the entire period of record were below all criteria levels at tributary sites BIG, LON, and HAM, and lake sites LCRO and LHAM (fig. 23A). Sites JUN, COL, BOG, and CRO exceeded the whole-body contact geometric mean criterion of 200 col/100 mL. The geometric mean concentrations of fecal streptococci for the entire period of record are shown in figure 23B. Though no criteria currently (2001) exist for fecal streptococci, the high geometric mean concentrations found at sites JUN, COL, and CRO should be noted, as well as the low geometric means at the two lake sites, LCRO and LHAM.

The geometric mean of *E. coli* concentrations for the period October 1996 to June 1998 at all tributary sites exceeded the whole-body contact geometric mean criterion of 126 col/100 mL; however, the geometric mean concentrations at the lake sites, LCRO and LHAM, were well below all criteria levels (fig. 23C). Sites JUN, COL, BOG, CRO, and HAM had geometric mean concentrations greater than the whole-body contact single-sample exceedance criterion for beach areas (235 col/100 mL). Site JUN had higher concentrations of *E. coli* than the other tributary sites (table 20).

To determine if criteria exceedances for fecal coliform were occurring at the same sites as *E. coli* exceedances, geometric mean concentrations for fecal coliform concentrations were determined for the same time period as that for the *E. coli* concentrations (figs. 23C, D). Six of the seven tributary sites exceeded the whole-body contact geometric mean criterion of 200 col/100 mL for fecal coliform. The geometric mean fecal coliform density of 921 col/100 mL at Juniper Creek (site JUN) approached the public water-supply and the fish and wildlife geometric mean criteria of 1,000 col/100 mL.

Concentrations of fecal bacteria in the tributaries were elevated during the study period and may be cause for concern, especially in Juniper Creek. Concentrations of indicator bacteria at the lake sites, however, were below all criteria, indicating the lake water was an acceptable source for drinking-water supply. Trend analyses of the fecal coliform and fecal streptococcus data showed significant increases in concentrations at Juniper Creek (site JUN; table 21) from 1990 to 1998. These trends are of particular concern because median fecal coliform concentrations at Juniper Creek were already above the whole-body contact criteria during the same period (appendix 1).

Table 20. Geometric means of bacterial concentrations at sites in the Converse Lake watershed for the period October 1990–June 1998

Type of bacteria	Concentrations, by site, in colonies per 100 milliliters								
	BIG	JUN	COL	LON	BOG	CRO	LCRO	HAM	LHAM
Fecal coliform	168	358	202	150	225	257	10	165	7
Fecal streptococci	263	573	407	361	361	522	7	346	5
Escherichia coli	216	1,185	454	173	262	375	10	272	8
Fecal coliform 1996–98	245	921	395	199	285	313	10	231	10

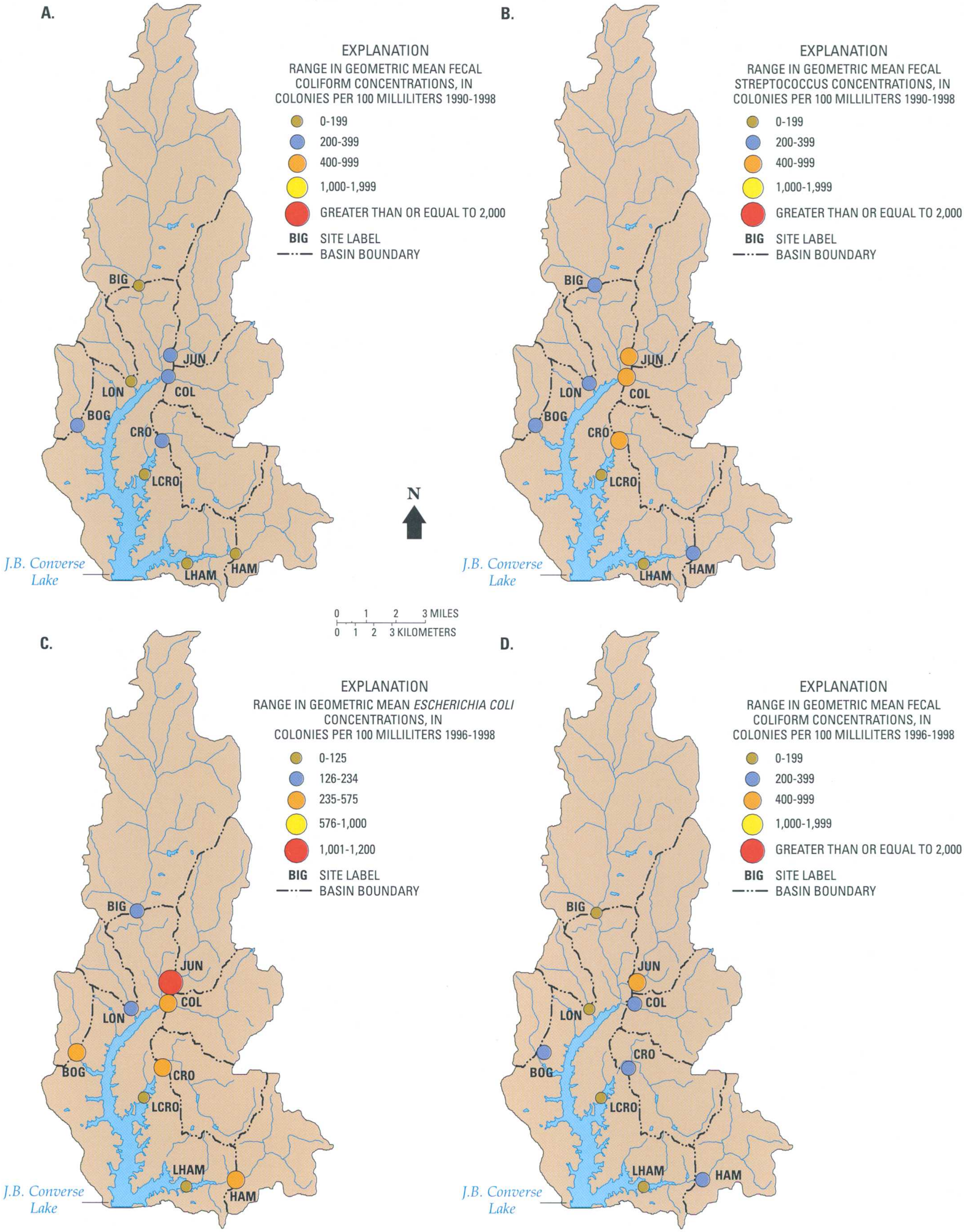


Figure 23. Ranges in geometric mean concentrations of fecal coliform and fecal streptococcus for 1990–98, and *E. coli* and fecal coliform for 1996–98.

Table 21. Results of the seasonal Kendall tau test for trends in unadjusted and flow-adjusted bacterial concentrations at selected sites in the Converse Lake watershed, 1990–98

[Trends reported in units of colonies per 100 milliliters per year; bold values represent significant trends with *p*-value less than or equal to 0.05; —, not applicable]

Fecal bacteria	Unadjusted			Adjusted		
	Trend	tau value	*p*-value	Trend	tau value	*p*-value
BIG CREEK (SITE BIG)						
Fecal coliform	8.25	0.27	0.090	6.075	0.11	0.5279
Fecal streptococcus	15.17	0.16	0.3250	44.42	0.20	0.2332
JUNIPER CREEK (SITE JUN)						
Fecal coliform	**76.67**	**0.40**	**0.0198**	52.55	0.28	0.1150
Fecal streptococcus	**96.61**	**0.42**	**0.0161**	**82.15**	**0.42**	**0.0161**
COLLINS CREEK (SITE COL)						
Fecal coliform	31.93	0.27	0.1319	19.95	0.18	0.3334
Fecal streptococcus	64.50	0.23	0.2165	-25.50	-0.21	0.2530
LONG BRANCH (SITE LON)						
Fecal coliform	11.67	0.33	0.1198	8.371	0.22	0.3203
Fecal streptococcus	-2.067	-0.08	0.7923	20.35	0.13	0.5808
BOGGY BRANCH (SITE BOG)						
Fecal coliform	-8.071	-0.07	0.8241	-4.526	-0.09	0.7404
Fecal streptococcus	-24.80	-0.04	0.9121	-45.12	-0.17	0.4395
CROOKED CREEK (SITE CRO)						
Fecal coliform	10.00	0.14	0.4390	12.02	0.20	0.2509
Fecal streptococcus	60.00	0.21	0.2068	46.00	0.18	0.2998
HAMILTON CREEK AT SNOW ROAD (SITE HAM)						
Fecal coliform	7.750	0.14	0.3989	9.150	0.14	0.3989
Fecal streptococcus	-15.83	-0.15	0.3596	-36.02	-0.30	0.0583
HAMILTON CREEK AT PUMP STATION (SITE LHAM)						
Fecal coliform	-0.7500	-0.16	0.6203	—	—	—
Fecal streptococcus	-0.1667	-0.20	0.5030	—	—	—

Spearman rank correlation coefficients for median concentrations of each type of bacteria and the percentage of each type of land use were calculated to identify possible links between land use and fecal contamination. Scatter plots are useful to illustrate the relations between the percentages of various land-use types and the median concentrations of selected bacteria (fig. 24). No significant correlations between percentages of land-use types and median concentrations of bacteria were observed.

Protozoan monitoring detected very few encysted protozoans during the study period. Assay results from November 1990 through August 1992 are presented in the report by Journey and others (1995). Results from June 1993 to May 1998 are shown in appendix 3 and summarized here. In August 1993, one *Giardia* cyst was found during the *Cryptosporidium* assay of the site LHAM sample. The species of *Giardia* could not be determined from this assay, and no *Giardia* cysts were found during the *Giardia lamblia* assay. One *Cryptosporidium* oocyst was detected in the January 1996 sample from the holding reservoir at the filtration plant. In June 1996, six *Giardia* cysts and one *Cryptosporidium* oocyst were detected at Highway 98, and six *Giardia* cysts were detected at site LHAM.

The low number of *Giardia* cyst and *Cryptosporidium* oocyst detections in the water samples makes it difficult to draw conclusions about actual concentrations of these pathogenic protozoans in the water supply or about factors that may influence

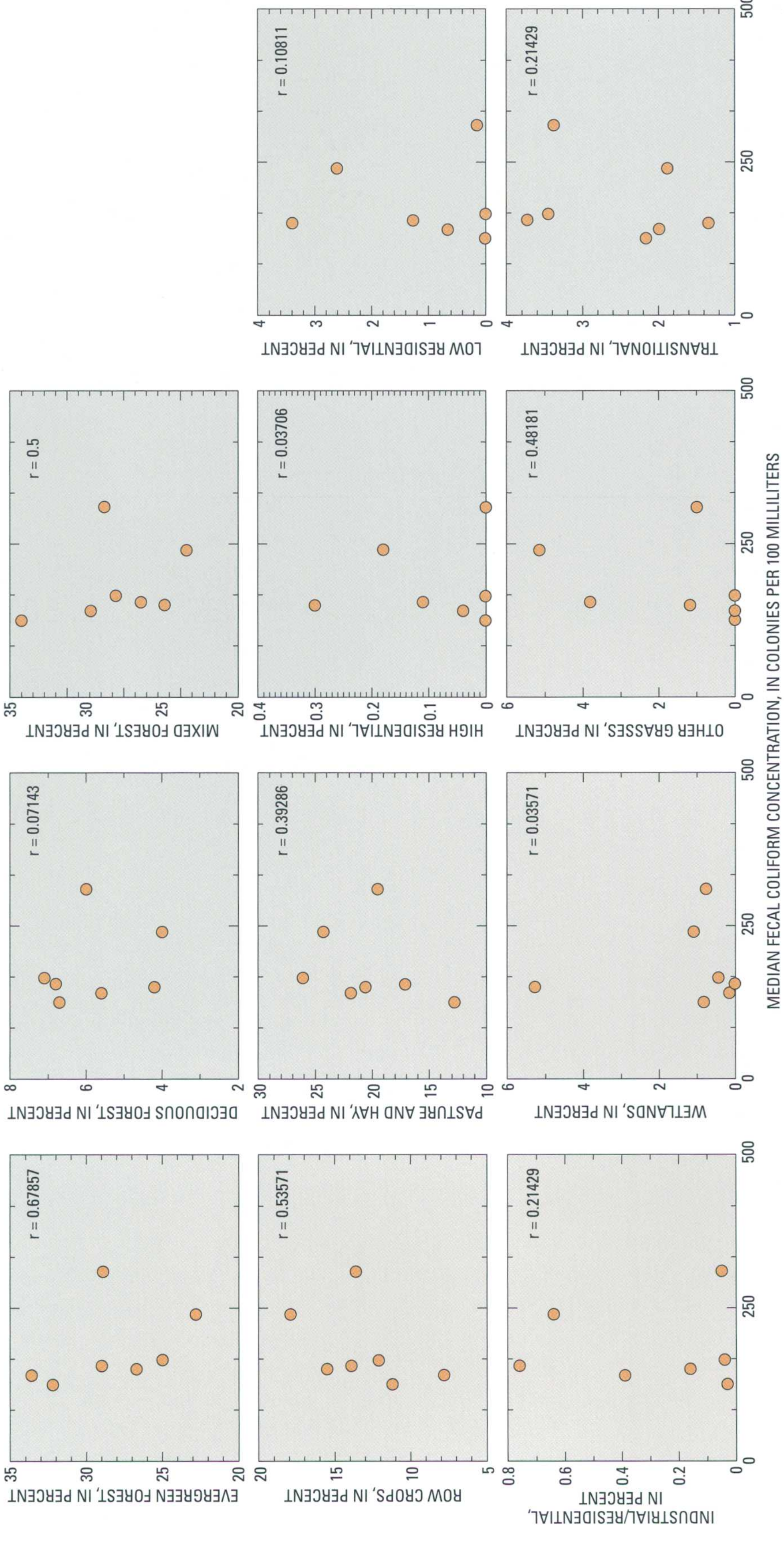


Figure 24A. Scatter plots showing relations between percentages of various land-use types and median fecal coliform concentrations at sites in the Converse Lake watershed.

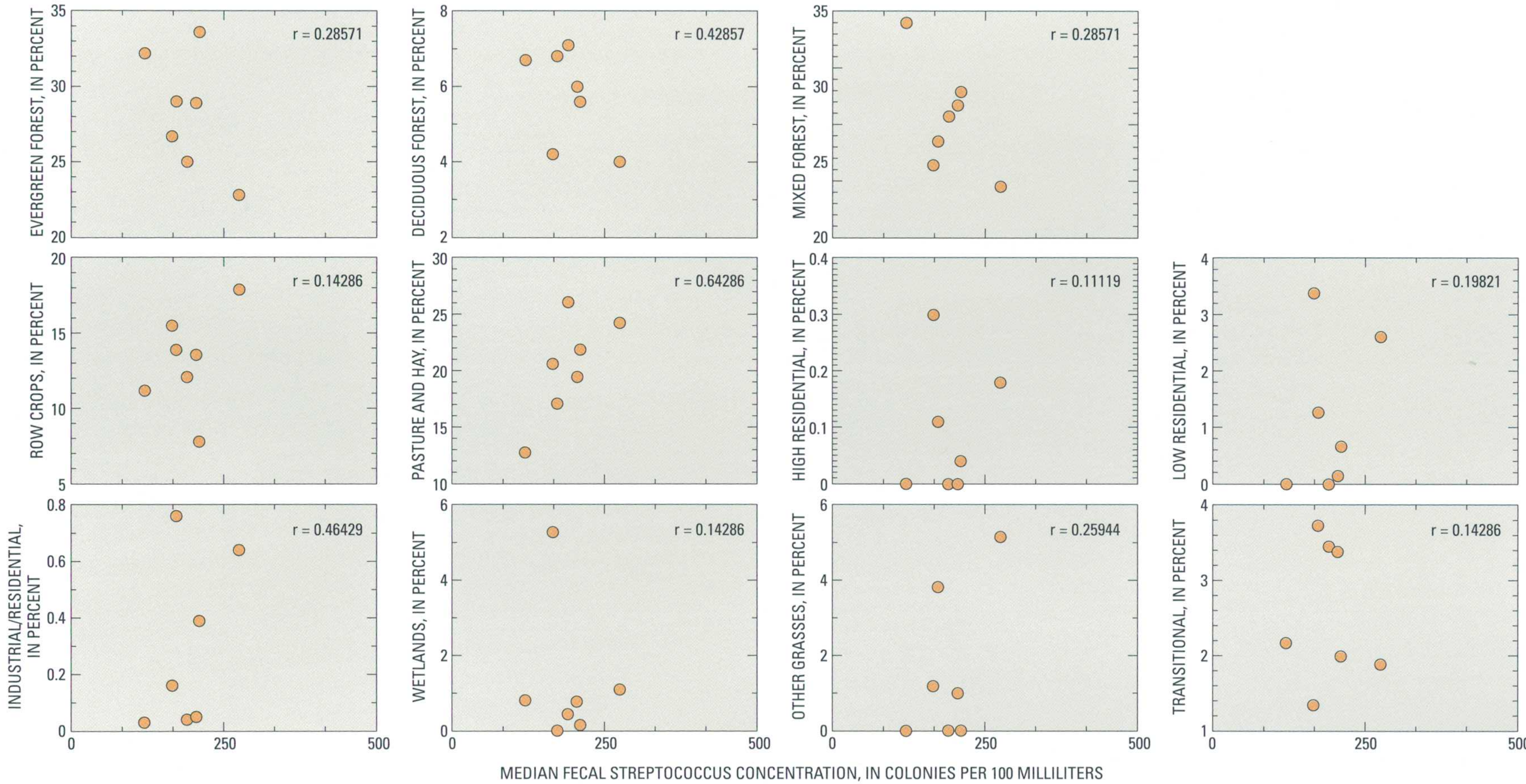


Figure 24B. Scatter plots showing relations between percentages of various land-use types and median fecal streptococcus concentrations at sites in the Converse Lake watershed.

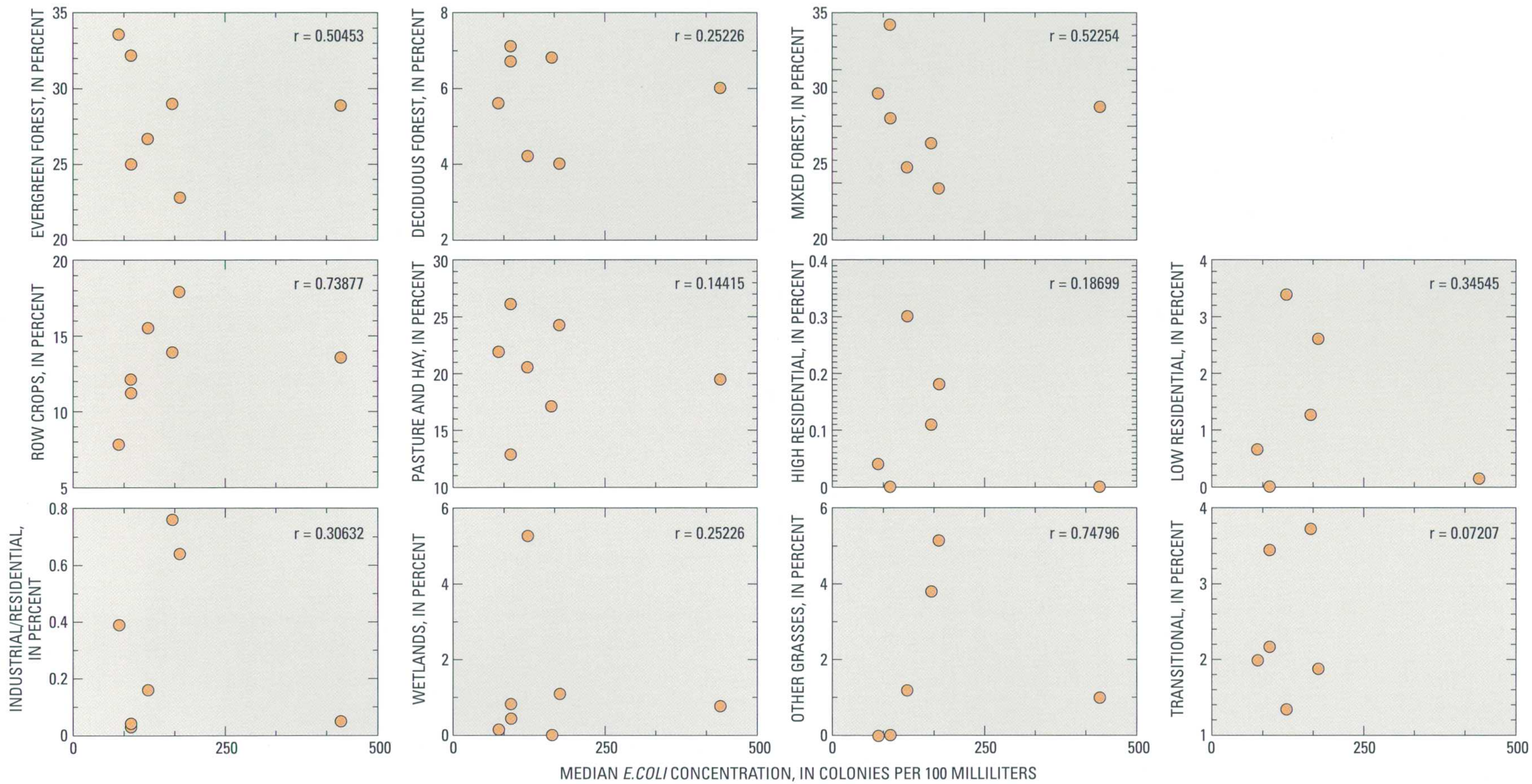


Figure 24C. Scatter plots showing relations between percentages of various land-use types and median *E. coli* concentrations at sites in the Converse Lake watershed.

these concentrations. Although concentrations of *Giardia* and *Cryptosporidium* seem to be small in the water supply, false negatives are possible with the sampling methods that were used. According to Rose (1990), "The interpretation of negative samples may be difficult and does not necessarily signify the absence of contaminating oocysts." More detections of *Giardia* and *Cryptosporidium* in Converse Lake occurred during spring and summer (May, June, and August) than during autumn and winter, suggesting a seasonality in the occurrence of cysts and oocysts. Continued monitoring of protozoan pathogen concentrations at the intake to the drinking-water system combined with bacteriological sampling may help define relations between concentrations of bacteria and pathogens in the watershed.

In summary, monitoring in the Converse Lake watershed for fecal contamination shows that some tributaries to Converse Lake have concentrations of fecal bacteria above existing criteria for whole-body contact uses. Concentrations of bacteria at lake sites LCRO (mouth of Crooked Creek) and LHAM (Hamilton Creek at pump station) were well below all criteria levels. Elevated concentrations of bacteria in the tributaries did not seem to cause elevated levels in the lake.

Juniper Creek (site JUN) had the highest geometric mean concentrations for all bacteria types during the study. Trend analyses show that flow-adjusted concentrations of fecal streptococcus were increasing at site JUN during the 8 years of data collection. This apparent increasing trend in bacteria is cause for concern because the current (2001) bacteria levels in Juniper Creek are above the suggested criteria levels.

Detections of *Giardia* and *Cryptosporidium* were few at sites in the lake and the raw-water intake during the monitoring period. The low number of detections makes it difficult to draw any conclusions about actual cyst concentrations in the water supply. Most of the detections occurred during the summer months, but so few cysts were detected that it is not clear if there is a seasonal influence on cyst density.

ORGANIC CARBON CHARACTERIZATION

The naturally occurring organic carbon present in Converse Lake and its tributaries was characterized by estimating the reactivity and identifying the general source of the organic carbon. This characterization was based on past research of the factors that control the reactive nature and occurrence of organic matter in a watershed (Rook, 1977; de Leer and Erkelens, 1989; Amy and others, 1990; Miller and others, 1990; Reckhow and others, 1990; Nieminski and others, 1993; Krasner and others, 1994; Aiken and Cotsaris, 1995; Singer and others, 1995; Korshin and others, 1996; Summers and others, 1996). An understanding of the reactive nature and source of organic carbon is needed to minimize the formation of disinfection by-products (DBPs), which are produced from a reaction between naturally occurring organic matter and chlorine when chlorine is added to water for disinfection. The DBPs of regulatory concern are trihalomethanes (THMs) and haloacetic acids (HAAs). This study addresses only THM formation—the sum of chloroform ($CHCl_3$), bromoform ($CHBr_3$), bromodichloromethane ($CHBrCl_2$), and dibromochloromethane ($CHBr_2Cl$).

Organic matter in raw water is measured by determining the concentrations of total organic carbon (TOC) and dissolved organic carbon (DOC). TOC is the total of all organic carbon compounds, both dissolved and particulate, present in the raw water. DOC is the organic carbon that passes through a 0.45-micron filter and may include colloidal organic matter. Oxidants, including chlorine, chlorine dioxide, and monochloroamine, are added to raw water during water treatment for the purpose of disinfecting the water supply. In addition to disinfection, chlorine reacts by cleaving the aromatic rings of organic carbon compounds in the water and releasing halogenated by-products that are a potential health risk. However, not all of the organic carbon compounds in organic matter have aromatic rings and, thus, may be less reactive and less a risk for THM formation.

Hydrology, soil type, and climate of the watershed affect the occurrence of naturally occurring reactive organic matter which, in turn, influences the occurrence of DBP precursors in the water supply (Aiken and Cotsaris, 1995). Hydrologic processes include transport of terrestrially derived, tannin- and lignin-rich organic carbon into a stream, river, or lake by overland flow and flushing of the shallow soil zone during rain events. Terrestrially derived (allochthonous) organic carbon compounds include humic and fulvic acids. These acids generally constitute about 50 to 60 percent of the dissolved organic carbon found in river and lake waters; these acids also have a high reactivity with chlorine (de Leer and Erkelens, 1989). Algal growth and microbial processes occur within the aquatic environment (autochthonous) and produce organic carbon compounds, such as carbohydrates, pigments, proteins, lipids, polysaccharides, and amino acids, which are not as reactive with chlorine (de Leer and Erkelens, 1989). Algal and microbial processes can dominate in slower moving waters, such as reservoirs. Ground-water discharge is a negligible source of organic carbon because concentrations generally are low.

Soils can influence the transport of organic carbon to streams or lakes. Iron-rich lateritic soils tend to adsorb the organic carbon in the deeper soil layers causing the organic carbon to slowly leach into the stream. Sandy soils do not hold or sorb the organic carbon as readily, thus allowing for quick flushing during rain events.

The tendency of naturally occurring organic carbon to react with chlorine is a function of several factors (Aiken and Cotsaris, 1995). Source, geochemistry, and degradation by microbial processes influence the reactivity of the organic carbon. Research on organic geochemistry of naturally occurring organic matter has shown that the ability of the organic carbon to react with chlorine depends, in part, on the aromaticity (the number of aromatic rings present in the organic matter) and the carbon-to-nitrogen ratio in the organic carbon (table 22). In general, terrestrial, lignin-rich vegetation (such as trees) has a higher carbon content and, consequently, higher carbon-to-nitrogen ratios than aquatic vegetation (such as emergent wetland plants); therefore, organic matter that is derived from terrestrial sources tends to react more readily with chlorine to form DBPs than organic matter from aquatic sources.

Absorption of light by natural waters provides a semiqualitative indicator of the concentration of naturally occurring organic matter in the water, especially ultraviolet light absorbance at 254 nanometer wavelength (Korshin and others, 1997). Most organic matter molecules that absorb light at ultraviolet ranges are aromatic groups, including phenols and aromatic acids (found in high concentrations in humic and fulvic acids). Previous studies have shown a good correlation between ultraviolet light absorbance at 254 nanometers and trihalomethane-formation potential (Reckhow and others, 1990).

Organic Carbon Analysis Methods and Approach

Sampling water for organic carbon, which may be precursors to disinfection by-products, consisted of collecting monthly surface-water samples over an 18-month period at seven tributary sites and two lake

Table 22. General geochemical characteristics of naturally occurring organic carbon compounds in surface water derived from lignin-derived (allochthonous) or microbial/algal-derived (autochthonous) sources (modified from Aiken and Cotsaris, 1995)

Source of naturally occurring organic matter in rivers and lakes	
Lignin-derived (allochthonous)	**Microbial/algal-derived (autochthonous)**
Low in nitrogen	High in nitrogen
High in aromatic carbon; low in aliphatic carbon	Low in aromatic carbon; high in aliphatic carbon
High phenolic content	Low phenolic content
Greater absorbance of ultraviolet light at 254 nanometers	Less absorbance of ultraviolet light at 254 nanometers
More reactive	Less reactive

sites in the Converse Lake watershed (table 23). Samples were analyzed for TOC, DOC, tannin and lignin, and chlorophyll *a* and *b* concentrations (site LHAM only) at the USGS Laboratory in Ocala, Florida. Field blanks of organic-free water were processed for TOC, DOC, and tannin and lignin following the same quality assurance and quality control procedures used for surface-water samples. Streamflow, water temperature, dissolved oxygen (concentration and percent saturation), pH, alkalinity, Secchi disk depth (at lake sites), and specific conductance were measured in the field at the time of sampling.

Table 23. Types and potential sources of organic carbon in surface-water samples collected in the Converse Lake watershed

Samples measured	Potential sources
Total and dissolved organic carbon	Concentrations of all organic carbon compounds
Tannin and lignin	Estimate of the amount of organic carbon compounds derived from terrestrial plant material (humics)
Chlorophyll *a, b*	Estimate of the amount of algae in water
Ultraviolet absorbance at 254 nanometers	Estimate of the reactivity of the organic carbon
Trihalomethane-formation potential	Measure of the amount of trihalomethanes formed as a result of chlorination
Trihalomethane yield	Measure of the amount of trihalomethanes formed per unit of organic carbon
Specific absorbance (ultra-violet absorbance/ dissolved organic carbon)	Estimate of the humic content of the dissolved organic carbon

Quarterly surface-water samples were collected at the three continuous-record stations and at the one lake site at the pumping station, and were analyzed for trihalomethane-formation potential (THM-FP) at the USGS National Water Quality Laboratory in Denver, Colorado. Surface-water samples were analyzed according to Standard Method 5710 by purge and trap gas chromatography/mass spectroscopy and by solid-phase microextraction for THMs (Symons and others, 1981; Greenberg and others, 1992a). Filtered and unfiltered water samples were analyzed for ultraviolet absorbance at 254 nanometers (UVA) at the USGS Alabama District Office using a Bucks Scientific CE 2041 ultraviolet-visible spectrum (UV-Vis) spectrophotometer and a 4-cell changer that contained quartz cells with 1-cm pathlength. The filtered sample data represented the reactivity of DOC; the unfiltered samples represented the reactivity of TOC. Each sample was analyzed in triplicate, and the UVA results were averaged to obtain the final results for the filtered (UVA-DOC) and unfiltered (UVA-TOC) samples, which had units of absorbance per centimeter^{-1} (cm^{-1}). Laboratory blanks of organic-free water were analyzed in all cells before and after sample analysis for quality assurance and quality control. Specific ultraviolet absorbance (SUVA) was determined as the ratio of ultraviolet absorbance to DOC concentration in units of liters per milligram per centimeter.

Characterizing the origin of the reactive organic carbon at each tributary and lake site involved several interpretive approaches, including statistical, graphical, and spatial analyses of the data. The results were used to evaluate the reactivity of the organic carbon and the relation of sources and spatial distribution of the reactive organic carbon to land use in the watershed. Statistical summaries of these data are presented in appendix 1. The tendency of the organic carbon at each site to react with chlorine to form disinfection by-products was estimated by the UVA of the water sample at that site. Trihalomethane-formation potential was compared to UVA levels for verification of the UVA-estimated reactivity of the organic carbon. Seasonal variability of reactive organic carbon in the lake and its tributaries was determined. Spearman rho correlation coefficients (previously described) were determined for the total and dissolved organic carbon concentrations, tannin and lignin (terrestrial plant material) concentrations, Secchi disk depth, and chlorophyll (aquatic plant material) concentrations to identify a probable source of the organic carbon (table 23). The spatial distribution of median TOC, DOC, tannin and lignin, and UVA levels were determined to identify the subbasin(s) contributing the greatest amount of reactive organic carbon to the lake.

Results of Organic Carbon Analysis

The USEPA set a maximum contaminant level (MCL), effective in 1999, of 80 µg/L for total THMs in finished water (U.S. Environmental Protection Agency, 1998), a reduction from the previous MCL of 100 µg/L. The MAWSS submitted quarterly monitoring information to the USEPA on the formation of THM in treated water samples collected from July 1997 to June 1988, as mandated in the ICR of the Safe Drinking Water Act (U.S. Environmental Protection Agency, 1996a,b,c). Municipal surface-water supply systems in Birmingham, Tuscaloosa, and Huntsville, Alabama, also submitted quarterly THM information. During the monitored period, the treated water from the MAWSS (Mobile) and Birmingham exceeded the 80-µg/L MCL during the summer and fall (fig. 25; U.S. Environmental Protection Agency, 2000). The results of the monitoring indicated that the greatest mean THM concentration was in treated water from the MAWSS (76 µg/L), followed by mean THM concentrations in treated water for Birmingham (67 µg/L), Tuscaloosa (54 µg/L), and Huntsville (46 µg/L). These mean THM concentrations are similar to those reported for municipal water supplies in North Carolina (Singer and others, 1995), but are lower than levels reported in Ohio and Florida (Summers and others, 1996; fig. 26). Nieminski and others (1993) reported a range of 1 to 97 µg/L of THM concentrations in treated water from 35 water-supply utilities in Utah.

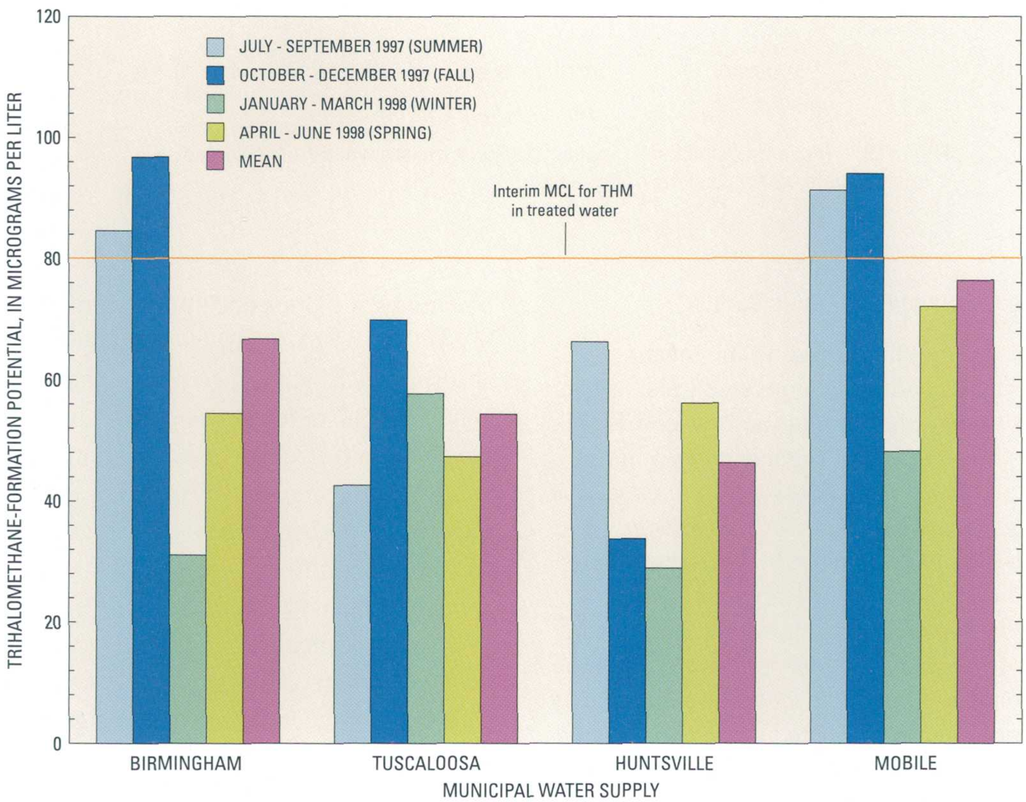


Figure 25. Quarterly and mean results of monitoring for trihalomethane concentrations in treated water at four municipal water supplies in Alabama as part of the Information Collection Rule requirements.

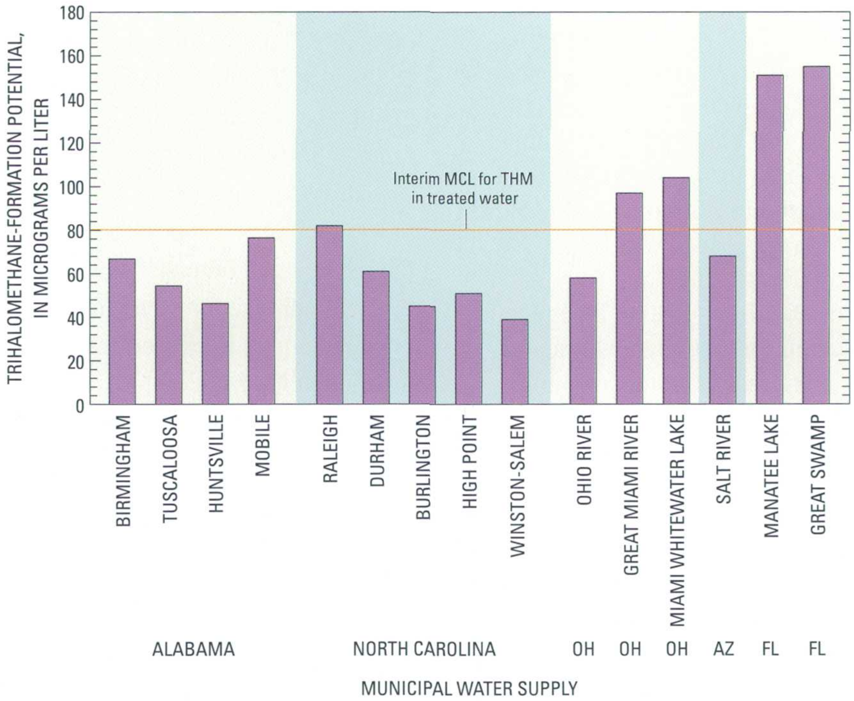


Figure 26. Mean trihalomethane concentrations in treated water from selected municipal water supplies in the United States.

Estimation of Reactivity of the Organic Carbon

The first step in understanding the reactive nature of the organic carbon in Converse Lake and its tributaries was to identify the relation between THM formation and the presence of organic carbon in the water. If TOC and DOC were consistently of a reactive nature, a strong, statistically significant relation between THM-FP and organic carbon concentrations could be expected. The reactive fraction of TOC and DOC in the lake and tributaries, however, could vary with season or flow; thus, a better indication might be the aromatic content of the organic carbon estimated by UVA or algal production estimated by chlorophyll. In this study, the relation between THM-FP and UVA was stronger and statistically more significant than the relation between THM-FP and TOC or DOC.

When water samples were collected for THM-FP analyses, concurrent water samples were analyzed for potential surrogate concentrations of TOC, DOC, UVA-TOC, UVA-DOC, tannin and lignin, and specific absorbance, which is a computed value of the UVA-DOC to DOC ratio. The degree of correlation among the potential surrogate concentrations (sampled monthly at all sites) and THM-FP (sampled quarterly at four sites) was determined by using Spearman rho correlation coefficients. This statistical analysis was applied to the data to establish the best surrogate for THM-FP, which allowed monthly extrapolation of the reactive carbon data. The results of the statistical correlation indicated statistically significant relations between THM-FP and UVA-TOC, UVA-DOC, and tannin and lignin (p-value < 0.05; fig. 27), with UVA-TOC having the strongest correlation (0.7021). Therefore, UVA was selected to be the surrogate measure of the reactive carbon in a sample.

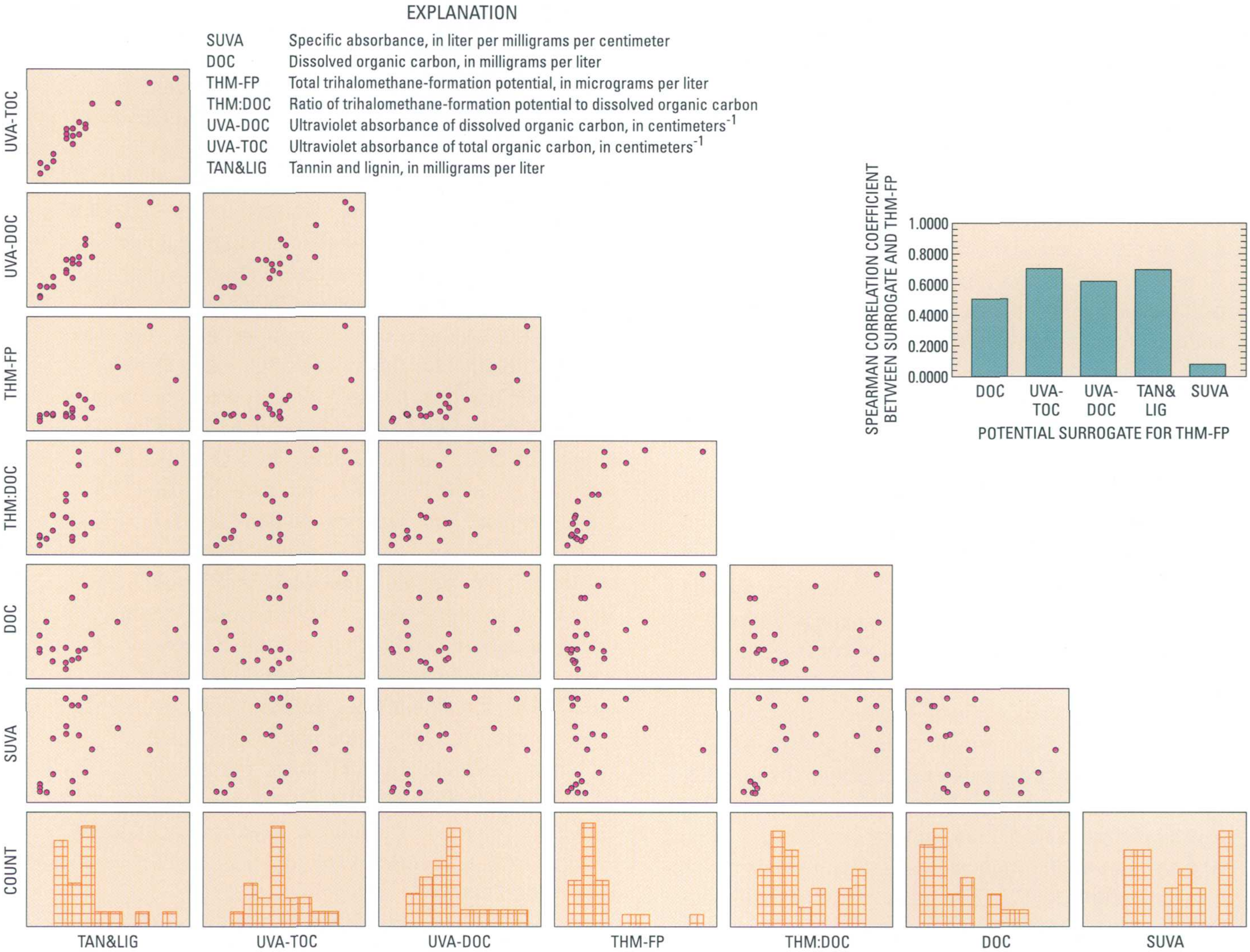


Figure 27. Correlation coefficients and scatter plots of trihalomethane-formation potential and potential surrogate concentrations in the Converse Lake watershed, 1996–98.

Spatial and Temporal Distribution

The degree of spatial and temporal variability of TOC, DOC, tannin and lignin, UVA, specific absorbance, and THM-FP levels was determined, and differences over time and among subbasins were assessed. A combination of graphical and statistical techniques was used, and GIS coverages were developed to better evaluate spatial distribution and temporal variability of reactive organic carbon. The amount of organic carbon in the water from tributary sites varied to some degree from subbasin to subbasin and over time during the study period (October 1996 to June 1998). In general, the lake sites had intermediate organic carbon levels that were more constant spatially and temporally than the tributary sites.

Organic carbon contributions from the tributaries to the lake were evaluated. Median DOC and TOC concentrations were lowest in Crooked Creek, Long Branch, and Hamilton Creek and highest in Boggy Branch and Big Creek (appendix 1; figs. 28, 29). The greatest range in concentrations in DOC and TOC concentrations was observed in Juniper Creek; the smallest range in concentrations was observed at the lake sites (fig. 28). The dissolved fraction of the organic carbon generally accounted for more than 90 percent of the total organic carbon at all sites.

Tannin and lignin were used to estimate the terrestrial-source component of the organic carbon. Median tannin and lignin concentrations displayed a similar spatial pattern as the organic carbon, with the lowest median value found in Crooked Creek (0.5 mg/L) and the highest found in Big Creek (1 mg/L) (figs. 28, 29). The greatest interquartile range in concentrations in tannin and lignin concentrations was identified in Juniper Creek; the least, at the lake sites (fig. 28). Tannin and lignin generally accounted for about 22 percent of the dissolved organic carbon found in water from the tributary sites, and 18 and 15 percent at the lake sites at the mouth of Crooked Creek and at the pump station (sites LCRO and LHAM, respectively).

Median UVA values for water collected at tributary sites ranged from 0.165 (Crooked Creek) to 0.256 cm^{-1} (Boggy Branch) for unfiltered TOC samples (figs. 29, 30), and from 0.122 (Crooked Creek) to 0.204 cm^{-1} (Boggy Branch) for filtered, DOC samples (fig. 30). Median UVA values at the lake sites were intermediate to the range of values for Boggy Branch and Crooked Creek, and had less variability. Median UVA values for TOC samples at the lake sites were 0.168 cm^{-1} for the mouth of Crooked Creek (site LCRO) and 0.158 cm^{-1} for the pump station at the mouth of Hamilton Creek (site LHAM). Median UVA values for DOC samples at sites LCRO and LHAM were 0.151 and 0.145 cm^{-1}, respectively. The UVA values for the DOC samples were normalized for the amount of dissolved organic carbon that was present by computing the specific ultraviolet absorbance (SUVA). Examination of the median SUVA values identified a different pattern. The highest median SUVA values were at the Crooked (site CRO) and Hamilton (site HAM) Creek sites (0.062 and 0.060 cm^{-1}/mg/L, respectively); the lowest median SUVA value was at the lake site (LHAM) at the pump station (0.032 cm^{-1}/mg/L) (fig. 30). This suggests that the DOC in Crooked and Hamilton Creeks may be more reactive than at the other sites, and that the DOC in the lake is less reactive.

Results of the THM-FP analyses identified the highest THM-FP concentrations were in water from

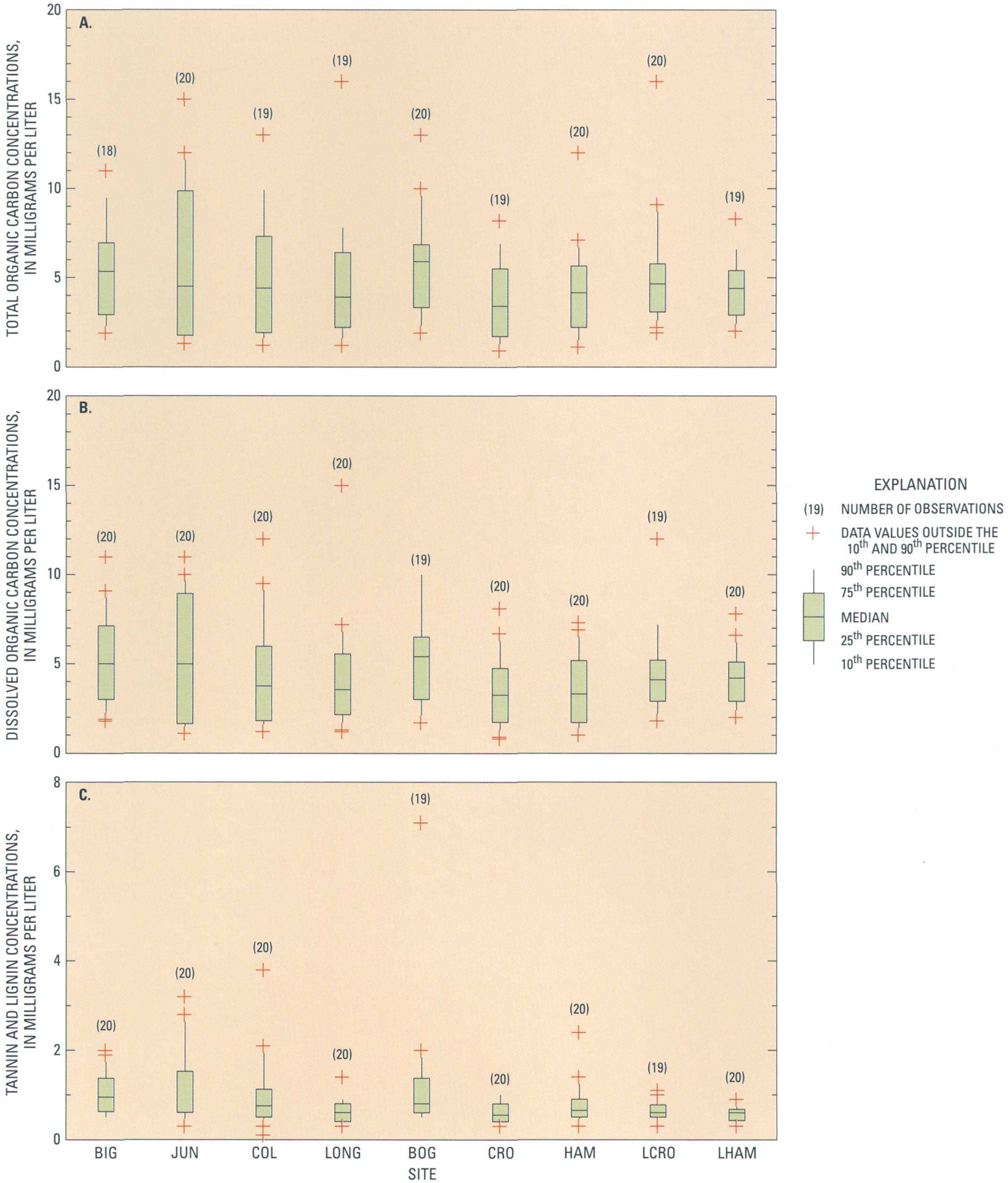


Figure 28. Boxplots of total organic carbon, dissolved organic carbon, and tannin and lignin concentrations at selected sites in the Converse Lake watershed, 1996–98.

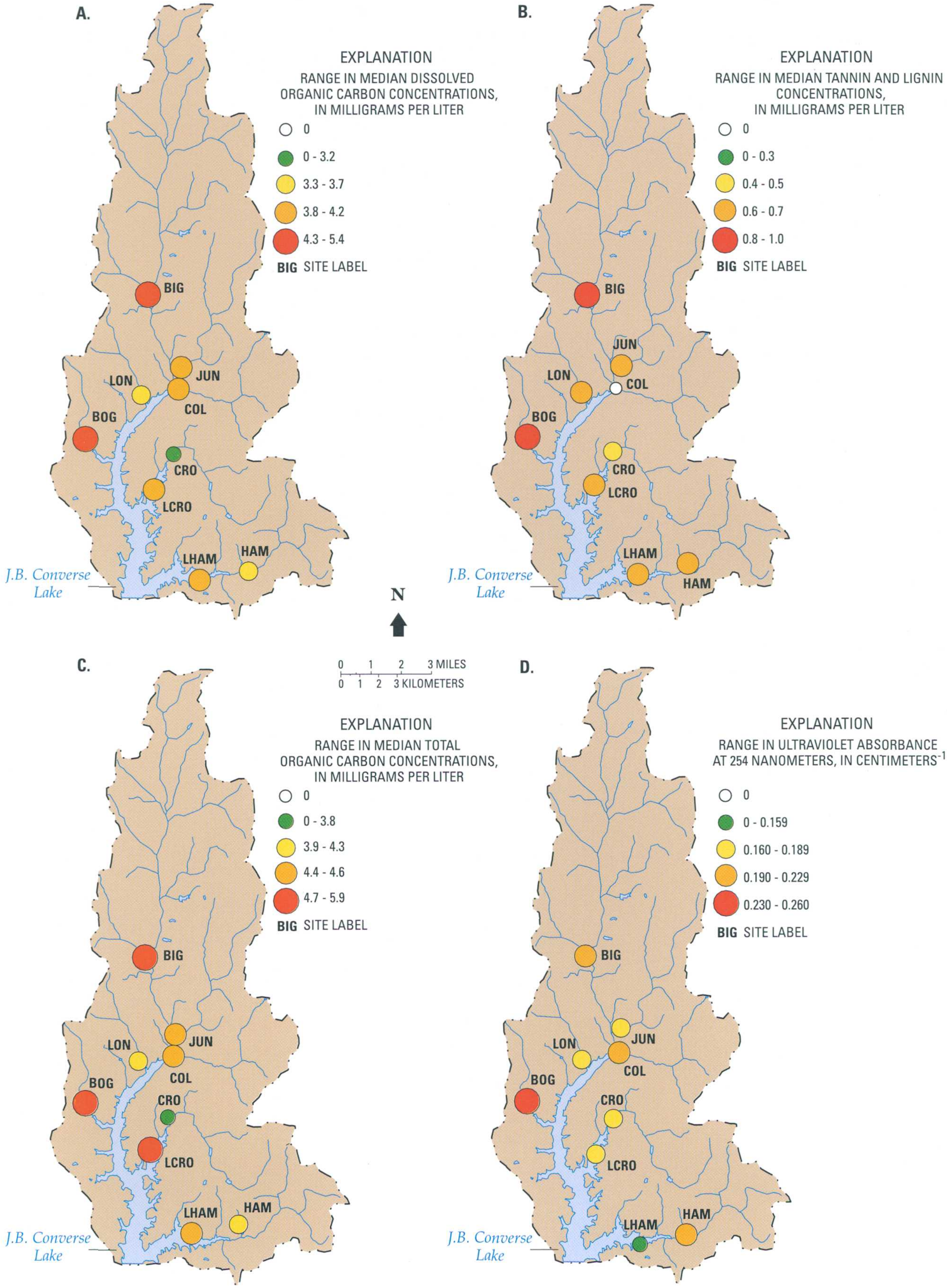


Figure 29. Range in median concentrations of dissolved organic carbon, tannin and lignin, total organic carbon, and ultraviolet absorbance at 254 nanometers in the Converse Lake watershed, 1996–98.

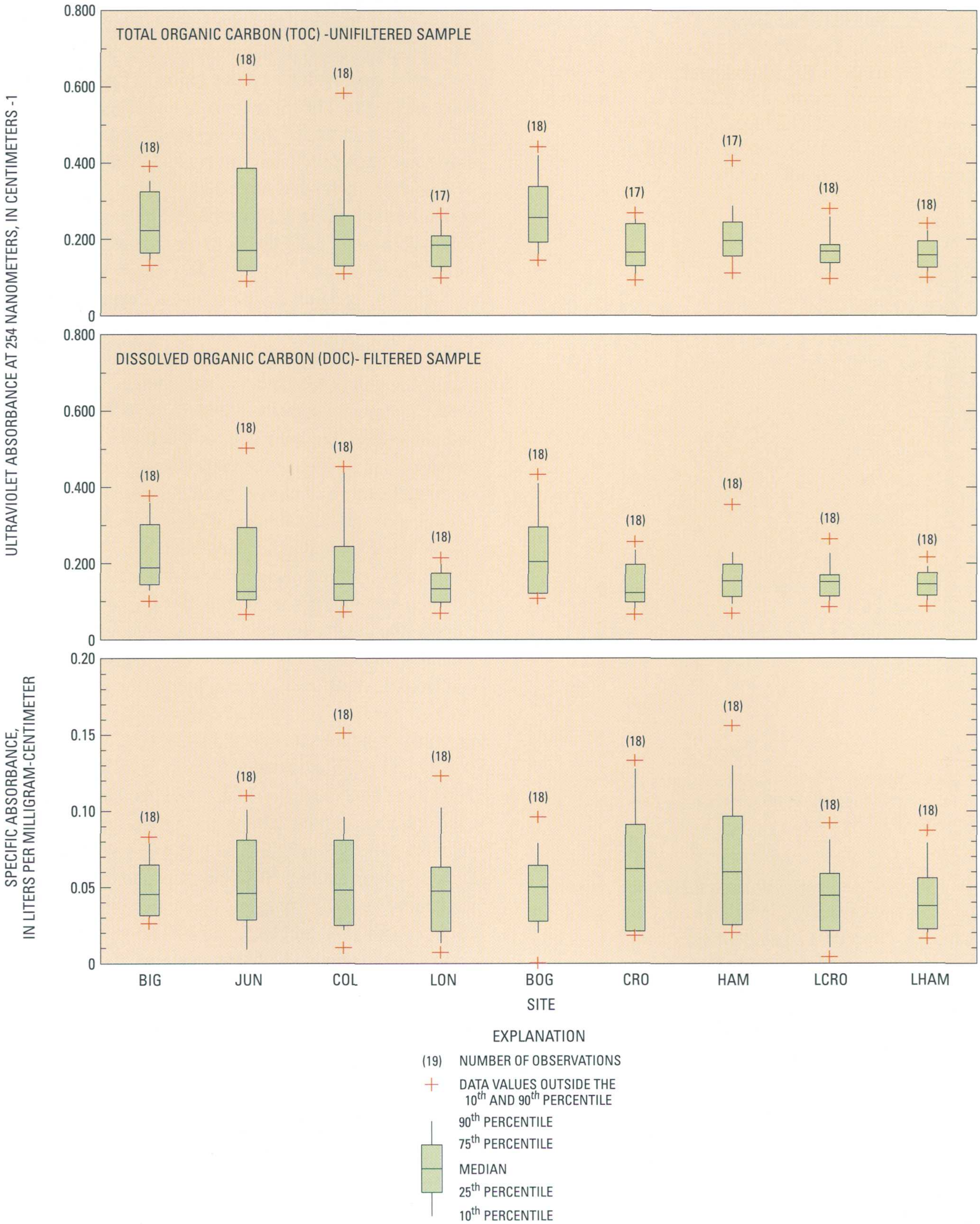


Figure 30. Boxplots of ultraviolet absorbance at 254 nanometers for unfiltered (TOC) and filtered (DOC) samples and specific absorbance at selected sites in the Converse Lake watershed, 1996–98.

Big Creek (fig. 31). The median THM-FP concentration of five samples was 644 µg/L in Big Creek, 322 µg/L in Hamilton Creek, 318 µg/L in the lake at the pump station, and 277 µg/L in Crooked Creek (appendix 1). The highest THM-FP concentrations at all sites were found during or immediately after runoff events.

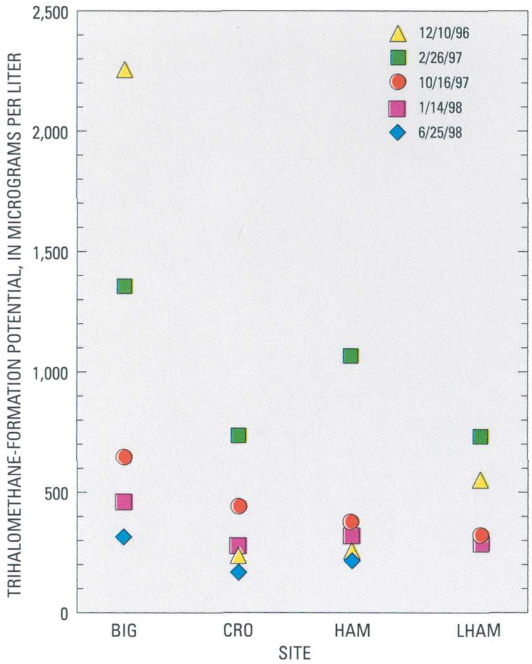


Figure 31. Range in trihalomethane-formation potential for selected tributary and lake sites in the Converse Lake watershed, 1996–98.

Previous investigations in California reported ranges in UVA from 0.255 to 1.33 cm^{-1} for agricultural drains and from 0.043 and 0.148 cm^{-1} for lakes and rivers (Amy and others, 1990; Krasner and others, 1994). In these same investigations, SUVA ranged from 0.038 to 0.060 cm^{-1}/mg/L for agricultural drains and from 0.017 to 0.034 cm^{-1}/mg/L for lakes and rivers. In the Converse Lake study, UVA and SUVA values at the lake sites, especially at the pump station, were within the same range as those values found in the California lakes and rivers. The tributary sites had UVA and SUVA values that overlapped the lower range for agricultural drains and the upper range for rivers in California. THM-FP levels ranged from 239 to 4,526 µg/L in agricultural drains in California, and from 144 to 360 µg/L in rivers and lakes. In the Converse Lake study, the levels of THM-FP in Big Creek were within the range for agricultural drains in California; the other Converse Lake study sites had THM-FP levels that overlapped the two ranges.

The computed land-use percentages from 1992 MRLC data were correlated with median TOC, UVA, and tannin and lignin concentrations for each tributary subbasin. The degree of correlation was used to identify whether the more reactive organic carbon was related to natural (forested) conditions or anthropogenic influences in the watershed (fig. 32; table 24). Negative correlation coefficients indicated an inverse relation between land-use percentages and reactive organic carbon (the greater the land-use percentages in a subbasin, the less reactive the organic carbon); positive coefficients signified a direct relation (the greater the land-use percentages, the more reactive the organic carbon). Deciduous forests had a statistically significant positive correlation (p-value < 0.05) to DOC (0.8829), TOC (0.8571), and UVA-TOC (0.8214). Unlike the California agricultural drains, the agricultural land-use categories of row crop, and pasture and hay showed no significant correlation. High-intensity and low-intensity residential land-use categories were negatively correlated to TOC and DOC but had no significant correlation to tannin and lignin or UVA. These findings suggest that forested land contributed more reactive organic carbon to the watershed than land influenced by agricultural and residential activities.

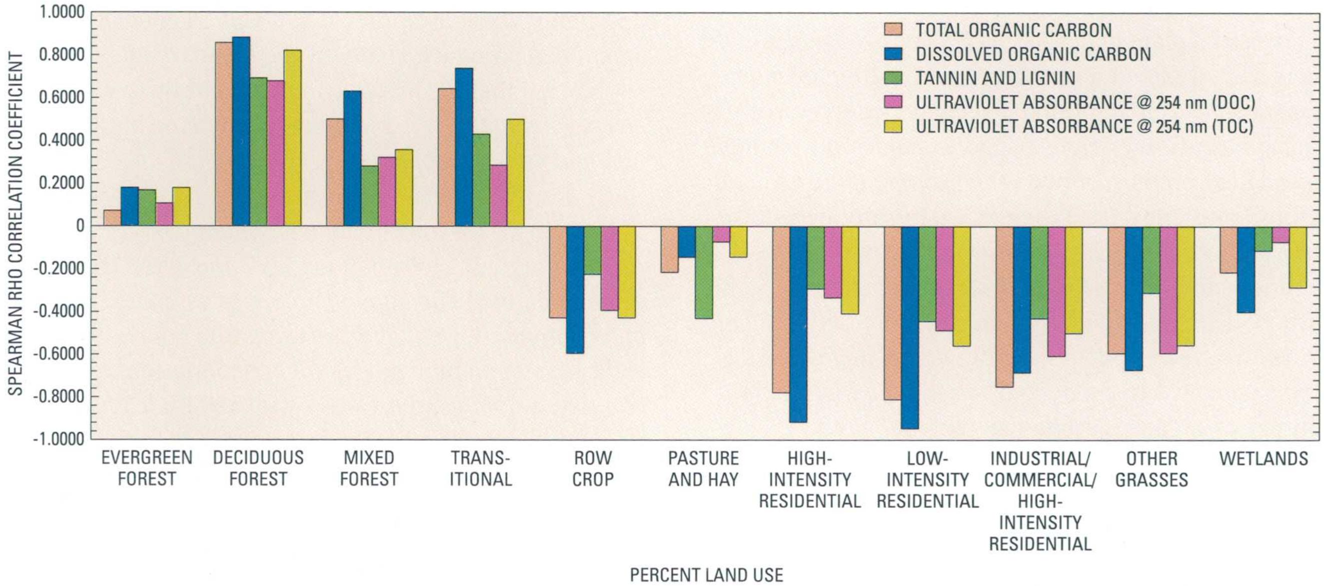


Figure 32. Correlation between percent land-use categories and median concentrations of total organic carbon, dissolved organic carbon, tannin and lignin, and ultraviolet absorbance at 254 nanometers in the Converse Lake watershed, 1996–98.

Table 24. Spearman rho correlation coefficients for land-use categories and median levels of total organic carbon, dissolved organic carbon, tannin and lignin, and ultraviolet absorbance at 254 nanometers in the Converse Lake watershed

[Coefficients with statistically significant relations are bold (*p*-value < 0.05). MRLC, multi-resolution land characteristic]

MRLC land-use category	Total organic carbon	Dissolved organic carbon	Tannin and lignin	Ultraviolet absorbance at 254 nanometers (dissolved)	Ultraviolet absorbance at 254 nanometers (total)
Evergreen forest	0.0714	0.1802	0.1684	0.1071	0.1786
Deciduous forest	**0.8571**	**0.8829**	0.6924	0.6786	**0.8214**
Mixed forest	0.5000	0.6307	0.2807	0.3214	0.3571
Transitional	0.6429	0.7388	0.4304	0.2857	0.5000
Row crops	-0.4286	-0.5946	-0.2245	-0.3929	-0.4286
Pasture and hay	-0.2143	-0.1442	-0.4304	-0.0714	-0.1429
High-intensity residential	**-0.7783**	**-0.9163**	-0.2912	-0.3336	-0.4077
Low-intensity residential	**-0.8108**	**-0.9455**	-0.4437	-0.4865	-0.5586
Industrial/commercial/high-intensity residential	-0.7500	-0.6847	-0.4304	-0.6071	-0.5000
Other grasses	-0.5930	-0.6732	-0.3107	-0.5930	-0.5559
Wetlands	-0.2143	-0.4000	-0.1123	-0.0714	-0.2857

Sources of Reactive Organic Carbon

Tannin and lignin, derived from the breakdown of terrestrial plant material (leaves and crops), can enter lakes and streams by runoff or soil flushing during storm events or by continual seepage from the soil during base-flow periods. These organic compounds have a high amount of phenolic groups (more aromatic carbon) and, thus, tend to produce by-products during chlorination. Decaying organic matter in the lake sediment and algal growth also can contribute organic carbon. The organic compounds that are derived from algae have fewer phenolic groups and, therefore, a lower tendency to produce by-products. Manmade sources of organic carbon can include human wastewater (septic-tank effluent), livestock wastes, and cropland. These organic carbon compounds can vary in their tendencies to produce by-products.

At the tributary and lake sites, Spearman rho correlation coefficients were computed for UVA-TOC, UVA-DOC, specific absorbance, streamflow, TOC, DOC, tannin and lignin, pH, acid-neutralizing capacity, and water temperature (estimate of season) to determine the interrelations, if any, among these constituents (table 25). At all tributary sites, the strongest correlation was between UVA-TOC (selected as the best surrogate for trihalomethane-formation potential) and tannin and lignin, indicating a terrestrial source for the most reactive organic carbon. This correlation was statistically significant (p-value < 0.05) for Big Creek (1.000), Juniper Creek (0.955), Boggy Branch (0.926), Crooked Creek (0.886), and Hamilton Creek (0.975). Statistically significant correlations (p-value < 0.05) also occurred between tannin and lignin and TOC and DOC, respectively, at Juniper Creek (0.941, 0.941), Boggy Branch (0.940, 0.926), Crooked Creek (0.943, 0.886), and Hamilton Creek (0.947, 0.975; table 25), indicating that the major source of all organic carbon compounds in these streams was terrestrial. No statistically significant correlation was found between streamflow and tannin and lignin concentrations, UVA-TOC, UVA-DOC, or specific absorbance at any of the tributary sites, suggesting that the reactive organic carbon reaches the streams from the soil and litter zone during both runoff and base-flow seepage.

For the lake sites, Spearman rho correlations were used to determine whether the major source of the reactive organic carbon in the lake was terrestrial or algal in nature. The algal source was estimated by chlorophyll *a* levels, and the terrestrial source was estimated by tannin and lignin concentrations. The reactive organic carbon was estimated by UVA-TOC, which was identified as the best surrogate for THM-FP, and UVA-DOC. An extremely strong, positive, statistically significant correlation (p-value < 0.01) was found between chlorophyll *a*, TOC, and DOC (1.000; table 25), indicating that the major source of organic carbon in the lake was algae. The correlations, however, between UVA-TOC, UVA-DOC, chlorophyll *a*, TOC, and DOC were not statistically significant. UVA-TOC had the strongest correlation with tannin and lignin concentrations (0.949), indicating a terrestrial source for the most reactive organic carbon.

In summary, naturally occurring, terrestrial organic carbon compounds from decaying organic material such as fallen leaves were the major source of reactive organic carbon in the Converse Lake watershed. In the lake, algae was considered the major source of organic carbon as indicated by strong, positive, statistically significant correlations among chlorophyll *a*, TOC, and DOC. The algal-derived organic carbon, however, was not considered the major source of the reactive organic carbon as indicated by the absence of significant statistical correlations among chlorophyll *a*, TOC, DOC, and UVA (the surrogate used to represent THM-FP).

Table 25. Spearman rho correlation matrix for selected constituents in seven tributary sites and one lake site in the Converse Lake watershed

[ANC, acid-neutralizing capacity; TOC, total organic carbon; DOC, dissolved organic carbon, UVA_{TOC}, ultraviolet absorbance of TOC at 254 nanometers; UVA_{DOC}, ultraviolet absorbance of DOC at 254 nanometers; —, no data. Values in bold represent statistically significant correlations (p-value < 0.05)]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

Constituent	Streamflow	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Streamflow	1.000									
pH	-0.447	1.000								
Acid-neutralizing capacity (ANC)	-0.211	0.825	1.000							
Water temperature	0.300	0.224	0.527	1.000						
Tannin and lignin	0.500	-0.224	0.158	**0.900**	1.000					
Total organic carbon (TOC)	0.100	-0.447	-0.211	0.600	0.800	1.000				
Dissolved organic carbon (DOC)	0.100	-0.447	-0.211	0.600	0.800	**1.00**	1.000			
UVA-254$_{TOC}$	0.500	-0.224	0.158	**0.900**	**1.00**	0.800	0.800	1.000		
UVA-254 $_{DOC}$	0.800	-0.224	0.158	0.800	**0.900**	0.500	0.500	**0.900**	1.000	
Specific absorbance	0.300	0.224	0.000	-0.500	-0.600	**-0.900**	**-0.900**	-0.600	-0.200	1.000

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

Constituent	Streamflow	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Streamflow	1.000									
pH	0.572	1.000								
Acid-neutralizing capacity (ANC)	-0.319	0.086	1.000							
Water temperature	-0.725	-0.235	0.235	1.000						
Tannin and lignin	0.334	0.154	-0.770	-.137	1.000					
Total organic carbon (TOC)	0.086	0.058	**-0.812**	0.232	**0.941**	1.000				
Dissolved organic carbon (DOC)	0.086	0.058	**-0.812**	0.232	**0.941**	**1.000**	1.000			
UVA-254$_{TOC}$	0.465	0.279	-0.588	-0.147	**0.955**	**0.812**	**0.812**	1.000		
UVA-254 $_{DOC}$	0.371	0.319	-0.522	0.232	**0.941**	**0.829**	**0.829**	**0.986**	1.000	
Specific absorbance	-0.143	0.406	**-0.841**	0.203	-0.638	-0.714	-0.714	-0.464	-0.429	1.000

Table 25. Spearman rho correlation matrix for selected constituents in selected sites, Converse Lake watershed—Continued

[ANC, acid-neutralizing capacity; TOC, total organic carbon; DOC, dissolved organic carbon, UVA_{TOC}, ultraviolet absorbance of TOC at 254 nanometers; UVA_{DOC}, ultraviolet absorbance of DOC at 254 nanometers; —, no data. Values in bold represent statistically significant correlations (*p*-value < 0.05)]

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

Constituent	Streamflow	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Streamflow	1.000									
pH	-0.058	1.000								
Acid-neutralizing capacity (ANC)	0.412	0.806	1.000							
Water temperature	-0.638	-0.074	-0.254	1.000						
Tannin and lignin	0.464	-0.470	-0.119	0.279	1.000					
Total organic carbon (TOC)	0.086	**-0.812**	-0.706	0.377	0.754	1.000				
Dissolved organic carbon (DOC)	-0.086	**-0.812**	-0.706	0.522	0.754	**0.943**	1.000			
UVA-254$_{TOC}$	0.200	0.260	0.412	0.406	0.667	0.143	0.257	1.000		
UVA-254 $_{DOC}$	0.371	0.319	0.618	0.232	0.667	-0.029	0.086	0.943	1.000	
Specific absorbance	—	—	—	—	—	—	—	—	—	—

Long Branch near Wilmer, 02479955 (site LON)

Constituent	Streamflow	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Streamflow	1.000									
pH	-0.105	1.000								
Acid-neutralizing capacity (ANC)	-0.632	0.833	1.000							
Water temperature	-0.400	-0.211	-0.316	1.000						
Tannin and lignin	0.258	0.272	0	0.775	1.000					
Total organic carbon (TOC)	0	-0.316	-0.316	0.800	0.774	1.000				
Dissolved organic carbon (DOC)	0	-0.316	-0.316	0.800	0.775	**1.000**	1.000			
UVA-254$_{TOC}$	-0.200	0.738	0.632	0.800	0.774	0.400	0.400	1.000		
UVA-254 $_{DOC}$	-0.400	0.211	0.316	**1.000**	0.774	0.800	0.800	0.769	1.000	
Specific absorbance	—	—	—	—	—	—	—	—	—	—

Table 25. Spearman rho correlation matrix for selected constituents in selected sites, Converse Lake watershed—Continued

[ANC, acid-neutralizing capacity; TOC, total organic carbon; DOC, dissolved organic carbon, UVA_{TOC}, ultraviolet absorbance of TOC at 254 nanometers; UVA_{DOC}, ultraviolet absorbance of DOC at 254 nanometers; —, no data. Values in bold represent statistically significant correlations (*p*-value < 0.05)]

Boggy Branch near Wilmer, 02479960 (site BOG)

Constituent	Streamflow	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Streamflow	1.000									
pH	-0.377	1.000								
Acid-neutralizing capacity (ANC)	**-0.882**	0.667	1.000							
Water temperature	-0.348	-0.143	0.058	1.000						
Tannin and lignin	0.250	-0.772	-0.548	0.648	1.000					
Total organic carbon (TOC)	0.500	**-0.841**	-0.750	0.377	**0.940**	1.000				
Dissolved organic carbon (DOC)	0.522	-0.771	-0.783	0.423	**0.926**	**0.986**	1.000			
$UVA\text{-}254_{TOC}$	0.203	-0.486	-0.406	0.771	**0.926**	0.812	0.829	1.000		
$UVA\text{-}254_{DOC}$	0.377	-0.145	-0.319	0.543	**0.617**	0.522	0.543	**0.829**	1.000	
Specific absorbance	-0.116	0.657	0.493	-0.314	-0.679	**-0.754**	**-0.771**	-0.486	0.029	1.000

Crooked Creek near Fairview, 02479980 (site CRO)

Constituent	Streamflow	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Streamflow	1.000									
pH	0.145	1.000								
Acid-neutralizing capacity (ANC)	0.334	0.616	1.000							
Water temperature	-0.314	-0.058	0.516	1.000						
Tannin and lignin	0.486	-0.290	0.455	0.543	1.000					
Total organic carbon (TOC)	0.429	-0.493	0.152	0.429	**0.943**	1.000				
Dissolved organic carbon (DOC)	0.371	-0.667	0.030	0.314	**0.886**	**0.943**	1.000			
$UVA\text{-}254_{TOC}$	0.429	0.029	0.759	0.714	**0.886**	0.714	0.600	1.000		
$UVA\text{-}254_{DOC}$	0.543	0.116	**0.0820**	0.543	0.771	0.543	0.486	**0.943**	1.000	
Specific absorbance	-0.200	0.522	0.152	-0.086	-0.657	-0.771	**-0.829**	-0.257	-0.086	1.000

Table 25. Spearman rho correlation matrix for selected constituents in selected sites, Converse Lake watershed—Continued

[ANC, acid-neutralizing capacity; TOC, total organic carbon; DOC, dissolved organic carbon, UVA_{TOC}, ultraviolet absorbance of TOC at 254 nanometers; UVA_{DOC}, ultraviolet absorbance of DOC at 254 nanometers; —, no data. Values in bold represent statistically significant correlations (*p*-value < 0.05)]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

Constituent	Streamflow	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Streamflow	**1.000**									
pH	0.433	1.000								
Acid-neutralizing capacity (ANC)	-0.526	0.406	1.000							
Water temperature	-0.667	0.211	**0.975**	1.000						
Tannin and lignin	-0.553	-0.351	0.237	0.410	1.000					
Total organic carbon (TOC)	-0.395	-0.054	0.289	0.410	**0.947**	1.000				
Dissolved organic carbon (DOC)	-0.462	-0.158	0.359	0.500	**0.975**	**0.975**	1.000			
$UVA\text{-}254_{TOC}$	-0.462	-0.158	0.359	0.500	**0.975**	**0.975**	**1.00**	1.000		
$UVA\text{-}254_{DOC}$	-0.403	0.264	0.359	0.400	0.667	0.821	0.700	0.700	1.000	
Specific absorbance	0.616	0.527	-0.103	-0.300	**-0.975**	**-0.872**	**-0.900**	**-0.900**	-0.600	1.000

Hamilton Creek (Big Creek Lake intake) near Semmes, 02480004 (site LHAM)

Constituent	Chlorophyll *a*	pH	ANC	Water temperature	Tannin and lignin	TOC	DOC	UVA_{TOC}	UVA_{DOC}	Specific absorbance
Chlorophyll *a*	1.000									
pH	**-1.000**	1.000								
Acid-neutralizing capacity (ANC)	-0.258	0.258	1.000							
Water temperature	0.400	-0.400	0.775	1.000						
Tannin and lignin	-0.316	0.316	0.574	0.211	1.000					
Total organic carbon (TOC)	**1.000**	**-1.00**	-0.258	0.400	-0.316	1.000				
Dissolved organic carbon (DOC)	**1.000**	**-1.00**	-0.258	0.400	-0.316	**1.000**	1.000			
$UVA\text{-}254_{TOC}$	-0.400	0.400	0.775	0.400	**0.949**	-0.400	-0.400	1.000		
$UVA\text{-}254_{DOC}$	-0.400	0.400	0.775	0.400	**0.949**	-0.400	-0.400	0.800	1.000	
Specific absorbance	-0.800	0.800	0.775	0.200	0.632	-0.800	-0.800	-0.400	-0.400	1.000

SUMMARY AND CONCLUSIONS

J.B. Converse (Converse) Lake is a 3,600-acre, tributary-storage reservoir in southwestern Alabama. The 103-mi^2 watershed is located in Mobile County west of the city of Mobile near the Alabama-Mississippi State line. The lake is designated for aquatic-life and public-water supply use by the ADEM.

The climate in the Converse Lake watershed is subtropical. The mean annual precipitation for the Mobile area is 64 in.; the mean annual temperature is 67.5 °F. The study area lies within a single district of the Coastal Plain Physiographic Province—the Southern Pine Hills District of the East Gulf Coastal Plain Physiographic section. Two geologic units of Tertiary age, the Miocene Series undifferentiated and the Citronelle Formation of Pliocene age, underlie the watershed and consist of semiconsolidated to unconsolidated sand, silt, gravel, and clay. These units dip and thicken to the southwest.

Converse Lake receives inflow from seven major tributaries that drain about three-fourths of the total watershed; three of the tributaries are monitored by streamflow gages. Big Creek, Crooked Creek, and Hamilton Creek had mean annual streamflows of 72.2, 19.4, and 25.0 ft^3/s, respectively, for the period 1990 to 1998. Hamilton Creek subbasin had the greatest streamflow yield of 3.04 $(ft^3/s)/mi^2$; Crooked and Big Creeks had yields of 2.40 and 2.29 $(ft^3/s)/mi^2$, respectively. Hamilton Creek had better sustained flows and contributed increasingly greater percentages of the total inflow to the lake during low-flow periods, until it equaled or slightly exceeded the streamflow yield at Big Creek.

The Converse Lake watershed is forested and rural. Forests cover over 64 percent of the watershed; agricultural use accounts for about 31 percent of the watershed. Residential and commercial development account for only 1 percent of the total land use in the watershed. The Big Creek subbasin is covered by forested land with some agricultural land. The Crooked Creek subbasin has the greatest percentage of agricultural land use (42 percent) in the watershed, consisting mostly of plant nurseries. The percentage of residential area (3.4 percent) in the Crooked Creek subbasin is second only to the amount of residential land use in the Hamilton Creek subbasin (3.9 percent). Point sources in the watershed consist of two hazardous- and solid-waste sites and two permitted compliance system sites; no waste or by-product releases (to air, water, or ground water) were reported during the study period.

Waters in Converse Lake and its tributaries have low pH and low specific conductance values, which is typical of waters in humid climates that drain highly resistant sands and gravels. Although all sites in the Converse Lake watershed had pH levels that periodically fell below the ADEM criterion of 6, Big Creek and Boggy Branch had median pH values of 5.6 and 5.9, respectively. Statistical correlations indicated that the greater the amount of commercial, industrial, and residential development (human influences), the greater the tendency for the streamwater to have a more neutral median pH and a greater capacity to neutralize acid. This correlation, in conjunction with the environmental factors of resistant rock types and acidic soil in the watershed, provide a strong indication that low pH and low ANCs are natural in origin, and not anthropogenic. The median specific conductance ranged from 23 (Collins Creek) to 43 µS/cm (Long Branch) for the study period.

All tributary sites in the Converse Lake watershed had minimum dissolved-oxygen concentrations above the ADEM criteria of 5 mg/L except for Boggy Branch, which had a minimum dissolved-oxygen concentration of 3.7 mg/L. Median dissolved-oxygen concentrations ranged from 6.9 (Boggy Branch) to 8.6 mg/L (Juniper Creek and Long Branch) for the study period. Converse Lake becomes stratified during August and September when dissolved-oxygen levels typically fall below 1 mg/L at depths greater than 20 ft.

No substantial differences were observed in water chemistry among tributary sites. Big Creek had a relatively high nitrate component, especially during base-flow periods, suggesting a ground-water source. Increases in calcium and bicarbonate concentrations in Crooked Creek and Hamilton Creek during high streamflow periods suggested a runoff or soil-zone flushing source. Converse Lake and its tributaries had median total iron concentrations that exceeded the ADEM secondary standard for drinking water of 300 µg/L; only Boggy Branch had median total manganese concentrations that exceeded the secondary standard of 50 µg/L.

Total nitrogen (with the exception of Long Branch), total Kjeldahl nitrogen (with the exception of Hamilton Creek), total organic nitrogen (with the exception of Boggy Branch), ammonia (with the exception of Long Branch), total inorganic nitrogen, and total phosphorus (with the exception of Long and Boggy Branches) exhibited a significant, positive relation with streamflow, which indicates the dominant source of nutrient input to the watershed is from nonpoint sources.

In comparison to published values, the computed total phosphorus yields for Big Creek, Collins Creek, Long Branch, and Boggy Branch were within the expected range of forested land that had minor agriculture (pasture, crops, mixed agriculture). Total phosphorus yields were higher in the Crooked and Hamilton Creek subbasins (0.52 and 0.40 (kg/ha)/yr, respectively) compared to the other tributary subbasins, probably as a result of higher percentages of residential and nonrow crop (plant nurseries) land use in these subbasins. Juniper Creek subbasin had a similar total phosphorus yield of 0.45 (kg/ha)/yr present but little to no residential influence. The total nitrogen yields at the tributary sites also fell within the published ranges for forest, agriculture (pasture, nonrow crops), and urban land uses.

For the 1991 water year, the total phosphorus yields ranged from 0.10 (Long Branch) to 0.52 (kg/ha)/yr (Crooked Creek); total nitrogen yields ranged from 3.83 (Collins Creek) to 8.45 (kg/ha)/yr (Big Creek). The nutrient loads at Big Creek, Crooked Creek, and Hamilton Creek accounted for over 70 percent of the total load in the watershed. Big Creek had the highest nutrient loads, accounting for almost 60 percent of the total nitrogen and total Kjeldahl nitrogen, 47 percent of the total inorganic nitrogen, and 36 percent of total phosphorus loads. Crooked and Juniper Creeks each contributed 21 percent of the total phosphorus load in 1991; Hamilton Creek contributed about 16 percent of the total phosphorus load. Total phosphorus yields from Crooked, Juniper, and Hamilton Creek subbasins were 2 to 5 times those of the other tributary subbasins.

During the study period, annual nutrient loads and yields were highest for the 1991 and 1998 water years and lowest for the 1992 and 1994 water years (with the exception of total inorganic nitrogen in 1995). A combined mean annual load of 75,400 kg of total nitrogen, 36,950 kg of total Kjeldahl nitrogen, 28,870 kg of total inorganic nitrogen, and 3,480 kg of total phosphorus were contributed to the lake by Big Creek, Hamilton Creek, and Crooked Creek. Of the combined loads, 62 percent of the total nitrogen, 81 percent of the total Kjeldahl nitrogen, 54 percent of the total inorganic nitrogen, and 47 percent of the total phosphorus originated from the forested subbasin of Big Creek. The more residential and agricultural subbasins of Crooked Creek and Hamilton Creek, however, yielded over twice the total phosphorus per hectare of land use. Crooked and Hamilton Creek subbasins also had higher total inorganic nitrogen yields. The mean annual nutrient yields were averaged to obtain a watershed yield for each nutrient species—0.0933 (kg/ha)/yr of orthophosphate, 0.358 (kg/ha)/yr of total phosphorus, 2.72 (kg/ha)/yr of total inorganic nitrogen, 0.0035 (kg/ha)/yr of total ammonia, 3.20 (kg/ha)/yr of total Kjeldahl nitrogen, and 6.46 (kg/ha)/yr of total nitrogen.

The trend analysis detected little or no change in nutrient concentrations at the tributary and lake sites in the Converse Lake watershed for the 1991 to 1998 water years. A complex relation seemed to exist between annual nutrient contributions to Converse Lake from the tributaries, and the lake's ability to assimilate these contributions by biomass uptake, sedimentation, and outflow. The lack-of-fit of the estimated in-lake phosphorus concentration from a simple input-output empirical model to the observed value in Converse Lake accentuated the need for a more robust model of lake water quality and trophic response.

Monitoring in the Converse Lake watershed showed that some tributaries to the lake had fecal bacterial concentrations that were above the ADEM criteria for whole-body contact uses. Bacterial concentrations at lake sites at the mouth of Crooked Creek and Hamilton Creek at the pump station were well below ADEM criteria levels. Elevated bacterial concentrations in the tributaries did not appear to cause elevated levels in the lake.

Juniper Creek had the highest geometric mean concentrations for all bacteria types during the study. Trend analysis indicated that flow-adjusted fecal streptococcus concentrations increased at Juniper Creek during the 8 years of data collection. The increasing trend in bacteria is cause for concern because the median fecal bacteria levels in Juniper Creek for 1990–98 were above the ADEM whole-body criteria levels.

There were few detections of *Giardia* and *Cryptosporidium* at sites in the lake and in the raw-water intake during the monitoring effort. The low number of detections made it difficult to arrive at any conclusions about actual cyst concentrations in the water supply. Most of the detections occurred during the summer, but so few cysts were detected that it is not clear if there is a seasonal influence on cyst density.

In the Converse Lake watershed, naturally occurring, terrestrial organic carbon compounds derived from decaying organic material, such as fallen leaves, were the major source of reactive organic carbon, which tends to form trihalomethanes in the presence of chlorine. In the lake, algae was considered the major source of organic carbon as indicated by strong, positive, statistically significant correlations among chlorophyll *a*, TOC, and DOC. The algal-derived organic carbon, however, was not considered a major source of the reactive organic carbon as indicated by the absence of significant statistical correlations between chlorophyll *a*, TOC, DOC, and UVA (the surrogate used to represent THM-FP).

In conclusion, water quality in Converse Lake and its tributaries meets the criteria mandated by the ADEM and the Clean Water Act, which require that all waters be "fishable and swimmable." The exceptions include natural acidic pH levels, iron and manganese levels above secondary or aesthetic criteria, and fecal bacterial levels in some tributaries above "swimmable" criteria. Water-management concerns also include potential sources of reactive organic carbon that form trihalomethanes when raw water is chlorinated, and excessive nutrient loads to the lake that can produce borderline mesotrophic/eutrophic conditions.

Results of this study have long-range watershed management implications. Though the low pH levels seem to be naturally occurring, future changes in land use could lower pH levels even more, especially since the soils have very little acid-neutralizing capacity. Identification of fecal bacterial sources, and implementation and evaluation of best-management practices, may be considered to prevent bacterial contamination in the lake. The major source of reactive organic carbon was determined to be from the decay of plant material from land rather than from in-lake algal production. The trophic state of the lake seems to be moving toward a more eutrophic state; however, the changes are not fully explained by nutrient contributions from the tributaries to the lake. A better understanding of the major factors affecting the trophic state of the lake is needed.

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Appendixes

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00061	Discharge, instantaneous (ft^3/s)	82	1,050	15	79	224	81	48	30	18
00095	Specific conductance (µS/cm at 25 °C)	80	49	19	25	30	26	24	23	21
00400	Field pH, whole water (standard unit)	62	6.6	4.5	5.6	6.2	5.9	5.6	5.2	4.8
00020	Air temperature (°C)	58	34.1	5.0	22.3	33.0	28.8	23.0	15.9	6.6
00010	Water temperature (°C)	81	30.0	7.8	17.9	24.3	22.6	17.5	13.8	10.2
00025	Air pressure (mm of Hg)	64	772	750	760	767	763	760	758	750
00300	Dissolved oxygen (mg/L)	60	11	6	8	10	9	8	7	6
00301	Dissolved oxygen (percent of saturation)	59	96	63	83	92	89	84	77	68
31625	Fecal coliform (col/100 mL)	58	6,000	20	468	2,095	263	125	69	36
31673	Fecal streptococcus (col/100 mL)	60	9,000	11	652	2,465	703	240	115	19
31633	*Escherichia coli* (col/100 mL)	19	1,900	19	435	1,900	400	190	120	19
00900	Hardness, total (mg/L as $CaCO_3$)	31	7.0	4.0	5.2	7.0	6.0	5.0	5.0	4.0
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	24	5.0	1.0	3.4	5.0	4.0	4.0	3.0	1.0
00915	Calcium, dissolved (mg/L as Ca)	32	1.1	0.6	0.8	1.1	1.0	0.8	0.7	0.7
00925	Magnesium, dissolved (mg/L as Mg)	32	1.0	0.5	0.7	1.0	0.8	0.7	0.7	0.5
00930	Sodium, dissolved (mg/L as Na)	32	2.3	1.1	1.8	2.2	2.0	1.9	1.7	1.4
00935	Potassium, dissolved (mg/L as K)	32	0.9	0.3	0.5	0.8	0.6	0.4	0.3	0.3
00452	Carbonate, dissolved (mg/L as CO_3)	60	0.0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	60	5.0	0.0	1.9	5.0	3.0	2.0	1.0	0.0
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	60	4	0	2	4	2	2	1	0
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	60	5.0	0.0	2.7	5.0	3.0	3.0	2.0	1.0
00945	Sulfate, dissolved (mg/L as SO_4)	32	2.1	0.4	1.1	2.0	1.7	1.1	0.5	0.5

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	42	10.0	2.2	3.8	5.2	4.0	3.6	3.4	2.6
00950	Fluoride, dissolved (mg/L as F)	32	<0.100	<0.100	--	<0.100	<0.100	<0.100	<0.100	<0.100
71870	Bromide, dissolved (mg/L as Br)	15	<0.05	<0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05
00955	Silica, dissolved (mg/L as SiO_2)	32	8.5	3.7	6.1	7.7	6.8	6.1	5.5	4.2
70300	Total dissolved solids, residue at 180 °C (mg/L)	32	72.0	10.0	26.0	53.2	30.8	24.5	18.5	11.3
70301	Total dissolved solids (mg/L)	29	24.0	15.0	18.1	23.0	19.0	18.0	16.0	15.0
80154	Suspended sediment concentration (mg/L)	15	25.0	4.0	11.3	25.0	19.0	7.0	7.0	4.0
00615	Nitrite, total (mg/L as N)	48	0.01	<0.01	0.010*	0.01	<0.01	<0.01	<0.01	<0.01
00613	Nitrite, dissolved (mg/L as N)	34	0.01	<0.01	--	0.01	<0.01	<0.01	<0.01	<0.01
00620	Nitrate, total (mg/L as N)	10	0.55	0.16	0.30	0.55	0.40	0.25	0.18	0.16
00630	Nitrite plus nitrate, total (mg/L as N)	48	0.70	0.10	0.38	0.66	0.50	0.37	0.23	0.10
00631	Nitrite plus nitrate, dissolved (mg/L as N)	48	0.70	0.02	0.38	0.66	0.51	0.36	0.26	0.05
00610	Ammonia, total (mg/L as N)	47	0.08	<0.010	0.03*	0.05	*0.04	*0.03	*0.02	<0.02
00608	Ammonia, dissolved (mg/L as N)	32	0.09	0.01	0.04	0.08	0.04	0.04	0.02	0.01
00605	Organic nitrogen, total (mg/L as N)	36	0.72	0.15	0.31	0.58	0.39	0.29	0.21	0.17
00600	Nitrogen, total (mg/L as N)	37	1.10	0.45	0.73	0.97	0.84	0.71	0.61	0.45
00625	Ammonia plus organic nitrogen, total (mg/L as N)	48	0.74	<0.200	0.32*	0.56	*0.36	*0.30	*0.21	<0.200
00665	Phosphorus, total (mg/L as P)	48	0.080	<0.01	0.021*	0.050	0.030	0.010	<0.020	<0.01
00666	Phosphorus, dissolved (mg/L as P)	47	0.070	<0.01	0.015*	*0.050	*0.020	<0.02	<0.02	<0.01
00671	Phosphorus, ortho (mg/L as P)	47	0.010	<0.01	0.010*	*0.010	*0.010	<0.01	<0.01	<0.01
01020	Boron, dissolved (µg/L as B)	32	48	<9	*10	36	6	<20	<20	<10
01045	Iron, total (µg/L as Fe)	32	1,200	60	439	1,025	608	390	203	119
01046	Iron, dissolved (µg/L as Fe)	32	560	50	215	534	278	195	113	70
01055	Manganese, total (µg/L as Mn)	32	76	9	37	68	51	36	26	10
01056	Manganese, dissolved (µg/L as Mn)	32	69	6	32	62	48	29	19	9

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	18	11	1.9	5.5	11.0	7.0	5.4	2.9	1.9
00681	Organic carbon, dissolved (mg/L as C)	20	11	1.8	5.1	10.9	7.1	5.0	3.0	1.8
38260	Detergents as MBAS (mg/L)	19	0.4	<0.1	0.109*	*0.400	*0.200	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	20	2	0.5	1.0	2.0	1.4	1.0	0.6	0.5
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	18	0.391	0.131	0.243	--	0.323	0.223	0.169	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.377	0.1	0.216	--	0.292	0.189	0.145	--
	Trihalomethane-formation potential (µg/L)	5	2,252	319	1,010	--	1,356	646	475	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	18	0.083	0.026	0.049	--	0.062	0.046	0.032	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00061	Discharge, instantaneous (ft^3/s)	56	126	7	23	86	22	15	12	8.155
00095	Specific conductance (µS/cm at 25 °C)	55	32	18	26	30	27	26	24	22
00400	Field pH, whole water (standard unit)	56	7	5.5	6.1	6.5	6.2	6.1	5.9	5.6
00020	Air temperature (°C)	51	31	6.4	21.4	31.0	27.0	22.8	16.1	8.3
00010	Water temperature (°C)	56	23.6	9.3	17.5	23.1	21.4	17.0	14.0	10.0
00025	Air pressure (mm of Hg)	56	773	752	760	766	762	760	758	753
00300	Dissolved oxygen (mg/L)	52	10.6	6.7	8.6	10.3	9.3	8.6	7.8	6.9
00301	Dissolved oxygen (percent of saturation)	52	120	75	89	99	92	89	85	76
31625	Fecal coliform (col/100 mL)	54	10,000	16	887	3,900	755	310	145	65
31673	Fecal streptococcus (col/100 mL)	55	22,000	50	2,020	18,400	1,000	410	250	81
31633	*Escherichia coli* (col/100 mL)	20	16,000	160	2,606	15,850	2,250	880	498	167
00900	Hardness, total (mg/L as $CaCO_3$)	26	14	5	6	12	6	6	5	5
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	25	4	0	3	4	3	3	2	0
00915	Calcium, dissolved (mg/L as Ca)	26	4.2	0.8	1.2	3.3	1.2	1.1	0.9	0.8
00925	Magnesium, dissolved (mg/L as Mg)	26	0.9	0.7	0.8	0.9	0.8	0.8	0.7	0.7
00930	Sodium, dissolved (mg/L as Na)	26	2.6	1.1	2.0	2.6	2.1	2.0	1.8	1.3
00935	Potassium, dissolved (mg/L as K)	26	0.8	0.3	0.5	0.8	0.6	0.4	0.4	0.3
00452	Carbonate, dissolved (mg/L as CO_3)	56	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	56	23	1	4	6	5	4	3	2
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	56	19	1	3	5	4	3	3	2
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	56	20	2	4	6	5	4	3	2
00945	Sulfate, dissolved (mg/L as SO_4)	26	1.9	0.2	0.7	1.7	0.9	0.5	0.4	0.3

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	26	4.5	3.1	3.8	4.4	4.0	3.8	3.7	3.2
00950	Fluoride, dissolved (mg/L as F)	26	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
71870	Bromide, dissolved (mg/L as Br)									
00955	Silica, dissolved (mg/L as SiO_2)	26	7.2	5.0	6.4	7.2	6.8	6.5	6.1	5.0
70300	Total dissolved solids, residue at 180 °C (mg/L)	26	72.0	9.0	26.8	72.0	31.3	22.0	17.5	10.8
70301	Total dissolved solids (mg/L)	26	30.0	17.0	19.7	26.9	20.0	19.0	19.0	17.0
80154	Suspended sediment concentration (mg/L)	16	123.0	5.0	39.6	123.0	76.0	22.0	10.8	5.0
00615	Nitrite, total (mg/L as N)	42	0.04	<0.01	0.006*	0.01	0.01	<0.01	<0.01	<0.01
00613	Nitrite, dissolved (mg/L as N)	28	0.01	<0.01	--	0.01	<0.01	<0.01	<0.01	<0.01
00620	Nitrate, total (mg/L as N)	11	0.51	0.01	0.32	0.51	0.42	0.33	0.23	0.01
00630	Nitrite plus nitrate, total (mg/L as N)	41	0.60	0.20	0.45	0.58	0.50	0.50	0.40	0.30
00631	Nitrite plus nitrate, dissolved (mg/L as N)	42	0.62	0.02	0.44	0.60	0.52	0.47	0.38	0.15
00610	Ammonia, total (mg/L as N)	41	0.07	<0.10	0.02*	*0.04	*0.03	*0.02	*0.01	<0.01
00608	Ammonia, dissolved (mg/L as N)	26	0.11	0.01	0.02	0.09	0.03	0.02	0.01	0.01
00605	Organic nitrogen, total (mg/L as N)	21	0.96	0.16	0.34	0.93	0.37	0.27	0.24	0.16
00600	Nitrogen, total (mg/L as N)	22	1.30	0.34	0.75	1.24	0.82	0.75	0.68	0.38
00625	Ammonia plus organic nitrogen, total (mg/L as N)	42	0.99	<0.2	0.246*	0.65	0.3	0.21	<0.2	<0.2
00665	Phosphorus, total (mg/L as P)	42	0.85	<0.01	0.040*	0.08	*0.030	*0.010	<0.02	<0.01
00666	Phosphorus, dissolved (mg/L as P)	41	0.05	<0.01	0.014*	*0.040	*0.020	<0.02	<0.02	<0.01
00671	Phosphorus, ortho (mg/L as P)	41	0.02	<0.01	0.009*	*0.010	*0.010	<0.01	<0.01	<0.01
01020	Boron, dissolved (µg/L as B)	26	27	<10	9*	23	7	<20	<20	<10
01045	Iron, total (µg/L as Fe)	26	4,500	150	519	3,142	490	380	268	154
01046	Iron, dissolved (µg/L as Fe)	26	240	30	132	240	170	125	78	37
01055	Manganese, total (µg/L as Mn)	26	110	10	31	89	34	30	20	10
01056	Manganese, dissolved (µg/L as Mn)	26	48	5.0	19	45	25	18	11	6.1

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	20	15.0	1.3	5.7	14.9	9.9	4.5	1.8	1.3
00681	Organic carbon, dissolved (mg/L as C)	20	11.0	1.1	5.0	11.0	8.9	4.0	1.7	1.1
38260	Detergents as MBAS (mg/L)	19	0.8	<0.1	0.1*	*0.8	*0.1	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	20	3.2	0.3	1.1	3.2	1.5	0.6	0.6	0.3
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	18	0.618	0.089	0.243	--	0.351	0.170	0.120	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.502	0.065	0.192	--	0.285	0.126	0.105	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	18	0.110	0.009	0.052	--	0.078	0.046	0.029	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00061	Discharge, instantaneous (ft^3/s)	56	90	7.8	18.6	46.4	18.8	14.0	11.0	8.5
00095	Specific conductance (µS/cm at 25 °C)	57	35	20	24	30	26	23	22	20
00400	Field pH, whole water (standard unit)	56	7.1	5.3	6.1	6.5	6.3	6.2	6.0	5.7
00020	Air temperature (°C)	53	35.2	6.6	21.9	32.6	28.7	23.6	15.8	8.1
00010	Water temperature (°C)	57	25.3	9	18.1	24.1	22.6	18.4	14.1	10.7
00025	Air pressure (mm of Hg)	55	772	751	760	768	763	760	758	753
00300	Dissolved oxygen (mg/L)	55	11.0	6.2	8.3	10.3	9.1	8.1	7.4	6.6
00301	Dissolved oxygen (percent of saturation)	53	97	70	88	96	92	88	84	75
31625	Fecal coliform (col/100 mL)	52	10,000	36	545	2,740	378	155	110	37
31673	Fecal streptococcus (col/100 mL)	56	26,000	12	1,239	6,060	758	345	193	71
31633	*Escherichia coli* (col/100 mL)	20	9,200	92	1,120	8,930	1,075	325	170	93
00900	Hardness, total (mg/L as $CaCO_3$)	26	17	3	6	15	6	5	4	3
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	26	8	0	2	6	2	2	1	0
00915	Calcium, dissolved (mg/L as Ca)	26	5.9	0.7	1.5	5.2	1.5	1.2	1.0	0.7
00925	Magnesium, dissolved (mg/L as Mg)	26	0.6	0.4	0.5	0.6	0.5	0.5	0.5	0.4
00930	Sodium, dissolved (mg/L as Na)	26	2.4	1.6	2.0	2.4	2.2	2.0	1.9	1.6
00935	Potassium, dissolved (mg/L as K)	26	0.7	0.3	0.4	0.7	0.6	0.4	0.3	0.3
00452	Carbonate, dissolved (mg/L as CO_3)	56	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	56	19	0	5	8	5	4	3	2
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	56	15	0	4	6	4	3	3	2
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	56	18	2	5	7	5	4	3	2
00945	Sulfate, dissolved (mg/L as SO_4)	26	1.6	0.5	1.0	1.6	1.3	0.9	0.6	0.5

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	26	4.2	2.5	3.5	4.1	3.6	3.6	3.4	2.8
00950	Fluoride, dissolved (mg/L as F)	26	<0.1	<0.1	--	--	--	--	--	--
71870	Bromide, dissolved (mg/L as Br)									
00955	Silica, dissolved (mg/L as SiO_2)	26	6.9	4.5	6.1	6.9	6.5	6.2	5.7	4.7
70300	Total dissolved solids, residue at 180 °C (mg/L)	26	86	10	24.5	67.1	28.3	23.0	18.0	11.4
70301	Total dissolved solids (mg/L)	26	30	16	18.3	26.9	19.0	18.0	17.0	16.0
80154	Suspended sediment concentration (mg/L)	16	370	2	42.1	370.0	27.5	8.5	4.0	2.0
00615	Nitrite, total (mg/L as N)	43	0.02	<0.01	0.007*	*0.010	<0.01	<0.01	<0.01	<0.01
00613	Nitrite, dissolved (mg/L as N)	28	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01
00620	Nitrate, total (mg/L as N)	8	0.24	0.07	0.15	0.24	0.18	0.15	0.12	0.07
00630	Nitrite plus nitrate, total (mg/L as N)	43	0.30	0.10	0.18	0.28	0.20	0.20	0.10	0.10
00631	Nitrite plus nitrate, dissolved (mg/L as N)	43	0.27	0.02	0.17	0.24	0.20	0.16	0.14	0.09
00610	Ammonia, total (mg/L as N)	42	0.05	--	0.02*	*0.04	*0.02	*0.02	*0.01	*0.01
00608	Ammonia, dissolved (mg/L as N)	27	0.07	<0.01	0.021	0.06	*0.03	*0.02	*0.01	<0.01
00605	Organic nitrogen, total (mg/L as N)	22	0.51	0.19	0.27	0.51	0.33	0.24	0.22	0.19
00600	Nitrogen, total (mg/L as N)	21	0.67	0.34	0.46	0.66	0.52	0.43	0.39	0.34
00625	Ammonia plus organic nitrogen, total (mg/L as N)	43	0.53	--	0.22*	*0.47	*0.26	*0.22	*0.15	*0.10
00665	Phosphorus, total (mg/L as P)	43	0.04	<0.01	0.017*	*0.040	*0.020	<0.02	<0.02	<0.01
00666	Phosphorus, dissolved (mg/L as P)	42	0.04	<0.01	0.012*	*0.040	0.01	<0.020	<0.020	<0.01
00671	Phosphorus, ortho (mg/L as P)	42	0.02	<0.01	0.008*	*0.010	*0.010	<0.01	<0.01	<0.01
01020	Boron, dissolved (µg/L as B)	26	45	<10.00	10*	22	8	<20.00	<20.00	<10.00
01045	Iron, total (µg/L as Fe)	26	930	270	586	920	700	650	423	284
01046	Iron, dissolved (µg/L as Fe)	26	600	60	256	558	363	235	138	60
01055	Manganese, total (µg/L as Mn)	26	50	15	26	48	30	23	20	15
01056	Manganese, dissolved (µg/L as Mn)	26	40	10	20	38	23	20	16	10

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	19	13	1.2	5.047	13	7.3	4.4	1.9	1.2
00681	Organic carbon, dissolved (mg/L as C)	20	12	1.2	4.5	11.9	6.0	3.8	1.8	1.2
38260	Detergents as MBAS (mg/L)	19	0.4	<0.1	0.01*	*0.4	*0.1	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	20	3.8	<0.1	0.9*	2.1	1.0	0.7	*0.5	<0.1
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	18	0.582	0.108	0.227	--	0.261	0.199	0.129	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.453	0.070	0.186	--	0.243	0.145	0.101	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	18	0.151	0.010	0.055	--	0.078	0.048	0.025	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Long Branch near Wilmer, 02479955 (site LON)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00061	Discharge, instantaneous (ft^3/s)	43	26	2.2	6.5	17.4	7.2	5.1	3.6	2.4
00095	Specific conductance (µS/cm at 25 °C)	45	50	22	42	49	45	43	41	27
00400	Field pH, whole water (standard unit)	43	7.7	5.2	6.4	7.0	6.6	6.3	6.2	5.6
00020	Air temperature (°C)	42	33.4	7.1	21.5	31.5	28.0	23.0	15.8	7.7
00010	Water temperature (°C)	45	25.6	9.2	18.3	25.3	22.7	18.6	14.2	10.0
00025	Air pressure (mm of Hg)	44	770	751	761	769	764	760	758	755
00300	Dissolved oxygen (mg/L)	44	10.9	7.1	8.7	10.8	9.5	8.6	7.9	7.2
00301	Dissolved oxygen (percent of saturation)	44	101	77	92	99	96	92	89	83
31625	Fecal coliform (col/100 mL)	43	2,000	28	243	1,320	250	140	93	29
31673	Fecal streptococcus (col/100 mL)	42	8,700	26	725	1,755	825	420	175	33
31633	*Escherichia coli* (col/100 mL)	19	1,400	47	257	1,400	290	150	88	47
00900	Hardness, total (mg/L as $CaCO_3$)	22	14	9	11	14	12	11	11	9
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	22	8	0	5	8	6	4	4	0
00915	Calcium, dissolved (mg/L as Ca)	22	3.6	2.1	2.8	3.6	3.0	2.8	2.5	2.1
00925	Magnesium, dissolved (mg/L as Mg)	22	1.4	0.9	1.1	1.4	1.2	1.0	1.0	0.9
00930	Sodium, dissolved (mg/L as Na)	22	2.9	1.9	2.4	2.9	2.6	2.4	2.2	1.9
00935	Potassium, dissolved (mg/L as K)	22	1.4	0.6	0.9	1.4	1.0	0.8	0.7	0.6
00452	Carbonate, dissolved (mg/L as CO_3)	43	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	43	15	3	8	15	9	8	6	4
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	43	12	2	7	12	8	7	5	3
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	43	13	3	8	13	9	8	6	4
00945	Sulfate, dissolved (mg/L as SO_4)	22	5.1	1.2	2.6	4.9	3.5	2.6	1.7	1.2

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Long Branch near Wilmer, 02479955 (site LON)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	22	6.2	3.9	4.8	6.1	5.1	4.7	4.4	3.9
00950	Fluoride, dissolved (mg/L as F)	<0.10	<0.10	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
71870	Bromide, dissolved (mg/L as Br)									
00955	Silica, dissolved (mg/L as SiO_2)	22	6.7	4.7	5.9	6.7	6.4	6.0	5.6	4.8
70300	Total dissolved solids, residue at 180 °C (mg/L)	22	90.0	20.0	35.5	82.8	40.0	32.0	30.0	20.3
70301	Total dissolved solids (mg/L)	21	30.0	24.0	27.4	30.0	28.5	28.0	26.0	24.0
80154	Suspended sediment concentration (mg/L)									
00615	Nitrite, total (mg/L as N)	30	0.01	--	0.010*	*0.011	*0.010	*0.010	<0.01	<0.01
00613	Nitrite, dissolved (mg/L as N)	18	0.014	--	0.008*	*0.014	*0.010	*0.008	*0.006	*0.005
00620	Nitrate, total (mg/L as N)	15	1.19	0.31	0.67	1.19	0.87	0.71	0.44	0.31
00630	Nitrite plus nitrate, total (mg/L as N)	30	1.20	0.10	0.59	1.09	0.80	0.60	0.38	0.16
00631	Nitrite plus nitrate, dissolved (mg/L as N)	30	1.20	0.02	0.59	1.09	0.76	0.57	0.36	0.14
00610	Ammonia, total (mg/L as N)	29	0.38	0.01	0.06	0.30	0.08	0.04	0.03	0.02
00608	Ammonia, dissolved (mg/L as N)	14	0.11	0.02	0.05	0.11	0.07	0.04	0.03	0.02
00605	Organic nitrogen, total (mg/L as N)	25	1.70	0.10	0.34	1.47	0.32	0.25	0.21	0.12
00600	Nitrogen, total (mg/L as N)	24	2.10	0.42	1.01	2.00	1.20	0.93	0.71	0.45
00625	Ammonia plus organic nitrogen, total (mg/L as N)	30	1.7	<0.20	0.36*	0.97	*0.38	*0.30	*0.20	<0.20
00665	Phosphorus, total (mg/L as P)	30	0.08	<0.01	0.017*	0.05	*0.020	<0.02	<0.02	<0.01
00666	Phosphorus, dissolved (mg/L as P)	29	0.04	<0.01	0.013*	*0.040	*0.017	<0.02	<0.02	*0.002
00671	Phosphorus, ortho (mg/L as P)	28	0.01	--	0.010*	*0.010	*0.010	*0.010	*0.010	*0.010
01020	Boron, dissolved (µg/L as B)	22	31	<10	12*	25	11	8	<20	<20
01045	Iron, total (µg/L as Fe)	22	6,400	350	1,058	5,695	1,225	640	508	356
01046	Iron, dissolved (µg/L as Fe)	22	1,000	30	294	934	390	220	138	42
01055	Manganese, total (µg/L as Mn)	22	280	20	56	252	63	42	30	21
01056	Manganese, dissolved (µg/L as Mn)	22	80	15	37	79	52	32	20	15

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Long Branch near Wilmer, 02479955 (site LON)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	19	16	1.2	4.8	16.0	6.4	3.9	2.2	1.2
00681	Organic carbon, dissolved (mg/L as C)	20	15	1.2	4.2	14.6	5.6	3.6	2.2	1.2
38260	Detergents as MBAS (mg/L)	18	0.3	<0.10	*0.07	*0.3	*0.1	<0.10	<0.10	<0.10
32240	Tannin and lignin (mg/L)	20	1.4	0.3	0.7	1.4	0.8	0.6	0.4	0.3
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	17	0.267	0.098	0.176	--	0.199	0.184	0.140	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.214	0.068	0.135	--	0.172	0.133	0.100	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	18	0.123	0.007	0.047	--	0.061	0.047	0.021	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Boggy Branch near Wilmer, 02479960 (site BOG)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00061	Discharge, instantaneous (ft^3/s)	43	60	1.3	7.1	21	7.2	5.2	2.6	1.44
00095	Specific conductance (µS/cm at 25 °C)	43	48	19	30	36	32	29	28	25
00400	Field pH, whole water (standard unit)	43	6.4	5	5.8	6.3	6.1	5.9	5.5	5.3
00020	Air temperature (°C)	41	35	-0.1	20.1	31.2	26.7	22.1	14.5	3.4
00010	Water temperature (°C)	43	26.4	4.8	17.9	26.4	23.7	17.1	12.6	6.9
00025	Air pressure (mm of Hg)	43	770	752	761	770	764	760	758	754
00300	Dissolved oxygen (mg/L)	43	11	3.7	7.2	9.9	8.2	6.9	6.1	5.1
00301	Dissolved oxygen (percent of saturation)	43	101	41	74	92	81	74	69	61
31625	Fecal coliform (col/100 mL)	42	6,000	24	584	4,330	453	165	100	50
31673	Fecal streptococcus (col/100 mL)	43	8,800	10	948	4,480	1,100	380	140	15
31633	*Escherichia coli* (col/100 mL)	20	4,200	57	643	4,170	548	190	115	57
00900	Hardness, total (mg/L as $CaCO_3$)	22	8	6	7	8	7	6	6	6
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	22	6	0	4	6	4	4	3	0
00915	Calcium, dissolved (mg/L as Ca)	22	1.4	0.9	1.1	1.4	1.2	1.1	0.9	0.9
00925	Magnesium, dissolved (mg/L as Mg)	22	1.2	0.8	1.0	1.2	1.1	0.9	0.9	0.8
00930	Sodium, dissolved (mg/L as Na)	22	3	1.4	2.2	3.0	2.5	2.2	2.0	1.4
00935	Potassium, dissolved (mg/L as K)	22	1.3	0.3	0.6	1.2	0.7	0.5	0.4	0.3
00452	Carbonate, dissolved (mg/L as CO_3)	43	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	43	7	1	3.7	7.0	5.0	3.0	2.0	1.2
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	43	6	1	3.1	5.8	4.0	3.0	2.0	1.0
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	43	7	2	4	7	5	4	3	2
00945	Sulfate, dissolved (mg/L as SO_4)	22	3.5	0.6	1.4	3.3	1.9	1.3	0.7	0.6

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Boggy Branch near Wilmer, 02479960 (site BOG)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	22	41	2.9	6.7	36.1	5.5	5.1	4.5	3.1
00950	Fluoride, dissolved (mg/L as F)	22	<0.1	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1
71870	Bromide, dissolved (mg/L as Br)									
00955	Silica, dissolved (mg/L as SiO_2)	22	8.6	4.5	6.8	8.6	7.8	6.9	5.9	4.5
70300	Total dissolved solids, residue at 180 °C (mg/L)	22	70	14	28.9	65.8	32.5	26.5	22.0	14.3
70301	Total dissolved solids (mg/L)	22	59	17	22.5	54.1	23.0	21.0	19.0	17.0
80154	Suspended sediment concentration (mg/L)	1	21	--	--	--	--	--	--	--
00615	Nitrite, total (mg/L as N)	29	0.01	<.01	0.01*	0.01	<0.01	<0.01	<0.01	<0.01
00613	Nitrite, dissolved (mg/L as N)	18	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01
00620	Nitrate, total (mg/L as N)	6	0.18	0.05	0.12	0.18	0.15	0.11	0.09	0.05
00630	Nitrite plus nitrate, total (mg/L as N)	29	0.3	0.1	0.14	0.25	0.20	0.20	0.10	0.10
00631	Nitrite plus nitrate, dissolved (mg/L as N)	30	0.3	0.06	0.14	0.26	0.17	0.13	0.10	0.07
00610	Ammonia, total (mg/L as N)	28	0.05	<0.01	0.02*	0.04	0.03	0.02	0.01	<0.01
00608	Ammonia, dissolved (mg/L as N)	15	0.05	0.01	0.02	0.05	0.03	0.02	0.01	0.01
00605	Organic nitrogen, total (mg/L as N)	24	1.5	0.20	0.36	1.28	0.35	0.29	0.24	0.20
00600	Nitrogen, total (mg/L as N)	26	1.6	0.30	0.52	1.30	0.53	0.46	0.41	0.30
00625	Ammonia plus organic nitrogen, total (mg/L as N)	30	1.5	<0.20	0.35*	0.64	0.36	0.30	0.24	<0.2
00665	Phosphorus, total (mg/L as P)	30	0.04	0.04	0.04	0.04	0.02	0.01	<0.02	<0.01
00666	Phosphorus, dissolved (mg/L as P)	29	0.040	<0.010	0.014*	0.030	0.020	<0.020	<0.020	<0.010
00671	Phosphorus, ortho (mg/L as P)	28	0.020	<0.010	0.007*	0.020	0.010	<0.010	<0.010	<0.010
01020	Boron, dissolved (µg/L as B)	22	34	<10	11*	26	9.0	4.0	<20	<10
01045	Iron, total (µg/L as Fe)	22	2,600	360	1,046	2,465	1,325	940	625	366
01046	Iron, dissolved (µg/L as Fe)	22	1,400	80	434	1,318	575	365	220	82
01055	Manganese, total (µg/L as Mn)	22	150	42	81	146	99	79	58	42
01056	Manganese, dissolved (µg/L as Mn)	22	140	33	69	136	80	67	48	34

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Boggy Branch near Wilmer, 02479960 (site BOG)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	20	13	1.9	5.6	12.9	6.9	5.9	3.3	1.9
00681	Organic carbon, dissolved (mg/L as C)	19	10	1.7	5.1	10.0	6.5	5.4	3.0	1.7
38260	Detergents as MBAS (mg/L)	18	0.6	<0.1	0.1*	0.6	0.1	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	20	7.1	0.5	1.2	6.8	1.4	0.8	0.6	0.5
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	18	0.325	0.144	0.268	--	0.325	0.256	0.194	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.433	0.107	0.221	--	0.270	0.204	0.125	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	17	0.096	0.022	0.051	--	0.064	0.050	0.032	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Crooked Creek near Fairview, 02479980 (site CRO)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00061	Discharge, instantaneous (ft^3/s)	78	239	6.6	17	32	17	13	10	7.79
00095	Specific conductance (µS/cm at 25 °C)	78	51	22	36	43	38	36	34	32
00400	Field pH, whole water (standard unit)	62	6.8	5.2	6.3	6.8	6.5	6.4	6.2	5.6
00020	Air temperature (°C)	59	33	1.5	20.7	31.0	26.2	22.0	16.4	3.6
00010	Water temperature (°C)	78	24.2	8.9	17.8	23.6	21.7	18.0	14.7	10.0
00025	Air pressure (mm of Hg)	65	773	750	761	771	763	760	759	755
00300	Dissolved oxygen (mg/L)	62	10.3	5.4	8.1	10.0	8.9	8.1	7.3	6.5
00301	Dissolved oxygen (percent of saturation)	62	101	61	84	97	89	85	81	70
31625	Fecal coliform (col/100 mL)	59	2,000	72	349	1,000	440	240	150	82
31673	Fecal streptococcus (col/100 mL)	61	5,800	74	808	2,930	935	550	285	90
31633	*Escherichia coli* (col/100 mL)	19	1,100	130	449	1,100	640	350	200	130
00900	Hardness, total (mg/L as $CaCO_3$)	32	14	6	9	13	10	9	7	6
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	30	5	0	3	5	3	3	2	1
00915	Calcium, dissolved (mg/L as Ca)	32	4	1.2	2.2	3.9	2.6	2.0	1.6	1.3
00925	Magnesium, dissolved (mg/L as Mg)	32	1	0.5	0.8	1.0	0.9	0.9	0.8	0.6
00930	Sodium, dissolved (mg/L as Na)	32	3.4	1.2	2.5	3.3	2.7	2.5	2.3	1.6
00935	Potassium, dissolved (mg/L as K)	32	1.7	0.5	0.9	1.6	1.1	0.8	0.6	0.5
00452	Carbonate, dissolved (mg/L as CO_3)	61	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	61	14	3	8	14	10	8	7	5
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	61	12	3	7	11	8	7	5	4
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	61	13	4	8	12	9	8	6	4
00945	Sulfate, dissolved (mg/L as SO_4)	32	3	0.8	1.5	2.9	1.8	1.4	1.1	0.8

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; μS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; μg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Crooked Creek near Fairview, 02479980 (site CRO)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	42	7.5	0.1	4.2	6.3	4.5	4.2	3.9	2.1
00950	Fluoride, dissolved (mg/L as F)	32	<0.1	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1
71870	Bromide, dissolved (mg/L as Br)	15	<0.05	<0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05
00955	Silica, dissolved (mg/L as SiO_2)	32	7.3	1.5	5.8	7.0	6.6	5.9	5.4	3.5
70300	Total dissolved solids, residue at 180 °C (mg/L)	32	86	12	29.6	61.3	33.8	29.5	21.3	13.3
70301	Total dissolved solids (mg/L)	31	28	20	24.0	28.0	26.0	24.0	22.0	20.6
80154	Suspended sediment concentration (mg/L)	14	71	1	11.4	71.0	11.8	5.0	3.8	1.0
00615	Nitrite, total (mg/L as N)	48	0.100	<0.010	0.006*	0.010	<0.010	<0.010	<0.010	<0.010
00613	Nitrite, dissolved (mg/L as N)	33	0.020	<0.010	--	<0.010	<0.010	<0.010	<0.010	<0.010
00620	Nitrate, total (mg/L as N)	10	0.43	0.16	0.30	0.43	0.35	0.33	0.25	0.16
00630	Nitrite plus nitrate, total (mg/L as N)	48	0.50	0.10	0.36	0.50	0.40	0.40	0.30	0.20
00631	Nitrite plus nitrate, dissolved (mg/L as N)	48	0.52	0.02	0.37	0.50	0.41	0.37	0.33	0.26
00610	Ammonia, total (mg/L as N)	47	0.05	0.01	0.02	0.04	0.03	0.02	0.01	0.01
00608	Ammonia, dissolved (mg/L as N)	32	0.07	0.01	0.02	0.06	0.03	0.02	0.01	0.01
00605	Organic nitrogen, total (mg/L as N)	31	2.3	0.17	0.37	1.29	0.40	0.29	0.22	0.18
00600	Nitrogen, total (mg/L as N)	33	2.6	0.51	0.75	1.40	0.76	0.70	0.62	0.52
00625	Ammonia plus organic nitrogen, total (mg/L as N)	48	2.3	<0.20	0.31*	0.50	0.33	0.25	<0.20	<0.20
00665	Phosphorus, total (mg/L as P)	48	0.18	<0.01	0.03*	0.05	0.03	0.02	<0.02	<0.01
00666	Phosphorus, dissolved (mg/L as P)	47	0.050	<0.010	0.016*	0.040	0.020	<0.020	<0.020	<0.010
00671	Phosphorus, ortho (mg/L as P)	47	0.030	<0.010	0.009*	0.020	0.010	0.010	<0.010	<0.010
01020	Boron, dissolved (μg/L as B)	32	34	<10	14*	31	13	<20	<20	<20
01045	Iron, total (μg/L as Fe)	32	4,900	320	828	2,495	980	725	455	333
01046	Iron, dissolved (μg/L as Fe)	32	680	60	272	622	370	235	140	67
01055	Manganese, total (μg/L as Mn)	32	100	20	34	94	40	28	22	20
01056	Manganese, dissolved (μg/L as Mn)	32	53	9	21	52	26	19	14	9.7

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Crooked Creek near Fairview, 02479980 (site CRO)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	20	8.2	<0.1	3.6*	6.9	5.2	3.4	1.3	<0.1
00681	Organic carbon, dissolved (mg/L as C)	21	8.1	0.10	3.3	8.0	4.7	3.2	1.4	0.17
38260	Detergents as MBAS (mg/L)	20	0.4	<0.1	0.1*	0.2	0.1	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	21	1	0.1	0.6	1	0.8	0.5	0.4	0.1
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	17	0.268	0.092	0.176	--	0.238	0.165	0.142	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.256	0.065	0.139	--	0.183	0.122	0.102	--
	Trihalomethane-formation potential (µg/L)	5	732	171	373	--	439	287	235	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	18	0.133	0.018	0.060	--	0.087	0.062	0.021	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; μS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; μg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Crooked Creek at mouth near Wilmer, 02479985 (site LCRO)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00078	Transparency (m)	15	4.2	0.8	2.3	4.2	3.1	2.3	1.6	0.8
00095	Specific conductance (μS/cm at 25 °C)	123	36	23	27	35	28	26	24	23
00400	Field pH, whole water (standard unit)	102	7	5	6.2	6.6	6.4	6.2	6.0	5.8
00020	Air temperature (°C)	19	32.7	9.7	22.9	32.7	30.4	24.1	18.1	9.7
00010	Water temperature (°C)	123	32.1	11.7	21.5	31.0	29.2	19.4	16.1	12.5
00025	Air pressure (mm of Hg)	28	767	755	762	767	764	763	760	755
00300	Dissolved oxygen (mg/L)	123	10.5	1.1	7.8	10.4	9.1	7.9	7.0	4.9
00301	Dissolved oxygen (percent of saturation)	28	109	70	93	109	96	94	88	75
31625	Fecal coliform (col/100 mL)	20	180	<1	31*	120	26	7	3	<1
31673	Fecal streptococcus (col/100 mL)	20	58	<1	14*	54	10	6	<2	<1
31633	*Escherichia coli* (col/100 mL)	19	170	<1	31*	170	42	8	3	1
00900	Hardness, total (mg/L as $CaCO_3$)	8	7	6	7	7	7	7	7	6
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	8	4	2	3	4	4	3	2	2
00915	Calcium, dissolved (mg/L as Ca)	8	1.8	1.4	1.7	1.8	1.8	1.7	1.5	1.4
00925	Magnesium, dissolved (mg/L as Mg)	8	0.7	0.6	0.7	0.7	0.7	0.7	0.7	0.6
00930	Sodium, dissolved (mg/L as Na)	8	2.4	1.6	1.9	2.4	2.1	1.9	1.8	1.6
00935	Potassium, dissolved (mg/L as K)	8	0.8	0.5	0.6	0.8	0.7	0.6	0.5	0.5
00452	Carbonate, dissolved (mg/L as CO_3)	21	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	21	8	4	5.5	7.9	6.5	5.0	4.5	4.0
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	21	6	3	4.6	6.0	5.0	5.0	4.0	3.0
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	21	7	4	6	7	7	6	5	4
00945	Sulfate, dissolved (mg/L as SO_4)	8	2.0	<0.2	1.5*	2.0	1.8	1.4	1.0	1.0

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Crooked Creek at mouth near Wilmer, 02479985 (site LCRO)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	8	4	2.9	3.6	4.0	3.8	3.7	3.3	2.9
00950	Fluoride, dissolved (mg/L as F)	8	<0.1	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1
71870	Bromide, dissolved (mg/L as Br)									
00955	Silica, dissolved (mg/L as SiO_2)	8	4	2.5	3.2	4.0	3.7	3.3	2.7	2.5
70300	Total dissolved solids, residue at 180 °C (mg/L)	8	30	10	21.8	30.0	29.0	22.0	16.5	10.0
70301	Total dissolved solids (mg/L)	7	18	15	16.3	18.0	17.0	16.0	15.0	15.0
80154	Suspended sediment concentration (mg/L)									
00615	Nitrite, total (mg/L as N)	7	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01
00613	Nitrite, dissolved (mg/L as N)	8	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01
00630	Nitrite plus nitrate, total (mg/L as N)	7	0.2	<0.1	0.1*	0.2	0.2	0.1	<0.1	<0.1
00631	Nitrite plus nitrate, dissolved (mg/L as N)	8	0.20	<0.02	0.12*	0.20	0.16	0.08	<0.02	<0.02
00610	Ammonia, total (mg/L as N)	7	0.04	0.02	0.03	0.04	0.03	0.03	0.02	0.02
00608	Ammonia, dissolved (mg/L as N)	1	<0.01	--	--	--	--	--	--	--
00605	Organic nitrogen, total (mg/L as N)	4	0.38	0.19	--	--	--	--	--	--
00600	Nitrogen, total (mg/L as N)	2	0.50	0.48	--	--	--	--	--	--
00625	Ammonia plus organic nitrogen, total (mg/L as N)	7	0.40	<0.20	--	0.40	0.36	0.22	<0.20	<0.20
00665	Phosphorus, total (mg/L as P)	7	0.04	<0.02	--	0.04	0.03	<0.02	<0.02	<0.02
00666	Phosphorus, dissolved (mg/L as P)	8	0.04	<0.02	--	0.04	<0.02	<0.02	<0.02	<0.02
00671	Phosphorus, ortho (mg/L as P)	8	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01
01020	Boron, dissolved (µg/L as B)	7	10	8	9.0	10	10	9	9	8
01045	Iron, total (µg/L as Fe)	8	660	210	365	660	460	315	255	210
01046	Iron, dissolved (µg/L as Fe)	8	310	110	183	310	258	150	133	110
01055	Manganese, total (µg/L as Mn)	8	54	8	26	54	43	24	9.5	8.0
01056	Manganese, dissolved (µg/L as Mn)	8	20	2	9.9	20	16	8.5	4.5	2.0

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Crooked Creek at mouth near Wilmer, 02479985 (site LCRO)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	20	16	1.9	5.2	16.0	5.8	4.7	3.1	1.9
00681	Organic carbon, dissolved (mg/L as C)	19	12	1.8	4.4	--	4.9	4.1	3.0	--
38260	Detergents as MBAS (mg/L)	19	0.3	<0.1	0.1*	0.3	0.1	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	20	1.1	0.3	0.6	1.1	0.8	0.6	0.5	0.3
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	18	0.280	0.096	0.168	--	0.184	0.168	0.144	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.263	0.085	0.151	--	0.166	0.151	0.119	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	17	0.092	0.011	0.044	--	0.057	0.050	0.023	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00061	Discharge, instantaneous (ft^3/s)	78	371	11	29	60	23	19	16	12
00095	Specific conductance (µS/cm at 25 °C)	79	42	21	34	41	36	34	33	30
00400	Field pH, whole water (standard unit)	61	6.6	5.3	6.1	6.5	6.2	6.1	5.9	5.7
00020	Air temperature (°C)	59	34.2	-1.2	21.2	34.0	27.8	22.8	15.0	3.0
00010	Water temperature (°C)	80	24.2	10.1	18.4	24.0	22.0	18.9	15.2	11.5
00025	Air pressure (mm of Hg)	63	768	750	760	766	762	760	759	752
00300	Dissolved oxygen (mg/L)	61	9.9	5.2	7.8	9.7	8.7	7.8	7.0	6.4
00301	Dissolved oxygen (percent of saturation)	60	98	60	83	96	86	83	79	70
31625	Fecal coliform (col/100 mL)	57	5,200	26	316	1,100	255	150	95	44
31673	Fecal streptococcus (col/100 mL)	61	19,000	12	1,006	2,380	655	330	140	54
31633	*Escherichia coli* (col/100 mL)	20	5,800	46	594	5,570	433	245	140	47
00900	Hardness, total (mg/L as $CaCO_3$)	31	9	5	7	9	8	7	6	6
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	31	4	1	2	4	3	2	2	1
00915	Calcium, dissolved (mg/L as Ca)	31	2.5	0.9	1.5	2.3	1.7	1.4	1.3	1.0
00925	Magnesium, dissolved (mg/L as Mg)	31	0.9	0.7	0.8	0.9	0.8	0.7	0.7	0.7
00930	Sodium, dissolved (mg/L as Na)	31	3.7	2.0	3.1	3.7	3.3	3.1	3.0	2.4
00935	Potassium, dissolved (mg/L as K)	31	0.8	0.3	0.5	0.7	0.7	0.5	0.4	0.3
00452	Carbonate, dissolved (mg/L as CO_3)	61	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	61	11	1	6	9	6	6	5	3
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	61	9	1	5	8	5	5	4	3
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	60	10	2	6	9	7	6	5	4
00945	Sulfate, dissolved (mg/L as SO_4)	31	2.4	0.6	1.1	2.2	1.3	1.1	0.8	0.6

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	40	7.3	2.3	4.9	6.6	5.1	4.8	4.6	4.1
00950	Fluoride, dissolved (mg/L as F)	30	<0.1	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1
71870	Bromide, dissolved (mg/L as Br)	14	0.07	<0.05	--	0.07	<0.05	<0.05	<0.05	<0.05
00955	Silica, dissolved (mg/L as SiO_2)	31	8.5	5.6	6.6	7.8	7.1	6.6	6.1	5.6
70300	Total dissolved solids, residue at 180 °C (mg/L)	31	96.0	12.0	28.6	62.4	34.0	28.0	21.0	13.2
70301	Total dissolved solids (mg/L)	31	27.0	22.0	23.8	26.4	25.0	24.0	23.0	22.0
80154	Suspended sediment concentration (mg/L)	15	48.0	1.0	18.7	48.0	28.0	14.0	5.0	1.0
00615	Nitrite, total (mg/L as N)	46	0.030	<0.010	0.005*	0.010	<0.010	<0.010	<0.010	<0.010
00613	Nitrite, dissolved (mg/L as N)	31	0.010	<0.010	--	0.010	<0.010	<0.010	<0.010	<0.010
00620	Nitrate, total (mg/L as N)	9	0.58	0.07	0.39	0.58	0.53	0.39	0.31	0.07
00630	Nitrite plus nitrate, total (mg/L as N)	47	0.60	0.10	0.51	0.60	0.60	0.50	0.50	0.30
00631	Nitrite plus nitrate, dissolved (mg/L as N)	47	0.63	0.07	0.50	0.62	0.57	0.50	0.46	0.31
00610	Ammonia, total (mg/L as N)	46	0.05	0.01	0.02	0.04	0.03	0.02	0.01	0.01
00608	Ammonia, dissolved (mg/L as N)	31	0.06	0.01	0.02	0.06	0.03	0.02	0.01	0.01
00605	Organic nitrogen, total (mg/L as N)	27	0.59	0.18	0.29	0.57	0.35	0.24	0.20	0.18
00600	Nitrogen, total (mg/L as N)	27	1.2	0.56	0.79	1.1	0.86	0.79	0.69	0.59
00625	Ammonia plus organic nitrogen, total (mg/L as N)	47	0.6	<0.20	0.24*	0.53	0.28	0.22	<0.20	<0.20
00665	Phosphorus, total (mg/L as P)	47	0.11	<0.010	0.021*	0.060	0.030	0.020	<0.020	<0.010
00666	Phosphorus, dissolved (mg/L as P)	46	0.050	<0.010	0.013*	0.040	0.020	<0.020	<0.020	<0.010
00671	Phosphorus, ortho (mg/L as P)	45	0.02	<0.01	0.009*	0.01	0.01	<0.01	<0.01	<0.01
01020	Boron, dissolved (µg/L as B)	31	27	<10	12*	27	11	<20	<20	<20
01045	Iron, total (µg/L as Fe)	31	1,100	270	580	1,040	810	530	370	288
01046	Iron, dissolved (µg/L as Fe)	31	600	50	234	516	310	210	120	62
01055	Manganese, total (µg/L as Mn)	31	47	10	27	42	33	28	22	10
01056	Manganese, dissolved (µg/L as Mn)	31	35	10	24	33	29	23	20	12

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	20	12	1.1	4.2	11.8	5.7	4.2	2.2	1.1
00681	Organic carbon, dissolved (mg/L as C)	20	7.3	1	3.6	7.3	5.2	3.3	1.7	1.0
38260	Detergents as MBAS (mg/L)	18	0.7	<0.1	0.1*	0.7	0.1	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	20	2.4	0.3	0.8	2.4	0.9	0.7	0.5	0.3
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	18	0.406	0.111	0.205	--	0.241	0.196	0.18	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	19	0.354	0.068	0.162	--	0.194	0.154	0.117	--
	Trihalomethane-formation potential (µg/L)	5	1,066	223	448	--	379	322	250	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	18	0.156	0.020	0.064	--	0.089	0.060	0.027	--

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Hamilton Creek (Big Creek Lake intake) near Semmes, 02480004 (site LHAM)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00078	Transparency (m)	20	3.55	0.88	2.22	3.54	2.68	2.08	1.77	0.90
00095	Specific conductance (µS/cm at 25 °C)	165	41	21	26	34	27	25	24	23
00400	Field pH, whole water (standard unit)	140	6.9	5.4	6.2	6.7	6.4	6.2	6.1	5.7
00020	Air temperature (°C)	41	35.2	9.0	22.6	35.0	28.9	22.4	16.6	11.3
00010	Water temperature (°C)	164	32.2	11.9	21.7	31.1	28.7	22.4	16.7	12.2
00025	Air pressure (mm of Hg)	54	770	748	762	768	764	762	760	755
00300	Dissolved oxygen (mg/L)	163	10.7	0.1	7.6	10.4	9.1	7.9	7	2.3
00301	Dissolved oxygen (percent of saturation)	53	108	66	92	106	97	92	88	77
31625	Fecal coliform (col/100 mL)	42	220	<1	23*	110	18	5	2	<1
31673	Fecal streptococcus (col/100 mL)	44	170	<1	12*	43	11	4	2	<1
31633	*Escherichia coli* (col/100 mL)	20	180	<1	28*	170	15	4	3	<1
00900	Hardness, total (mg/L as $CaCO_3$)	17	7	5	6	7	7	6	6	5
00904	Noncarbonate hardness, dissolved (mg/L as $CaCO_3$)	17	5	1	2	5	3	2	2	1
00915	Calcium, dissolved (mg/L as Ca)	17	1.7	1.0	1.4	1.7	1.6	1.4	1.2	1.0
00925	Magnesium, dissolved (mg/L as Mg)	17	0.7	0.6	0.7	0.7	0.7	0.7	0.7	0.6
00930	Sodium, dissolved (mg/L as Na)	17	2.3	1.6	2.1	2.3	2.2	2.1	2.0	1.6
00935	Potassium, dissolved (mg/L as K)	17	0.9	0.5	0.7	0.9	0.8	0.6	0.6	0.5
00452	Carbonate, dissolved (mg/L as CO_3)	46	0	--	--	--	--	--	--	--
00453	Bicarbonate, dissolved (mg/L as HCO_3)	46	12	2	4.7	7.7	5	5	3	2.4
39086	Alkalinity, dissolved (mg/L as $CaCO_3$)	46	10	1	3.9	6	4	4	3	2
00410	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	47	11	2	4.8	7	5	5	4	2.4
00945	Sulfate, dissolved (mg/L as SO_4)	17	2	<0.2	1.6*	2.0	1.8	1.6	1.4	<0.2

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Hamilton Creek (Big Creek Lake intake) near Semmes, 02480004 (site LHAM)

NWIS PARA-METER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00940	Chloride, dissolved (mg/L as Cl)	21	4	2.9	3.5	4.0	3.7	3.5	3.5	2.9
00950	Fluoride, dissolved (mg/L as F)	17	<0.1	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1
71870	Bromide, dissolved (mg/L as Br)	8	<0.05	<0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05
00955	Silica, dissolved (mg/L as SiO_2)	17	4.3	2.0	3.1	4.3	3.6	3.3	2.6	2.0
70300	Total dissolved solids, residue at 180 °C (mg/L)	17	32	10	20	32	25	18	16	10
70301	Total dissolved solids (mg/L)	15	18	14	16	18	17	16	15	14
80154	Suspended sediment concentration (mg/L)									
00615	Nitrite, total (mg/L as N)	31	0.01	<0.01	--	0.01	<0.01	<0.01	<0.01	<0.01
00613	Nitrite, dissolved (mg/L as N)	18	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01
00620	Nitrate, total (mg/L as N)	3	0.13	0.12	--	--	--	--	--	--
00630	Nitrite plus nitrate, total (mg/L as N)	27	0.2	<0.1	0.1*	0.2	0.2	0.1	<0.1	<0.1
00631	Nitrite plus nitrate, dissolved (mg/L as N)	33	0.2	<0.02	0.087*	0.19	0.15	0.07	0.02	<0.02
00610	Ammonia, total (mg/L as N)	30	0.05	0.01	0.022	0.05	0.03	0.02	0.01	0.01
00608	Ammonia, dissolved (mg/L as N)	25	0.061	0.01	0.021	0.061	0.025	0.02	0.01	0.01
00605	Organic nitrogen, total (mg/L as N)	23	0.92	0.16	0.34	0.84	0.43	0.28	0.26	0.17
00600	Nitrogen, total (mg/L as N)	20	0.65	0.31	0.43	0.65	0.47	0.43	0.35	0.31
00625	Ammonia plus organic nitrogen, total (mg/L as N)	31	0.93	<0.20	0.33*	0.53	0.38	0.29	0.25	<0.20
00665	Phosphorus, total (mg/L as P)	30	0.04	<0.01	0.02*	0.04	0.02	0.01	<0.02	<0.01
00666	Phosphorus, dissolved (mg/L as P)	31	0.04	<0.01	0.01*	0.03	0.02	<0.02	<0.01	<0.01
00671	Phosphorus, ortho (mg/L as P)	32	0.02	<0.01	0.007*	0.01	0.01	<0.01	<0.01	<0.01
01020	Boron, dissolved (µg/L as B)	15	28	<20	13*	*28	*17	9	<20	<20
01045	Iron, total (µg/L as Fe)	17	1,400	180	398	1,400	440	320	250	180
01046	Iron, dissolved (µg/L as Fe)	17	660	40	200	660	250	130	105	40
01055	Manganese, total (µg/L as Mn)	17	340	<10	40*	*340	33	*20	10	<10
01056	Manganese, dissolved (µg/L as Mn)	17	340	<10	26.4*	*340	*10	5	3	<10

Appendix 1. Summary of descriptive statistics for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, October 1990–June 1998—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mm, millimeter; mg/L, milligram per liter; col/100 mL, colonies per 100 milliliters; --, missing data; <, less than; *, estimated; µg/L, microgram per liter; MBAS, methylene blue activated substances; nm, nanometer; cm^{-1}, per centimeter; TOC, total organic carbon; DOC, dissolved organic carbon; m, meter]

Hamilton Creek (Big Creek Lake intake) near Semmes, 02480004 (site LHAM)

NWIS PARAMETER CODE	WATER-QUALITY CONSTITUENT	SAMPLE SIZE	DESCRIPTIVE STATISTICS			PERCENTILE RANGES				
			MAXIMUM	MINIMUM	MEAN	95%	75%	50% (MEDIAN)	25%	5%
00680	Organic carbon, total (mg/L as C)	20	8.3	2	4.4	--	5.3	4.4	3.1	--
00681	Organic carbon, dissolved (mg/L as C)	21	7.8	0.1	4.038	7.68	5.1	4.2	2.65	0.29
38260	Detergents as MBAS (mg/L)	20	0.4	<0.1	0.097*	*0.400	<0.1	<0.1	<0.1	<0.1
32240	Tannin and lignin (mg/L)	21	0.9	0.1	0.548	0.89	0.65	0.6	0.4	0.12
70953	Chlorophyll *a*, phytoplankton (µg/L)	17	9.7	--	2.6*	*9.7	*3.5	*1.6	*0.6	*0.09
70954	Chlorophyll *b*, phytoplankton (µg/L)	15	--	--	--	--	--	--	--	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as TOC)	18	0.241	0.099	0.162	--	0.188	0.158	0.131	--
	Ultraviolet absorbance at 254 nm (cm^{-1} as DOC)	18	0.215	0.086	0.145	--	0.174	0.145	0.119	--
	Trihalomethane-formation potential (µg/L)	5	729	293	438	--	548	321	298	--
	Specific absorbance (mg/L as DOC per cm^{-1} of DOC)	18	0.0870	0.0164	0.0421	--	0.0551	0.0327	0.0227	--

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98

[kg/d, kilograms per day]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

Total nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				**Water year 1992**		
October	50.4	3.67	4.01	October	52.3	2.62	3.10
November	63.0	3.91	4.70	November	93.8	4.69	6.46
December	83.5	4.76	6.01	December	74.6	3.62	4.44
January	318	34.9	38.1	January	187	12.5	14.9
February	168	9.70	12.0	February	254	25.1	27.9
March	187	13.8	16.5	March	102	4.73	5.92
April	140	8.45	10.4	April	55.9	3.08	3.57
May	667	144	148	May	49.3	2.89	3.30
June	191	13.0	14.7	June	55.8	3.06	3.59
July	205	14.9	16.9	July	49.4	2.83	3.28
August	96.4	6.10	6.89	August	92.7	5.76	7.21
September	85.5	4.83	5.70	September	52.4	2.81	3.37
	Water year 1993				**Water year 1994**		
October	37.7	2.61	2.88	October	73.3	5.28	6.59
November	215	20.3	22.7	November	80.5	5.39	6.42
December	181	16.0	18.3	December	85.4	5.62	6.54
January	174	16.3	18.7	January	91.1	5.82	6.92
February	127	6.97	8.39	February	68.5	4.06	4.80
March	173	11.0	12.8	March	94.1	5.40	6.62
April	118	6.18	7.61	April	86.2	4.64	5.86
May	242	49.0	52.8	May	47.4	2.79	3.29
June	143	10.0	11.8	June	58.5	3.24	3.94
July	99.5	6.33	7.24	July	178	15.2	17.0
August	105	7.15	8.14	August	51.3	3.21	3.70
September	76.4	4.92	5.68	September	38.8	2.91	3.17
	Water year 1995				**Water year 1996**		
October	60.5	4.15	4.77	October	126	14.9	17.1
November	43.5	3.20	3.52	November	130	11.8	13.5
December	80.0	6.50	7.91	December	214	45.3	48.4
January	86.2	5.95	7.02	January	164	15.2	16.9
February	93.1	6.17	7.57	February	161	14.2	16.0
March	123	8.93	10.7	March	190	17.7	19.6
April	154	13.3	15.4	April	191	14.7	19.6
May	197	22.7	25.1	May	75.2	5.03	5.63
June	80.4	4.64	5.89	June	91.7	6.56	7.48
July	94.4	6.41	7.79	July	119	9.79	10.8
August	122	10.6	12.5	August	92.2	8.15	8.85
September	47.2	3.50	3.90	September	63.6	6.02	6.39
	Water year 1997				**Water year 1998**		
October	49.1	4.99	5.23	October	110	15.6	16.4
November	56.1	5.87	6.17	November	170	26.3	27.8
December	69.6	7.25	7.76	December	138	20.4	21.1
January	109	11.1	11.8	January	257	40.6	41.9
February	122	12.1	13.1	February	155	23.1	23.8
March	95.6	9.39	10.2	March	192	30.0	31.3
April	83.7	8.31	9.00	April	115	17.9	18.4
May	80.2	8.31	9.00	May	71.8	11.9	12.1
June	182	20.7	22.0	June	65.4	11.3	11.6
July	206	25.4	26.7	July	107	19.4	19.8
August	103	13.3	13.8	August	86.4	16.3	16.7
September	58.6	8.03	8.26	September	722	364	372

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

Total Kjeldahl nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	14.7	1.50	1.68	October	17.3	1.21	1.46
November	23.0	2.00	2.82	November	48.8	4.18	6.31
December	36.3	3.07	4.51	December	29.9	2.13	2.75
January	252	50.4	55.1	January	127	14.8	17.8
February	103	9.57	12.4	February	208	36.6	40.9
March	134	18.8	23.0	March	54.6	3.53	4.75
April	96.4	9.10	12.1	April	23.2	1.87	2.19
May	857	332	344	May	20.2	1.73	2.00
June	143	13.9	16.3	June	25.0	1.96	2.38
July	164	17.9	21.2	July	20.5	1.61	1.97
August	49.0	4.52	5.21	August	60.7	6.01	8.24
September	40.2	3.42	4.19	September	20.6	1.46	1.95
	Water year 1993				Water year 1994		
October	11.2	0.994	1.14	October	39.3	4.72	6.78
November	166	26.2	29.7	November	38.9	3.87	5.21
December	129	21.0	24.8	December	40.5	3.86	4.86
January	127	23.2	27.1	January	46.9	4.48	5.80
February	73.1	5.77	7.25	February	29.8	2.46	3.11
March	124	12.4	14.7	March	53.8	4.71	6.19
April	76.3	5.86	7.72	April	51.1	4.18	5.69
May	302	119	129	May	20.5	1.66	2.15
June	116	12.8	15.7	June	28.7	2.27	3.09
July	60.5	5.56	6.63	July	151	20.6	23.6
August	64.1	6.39	7.64	August	21.4	1.74	2.25
September	37.3	3.42	4.27	September	12.1	1.11	1.27
	Water year 1995				Water year 1996		
October	25.0	2.30	2.94	October	88.7	19.1	22.8
November	13.2	1.17	1.37	November	72.4	10.4	12.9
December	41.8	5.85	7.94	December	174	68.9	74.0
January	42.2	4.26	5.50	January	93.4	13.9	16.0
February	49.0	5.15	6.95	February	93.6	13.6	15.9
March	78.1	10.2	12.6	March	127	19.8	22.3
April	117	18.9	22.2	April	125	15.4	17.9
May	178	37.7	41.9	May	32.1	2.46	3.03
June	45.9	4.14	5.96	June	45.9	3.97	5.18
July	57.2	6.11	8.28	July	65.0	6.67	8.03
August	86.3	13.2	16.6	August	41.5	4.10	4.97
September	15.1	1.23	1.48	September	20.7	1.89	2.19
	Water year 1997				Water year 1998		
October	12.9	1.18	1.34	October	42.5	6.12	7.09
November	15.4	1.46	1.69	November	76.7	14.9	16.9
December	22.5	2.21	2.81	December	48.9	6.98	7.85
January	42.8	4.43	5.35	January	117	22.3	23.9
February	52.1	5.45	6.63	February	56.7	8.12	8.86
March	39.5	4.17	5.36	March	87.4	16.9	18.7
April	34.6	3.49	4.41	April	40.2	6.02	6.44
May	34.2	3.70	4.73	May	20.7	3.34	3.55
June	105	14.2	16.1	June	17.9	3.02	3.20
July	119	17.5	19.5	July	37.1	4.67	7.03
August	40.1	5.07	5.69	August	25.7	4.67	5.04
September	15.4	1.88	2.06	September	612	492	504

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

Total inorganic nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991				**Water year 1992**			
October	51.4	13.3	14.9	October	41.7	7.32	9.17
November	57.2	13.4	15.6	November	52.2	8.85	11.6
December	66.0	14.3	17.0	December	52.4	9.39	11.7
January	115	32.0	36.1	January	77.5	15.3	18.8
February	92.7	18.6	23.0	February	86.6	21.3	24.8
March	90.3	18.7	22.7	March	60.0	10.1	13.0
April	74.3	15.3	18.6	April	44.1	8.96	10.8
May	118	45.8	48.5	May	38.4	8.24	9.68
June	71.5	16.8	19.5	June	36.6	7.17	8.72
July	66.9	16.3	18.8	July	32.7	6.61	7.91
August	48.1	11.0	12.8	August	37.8	6.92	8.71
September	46.3	9.29	11.2	September	32.6	5.81	7.31
Water year 1993				**Water year 1994**			
October	31.1	7.01	8.13	October	31.6	6.52	7.89
November	58.9	15.4	17.7	November	35.5	7.71	9.16
December	58.9	13.7	16.0	December	39.3	8.60	10.1
January	60.3	13.3	15.8	January	42.2	8.96	10.7
February	57.8	11.0	13.7	February	38.8	8.03	9.73
March	63.0	12.7	15.4	March	42.0	8.27	10.1
April	49.6	8.86	11.2	April	37.7	7.27	9.00
May	47.7	11.9	13.8	May	28.1	6.38	7.42
June	42.8	8.86	10.8	June	27.7	5.53	6.70
July	35.4	7.66	9.02	July	38.4	9.79	11.2
August	34.7	7.94	9.23	August	24.4	4.96	5.94
September	31.4	6.70	7.95	September	22.9	5.25	6.10
Water year 1995				**Water year 1996**			
October	27.2	5.66	6.74	October	29.9	7.19	8.43
November	26.6	5.90	6.91	November	35.3	8.43	9.81
December	33.1	7.36	8.72	December	38.8	10.8	12.2
January	37.2	8.06	9.59	January	45.6	10.9	12.6
February	38.9	8.05	9.87	February	46.3	10.5	12.5
March	41.8	8.69	10.5	March	48.0	11.8	13.6
April	42.1	9.44	11.3	April	47.1	10.6	12.4
May	41.1	10.8	12.4	May	29.8	5.76	7.00
June	28.5	5.49	6.81	June	29.1	5.89	7.14
July	27.9	5.69	6.89	July	30.0	6.77	7.93
August	29.1	6.57	7.79	August	26.9	6.12	7.11
September	22.8	4.57	5.51	September	24.4	5.21	6.17
Water year 1997				**Water year 1998**			
October	23.9	5.06	5.97	October	30.5	8.86	9.86
November	26.8	5.75	6.80	November	38.5	12.0	13.3
December	30.9	6.69	7.91	December	40.8	12.2	13.4
January	39.1	8.53	10.1	January	56.5	19.9	21.4
February	41.9	9.17	11.0	February	47.8	14.8	16.3
March	36.6	8.10	9.55	March	48.6	16.6	17.9
April	32.5	7.72	8.97	April	38.4	13.2	14.2
May	29.1	7.43	8.45	May	29.0	10.9	11.6
June	37.7	10.7	11.9	June	25.9	10.3	10.9
July	37.3	11.5	12.6	July	29.0	11.7	12.4
August	28.1	8.20	9.03	August	26.2	10.8	11.4
September	23.8	6.64	7.37	September	30.0	13.9	14.6

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Big Creek at County Road 63 near Wilmer, 02479945 (site BIG)

Total phosphorus

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	0.975	0.260	0.314	October	1.24	.290	.358
November	1.54	.384	.563	November	3.12	.825	1.23
December	2.38	.603	.889	December	2.39	.537	.714
January	10.9	3.88	4.79	January	7.22	2.03	2.68
February	5.23	1.37	1.86	February	9.41	2.86	3.78
March	5.50	1.53	2.17	March	3.11	.689	.925
April	3.56	.937	1.30	April	1.27	.349	.415
May	17.0	7.91	9.24	May	.983	.276	.325
June	4.72	1.45	1.72	June	1.15	.291	.365
July	5.23	1.81	2.15	July	.997	.245	.313
August	2.29	.060	.732	August	2.55	.762	1.06
September	2.19	.550	.709	September	1.32	.290	.404
	Water year 1993				Water year 1994		
October	0.896	0.212	0.265	October	2.67	.741	1.20
November	9.05	3.44	4.17	November	3.20	.782	1.15
December	7.79	2.50	3.31	December	3.62	.828	1.17
January	7.36	2.13	3.03	January	3.85	.847	1.26
February	4.99	1.06	1.47	February	2.56	.552	.782
March	6.49	1.52	2.04	March	3.53	.739	1.13
April	3.82	.825	1.16	April	2.86	.615	.930
May	7.32	3.09	4.40	May	1.20	.290	.396
June	4.35	1.31	1.71	June	1.54	.358	.509
July	2.87	.740	.937	July	6.03	2.24	2.69
August	3.27	.911	1.14	August	1.38	.324	.439
September	2.43	.590	.791	September	1.00	.238	.298
	Water year 1995				Water year 1996		
October	2.15	0.524	0.727	October	5.22	2.29	3.07
November	1.48	.349	.449	November	6.10	2.19	2.79
December	3.51	.981	1.58	December	10.3	4.95	6.69
January	3.84	.920	1.35	January	8.22	2.67	3.39
February	3.97	.925	1.45	February	7.57	2.26	3.01
March	5.03	1.25	1.87	March	8.15	2.51	3.20
April	5.83	1.68	2.37	April	7.59	2.29	2.85
May	7.08	2.55	3.33	May	2.33	.615	.758
June	2.45	.642	.939	June	2.90	.845	1.08
July	3.03	.948	1.28	July	4.02	1.39	1.66
August	4.23	1.61	2.11	August	3.12	1.01	1.21
September	1.40	.355	.443	September	2.12	.620	.740
	Water year 1997				Water year 1998		
October	1.63	0.469	0.546	October	4.66	1.92	2.30
November	2.16	.630	.753	November	8.08	3.65	4.39
December	3.02	.897	1.15	December	6.65	2.50	2.90
January	5.13	1.57	1.94	January	12.9	5.38	6.11
February	5.48	1.64	2.06	February	6.99	2.41	2.81
March	3.77	1.08	1.44	March	8.03	2.96	3.61
April	2.87	.834	1.10	April	4.06	1.34	1.56
May	2.51	.769	1.01	May	2.05	.694	.801
June	6.35	2.50	2.89	June	1.72	.601	.693
July	7.33	3.19	3.59	July	3.32	1.30	1.49
August	3.49	1.26	1.45	August	2.66	1.04	1.21
September	1.82	.594	.683	September	22.5	19.6	23.3

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

Total nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	19.1	3.20	3.28	October	22.4	2.00	2.18
November	20.6	2.66	2.81	November	25.8	2.62	2.87
December	22.8	2.28	2.49	December	23.4	2.36	2.54
January	47.0	6.14	6.50	January	36.4	4.10	4.39
February	32.0	2.22	2.65	February	49.9	7.10	7.45
March	39.4	3.01	3.46	March	38.1	3.48	3.80
April	36.7	2.72	3.16	April	27.3	2.42	2.64
May	72.8	11.3	11.7	May	21.3	2.18	2.33
June	49.2	4.17	4.62	June	24.7	2.36	2.59
July	43.0	3.91	4.27	July	24.8	2.76	2.94
August	28.4	2.56	2.80	August	21.3	2.58	2.73
September	26.8	2.38	2.62	September	18.6	2.52	2.62

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

Total Kjeldahl nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	6.54	1.62	1.74	October	6.61	1.40	1.53
November	7.45	1.57	1.86	November	8.87	2.08	2.43
December	8.47	1.58	1.91	December	6.84	1.41	1.57
January	22.4	6.82	7.38	January	14.6	3.23	3.69
February	14.2	2.38	3.00	February	21.9	5.89	6.48
March	19.2	4.20	4.78	March	15.3	2.67	3.10
April	18.5	3.57	4.26	April	9.23	1.71	1.93
May	44.4	14.6	15.3	May	6.52	1.36	1.50
June	27.0	5.85	6.46	June	8.62	1.84	2.13
July	21.6	4.90	5.40	July	8.11	2.08	2.25
August	10.7	2.31	2.54	August	6.28	1.73	1.86
September	9.50	2.02	2.27	September	4.72	1.46	1.54

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

Total inorganic nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	9.70	0.665	0.711	October	16.0	0.912	1.00
November	10.9	.626	.689	November	17.0	1.01	1.11
December	12.5	.657	.733	December	17.1	.983	1.08
January	18.5	1.39	1.48	January	20.4	1.13	1.25
February	16.8	.817	.939	February	23.5	1.62	1.74
March	19.2	.970	1.09	March	20.5	1.02	1.15
April	19.1	1.03	1.15	April	17.1	.896	1.00
May	26.5	2.75	2.83	May	14.4	.863	.940
June	21.7	1.34	1.45	June	13.9	.784	.866
July	20.2	1.30	1.40	July	12.8	.830	.894
August	17.1	1.04	1.13	August	11.2	.777	.830
September	16.8	.971	1.07	September	9.98	.802	.843

Juniper Creek at Glenwood Road near Fairview, 02479948 (site JUN)

Total phosphorus

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	0.220	0.134	0.155	October	1.31	0.585	0.713
November	.053	.284	.489	November	3.91	2.84	3.95
December	.770	.384	.622	December	2.00	.970	1.24
January	13.1	14.7	18.4	January	6.56	4.65	6.12
February	1.33	.657	1.15	February	19.5	21.9	28.3
March	3.00	2.21	3.59	March	2.42	1.21	1.65
April	1.12	.600	.902	April	.640	.339	.398
May	9.67	9.88	11.7	May	.313	.179	.209
June	1.60	.934	1.13	June	.586	.304	.451
July	1.56	.932	1.13	July	.628	.344	.426
August	.950	.481	.615	August	.670	.390	.492
September	1.40	.719	.926	September	.696	.438	.506

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

Total nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991				Water year 1992			
October	10.0	1.25	1.30	October	12.8	1.10	1.18
November	11.1	1.16	1.22	November	15.0	1.24	1.36
December	15.1	1.67	1.76	December	12.6	1.09	1.17
January	41.1	7.13	7.48	January	18.2	1.65	1.80
February	19.5	1.39	1.62	February	35.2	5.83	6.14
March	19.0	1.23	1.47	March	17.5	1.41	1.54
April	19.1	1.20	1.41	April	12.2	.91	1.00
May	55.6	11.4	11.8	May	10.0	1.09	1.14
June	28.4	1.84	2.09	June	14.2	1.20	1.31
July	25.7	1.74	1.96	July	12.6	1.24	1.32
August	17.4	1.21	1.34	August	9.95	1.00	1.06
September	15.7	1.14	1.26	September	9.51	1.18	1.22

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

Total Kjeldahl nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991				Water year 1992			
October	5.02	0.736	0.780	October	6.29	0.773	0.836
November	5.43	.663	.738	November	7.57	.890	1.01
December	7.75	.930	1.03	December	5.83	.687	.749
January	34.6	13.0	13.5	January	10.1	1.27	1.46
February	11.7	1.21	1.54	February	28.6	9.40	9.97
March	12.1	1.29	1.60	March	10.4	1.12	1.28
April	12.6	1.23	1.49	April	7.00	.718	.804
May	59.8	24.0	24.8	May	5.95	.783	.842
June	21.2	2.35	2.63	June	9.48	1.39	1.50
July	18.6	2.11	2.35	July	8.11	1.38	1.45
August	10.5	1.14	1.26	August	5.85	1.00	1.04
September	8.77	.953	1.07	September	5.23	1.09	1.12

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

Total inorganic nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	3.88	0.326	0.349	October	5.23	0.392	0.425
November	4.41	.315	.348	November	6.05	.426	.471
December	6.09	.424	.468	December	5.52	.391	.429
January	7.97	.596	.649	January	6.68	.447	.498
February	6.34	.370	.428	February	7.89	.635	.689
March	5.54	.335	.381	March	6.24	.408	.454
April	5.41	.341	.387	April	4.32	.267	.302
May	8.08	.670	.718	May	3.19	.244	.265
June	7.40	.516	.569	June	4.66	.378	.409
July	7.21	.512	.562	July	4.43	.413	.438
August	6.09	.418	.460	August	3.68	.331	.353
September	5.80	.394	.438	September	3.93	.455	.473

Collins Creek at Glenwood Road near Fairview, 02479950 (site COL)

Total phosphorus

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	0.248	0.092	0.099	October	0.515	0.159	0.175
November	.344	.107	.121	November	.789	.232	.270
December	.589	.176	.200	December	.712	.208	.232
January	1.37	.623	.671	January	1.25	.388	.452
February	.820	.206	.263	February	2.04	.811	.891
March	.744	.203	.256	March	1.08	.306	.351
April	.636	.163	.200	April	.610	.156	.179
May	1.47	.540	.597	May	.419	.127	.141
June	.865	.253	.286	June	.629	.214	.236
July	.778	.234	.263	July	.547	.211	.226
August	.523	.150	.167	August	.463	.171	.184
September	.542	.153	.173	September	.503	.240	.251

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Long Branch near Wilmer, 02479955 (site LON)

Total nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991		
October	1.51	0.487	0.499
November	5.35	1.01	1.06
December	9.61	2.24	2.32
January	34.8	37.1	37.3
February	19.6	3.35	3.61
March	12.9	6.25	6.41
April	13.6	2.13	2.31
May	19.9	7.82	8.16
June	22.0	2.40	2.77
July	19.6	3.23	3.47
August	13.2	2.25	2.40
September	6.41	1.52	1.58

Long Branch near Wilmer, 02479955 (site LON)

Total Kjeldahl nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991		
October	1.59	0.558	0.591
November	1.87	.520	.571
December	2.09	.608	.660
January	11.56	6.07	6.32
February	6.18	1.61	1.84
March	6.16	1.54	1.81
April	6.18	1.57	1.85
May	19.78	9.36	9.75
June	9.87	2.64	2.92
July	10.34	2.85	3.21
August	7.34	2.20	2.39
September	5.72	2.57	2.67

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Long Branch near Wilmer, 02479955 (site LON)

Total inorganic nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991			
October	2.58	0.282	0.299
November	3.68	.323	.354
December	5.15	.486	.525
January	37.0	7.08	7.37
February	17.0	1.45	1.65
March	15.9	1.34	1.58
April	11.6	.956	1.10
May	30.0	4.95	5.16
June	9.84	.861	.947
July	8.53	.789	.883
August	5.37	.536	.578
September	4.75	.720	.744

Long Branch near Wilmer, 02479955 (site LON)

Total phosphorus

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991			
October	0.058	0.051	0.052
November	.116	.168	.072
December	.148	.068	.074
January	.223	.118	.127
February	.234	.093	.104
March	.214	.078	.089
April	.202	.075	.086
May	.306	.172	.182
June	.308	.125	.139
July	.343	.127	.143
August	.361	.158	.173
September	.313	.220	.228

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Boggy Branch near Wilmer, 02479960 (site BOG)

Total nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991		
October	2.28	0.386	0.441
November	6.24	3.65	3.93
December	6.90	2.50	2.73
January	-128	301	303
February	8.42	2.33	3.15
March	-2.90	23.0	23.9
April	25.5	11.3	11.7
May	-77.2	201	204
June	22.0	6.17	6.61
July	-4.91	28.0	29.0
August	6.05	.798	.914
September	2.95	.915	.951

Boggy Branch near Wilmer, 02479960 (site BOG)

Total Kjeldahl nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991		
October	1.96	0.401	0.466
November	3.29	1.12	1.37
December	3.30	.765	.917
January	22.6	9.54	10.1
February	9.67	1.97	2.32
March	13.0	2.55	3.00
April	20.3	4.02	4.64
May	60.5	17.9	18.8
June	16.3	2.89	3.35
July	22.4	6.40	7.15
August	4.57	.808	.896
September	1.72	.453	.487

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Boggy Branch near Wilmer, 02479960 (site BOG)

Total inorganic nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991			
October	0.573	0.093	0.109
November	1.41	.361	.442
December	1.91	.341	.406
January	12.9	4.34	4.56
February	4.51	.713	.834
March	4.76	.773	.912
April	4.54	.698	.802
May	10.8	2.54	2.68
June	2.93	.414	.477
July	4.58	1.01	1.12
August	1.68	.244	.269
September	1.20	.259	.280

Boggy Branch near Wilmer, 02479960 (site BOG)

Total phosphorus

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991			
October	0.124	0.023	0.025
November	.139	.021	.023
December	.165	.024	.027
January	.230	.052	.054
February	.232	.034	.037
March	.243	.034	.038
April	.250	.038	.042
May	.290	.068	.070
June	.239	.037	.041
July	.239	.037	.040
August	.215	.036	.039
September	.196	.052	.053

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Crooked Creek near Fairview, 02479980 (site CRO)

Total nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	15.0	1.64	1.81	October	18.8	1.49	1.76
November	19.3	1.94	2.31	November	30.2	3.18	3.91
December	26.8	3.08	3.65	December	20.9	1.70	2.01
January	80.2	27.4	28.1	January	42.4	6.87	7.66
February	38.4	4.62	5.35	February	51.8	10.3	11.1
March	40.4	5.71	6.40	March	31.6	2.51	3.22
April	46.2	6.01	6.77	April	18.0	1.46	1.72
May	90.1	20.2	21.0	May	18.8	1.50	1.95
June	40.9	4.41	4.98	June	25.9	2.13	2.68
July	45.9	5.38	6.08	July	19.4	1.63	1.94
August	30.0	2.93	3.33	August	18.2	1.55	1.84
September	23.7	2.03	2.41	September	20.1	1.81	2.31
	Water year 1993				Water year 1994		
October	14.7	1.41	1.59	October	23.9	3.33	4.05
November	42.9	5.76	6.54	November	19.4	2.15	2.39
December	37.4	6.04	6.87	December	19.2	2.15	2.38
January	42.9	12.9	13.5	January	28.1	3.96	4.65
February	29.7	2.77	3.23	February	15.6	1.68	1.87
March	51.0	7.98	8.84	March	22.7	2.06	2.49
April	32.8	2.76	3.29	April	21.6	1.82	2.26
May	51.6	13.0	13.8	May	16.2	1.51	1.75
June	36.8	3.58	4.18	June	30.4	5.29	6.25
July	35.2	3.68	1.46	July	54.1	8.89	9.91
August	29.5	3.13	3.50	August	21.6	2.18	2.50
September	30.9	3.57	3.97	September	15.4	1.75	1.92
	Water year 1995				Water year 1996		
October	20.7	2.39	2.73	October	49.1	12.4	13.3
November	15.6	1.91	2.14	November	38.8	6.54	7.34
December	22.7	3.40	4.04	December	49.5	23.5	24.0
January	29.4	4.07	4.71	January	42.9	7.11	7.82
February	19.5	2.06	2.36	February	38.6	5.64	6.39
March	32.4	4.12	4.87	March	42.3	6.77	7.55
April	37.6	4.91	5.78	April	50.8	7.41	8.29
May	63.8	27.4	28.1	May	24.0	1.97	2.31
June	32.5	3.05	3.85	June	25.2	2.12	2.54
July	27.5	2.87	3.06	July	35.7	3.73	4.30
August	55.3	13.3	14.3	August	42.3	5.18	5.84
September	22.1	2.46	2.72	September	28.1	3.35	3.73
	Water year 1997				Water year 1998		
October	20.4	2.50	2.71	October	39.7	7.84	8.50
November	17.3	2.27	2.43	November	58.6	17.2	17.9
December	29.8	4.64	5.21	December	37.7	6.82	7.31
January	33.3	4.91	5.47	January	95.6	34.3	34.9
February	35.9	4.71	5.32	February	45.6	7.76	8.27
March	32.1	4.73	5.35	March	55.5	18.4	18.9
April	25.4	2.69	3.23	April	37.3	5.55	6.00
May	42.5	10.9	11.6	May	26.8	3.90	4.24
June	75.0	18.5	19.4	June	22.6	3.47	3.73
July	137	50.1	50.9	July	47.3	9.22	9.79
August	54.4	7.79	8.32	August	30.3	5.33	5.65
September	30.4	4.18	4.46	September	80.9	43.8	44.3

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Crooked Creek near Fairview, 02479980 (site CRO)

Total Kjeldahl nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991				Water year 1992			
October	5.72	1.11	1.23	October	6.58	.870	1.07
November	7.77	1.39	1.83	November	12.7	2.86	3.73
December	12.6	2.91	3.63	December	6.95	.940	1.66
January	57.5	42.7	43.8	January	22.7	9.26	10.4
February	23.3	6.29	4.52	February	33.5	16.4	17.7
March	28.3	9.24	10.5	March	17.4	2.90	3.99
April	38.0	10.2	11.7	April	8.76	1.19	1.46
May	92.9	45.5	47.5	May	10.8	1.47	2.23
June	29.1	5.41	6.43	June	15.3	2.24	3.07
July	33.2	7.14	8.50	July	9.34	1.32	1.66
August	15.3	2.51	2.97	August	7.67	1.07	1.36
September	10.0	1.45	1.82	September	7.31	1.22	1.77
Water year 1993				Water year 1994			
October	4.47	0.669	0.796	October	9.09	2.83	3.73
November	17.7	4.79	5.64	November	5.24	.879	1.04
December	16.1	6.91	7.95	December	5.18	.883	1.04
January	17.9	12.6	13.2	January	11.3	4.09	5.01
February	11.7	1.85	2.27	February	4.80	.778	.917
March	33.2	12.9	14.2	March	9.08	1.38	1.83
April	16.9	2.53	3.17	April	9.70	1.39	1.91
May	37.7	24.4	25.9	May	6.95	1.07	1.31
June	20.5	3.53	4.35	June	20.4	9.14	11.0
July	17.7	3.17	3.74	July	35.6	13.5	15.3
August	12.2	2.11	2.47	August	8.02	1.26	1.59
September	11.2	2.10	2.46	September	4.50	.763	.880
Water year 1995				Water year 1996			
October	6.02	1.06	1.38	October	22.0	16.6	14.7
November	3.91	.692	.876	November	13.3	5.02	5.93
December	7.52	2.47	3.19	December	14.6	11.2	11.7
January	10.9	3.17	3.89	January	16.0	5.84	6.57
February	6.05	.982	1.25	February	15.1	5.16	6.01
March	15.4	4.66	5.64	March	21.3	8.74	9.80
April	21.4	6.81	8.10	April	27.8	10.3	11.6
May	40.7	29.6	30.7	May	9.62	1.37	1.67
June	17.0	3.36	4.61	June	10.4	1.46	1.87
July	11.1	1.73	2.11	July	15.2	2.51	3.13
August	30.7	19.3	20.8	August	17.4	3.51	4.38
September				September	8.34	1.36	1.71
Water year 1997				Water year 1998			
October	4.90	0.790	0.925	October	13.3	5.43	6.19
November	3.76	.662	.756	November	21.4	13.3	13.9
December	8.97	2.66	3.23	December	11.0	3.69	4.19
January	10.9	3.16	3.75	January	37.9	24.5	25.1
February	13.07	3.14	3.77	February	16.3	4.92	5.46
March	14.0	4.47	5.22	March	23.3	15.5	16.0
April	10.8	2.14	2.82	April	16.1	4.18	4.73
May	27.1	16.0	17.2	May	11.2	2.74	3.17
June	49.5	26.3	27.7	June	8.88	2.19	2.51
July	85.0	58.8	59.9	July	22.4	7.57	8.37
August	21.5	4.44	5.04	August	10.5	2.72	3.09
September	8.60	1.56	1.78	September	27.2	18.6	19.2

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Crooked Creek near Fairview, 02479980 (site CRO)

Total inorganic nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	10.9	1.97	2.20	October	10.4	1.24	1.56
November	12.3	1.95	2.28	November	13.0	1.83	2.27
December	14.9	2.45	2.89	December	11.5	1.39	1.74
January	28.1	11.6	11.9	January	17.0	3.26	3.73
February	20.3	3.46	4.06	February	19.9	4.67	5.17
March	21.0	3.85	4.41	March	15.9	1.91	2.45
April	22.5	4.14	4.75	April	11.8	1.51	1.86
May	32.5	9.89	10.4	May	11.2	1.59	1.92
June	19.1	2.99	3.40	June	12.6	1.61	2.03
July	18.9	3.10	3.60	July	10.2	1.39	1.68
August	14.0	1.99	2.36	August	9.34	1.26	1.52
September	11.8	1.50	1.85	September	9.19	1.21	1.51
	Water year 1993				Water year 1994		
October	8.09	1.01	1.32	October	8.90	1.44	1.73
November	13.9	2.55	2.93	November	8.58	1.23	1.46
December	13.1	2.36	2.74	December	8.93	1.29	1.53
January	13.9	2.70	3.02	January	11.1	1.79	2.14
February	13.6	1.92	2.32	February	8.92	1.26	1.51
March	18.2	3.69	4.17	March	10.9	1.42	1.76
April	14.6	1.95	2.38	April	10.6	1.40	1.74
May	16.1	3.30	3.69	May	8.93	1.38	1.61
June	13.9	2.05	2.44	June	10.7	2.11	2.46
July	12.8	1.95	2.28	July	14.6	3.05	3.45
August	10.9	1.64	1.92	August	8.79	1.24	1.48
September	10.7	1.72	1.99	September	7.27	1.13	1.31
	Water year 1995				Water year 1996		
October	8.16	1.19	1.42	October	11.9	3.01	3.31
November	7.31	1.14	1.33	November	11.2	2.13	2.45
December	8.79	1.48	1.76	December	11.5	3.07	3.30
January	10.9	1.87	2.20	January	13.7	2.74	3.10
February	9.57	1.34	1.63	February	13.7	2.34	2.74
March	12.5	1.98	2.38	March	14.8	2.76	3.17
April	13.6	2.29	2.72	April	16.8	3.04	3.50
May	15.3	5.16	5.46	May	11.1	1.46	1.77
June	11.9	1.64	2.04	June	10.7	1.42	1.74
July	10.4	1.45	1.74	July	12.1	1.66	2.02
August	13.2	3.00	3.33	August	12.7	1.95	2.31
September	8.58	1.20	1.43	September	9.96	1.39	1.68
	Water year 1997				Water year 1998		
October	8.54	1.19	1.42	October	12.5	2.61	2.92
November	8.14	1.20	1.41	November	15.8	5.22	5.52
December	10.9	1.88	2.20	December	13.9	2.91	3.22
January	12.6	2.20	2.55	January	25.2	10.9	11.2
February	14.2	2.37	2.80	February	18.2	4.03	4.43
March	13.4	2.42	2.81	March	19.0	5.78	6.07
April	12.0	1.87	2.23	April	16.8	3.50	3.87
May	14.2	4.17	4.49	May	13.5	2.88	3.16
June	20.3	6.36	6.75	June	11.8	2.69	2.92
July	27.4	12.1	12.3	July	16.6	4.13	4.47
August	16.2	2.93	3.30	August	12.6	2.83	3.08
September				September	17.5	6.94	7.19

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Crooked Creek near Fairview, 02479980 (site CRO)

Total phosphorus

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
Water year 1991				Water year 1992			
October	0.323	0.078	0.092	October	.407	.088	.106
November	.585	.148	.212	November	1.17	.410	.563
December	1.26	.426	.565	December	.656	.132	.167
January	10.6	7.22	8.01	January	3.20	1.52	1.94
February	2.74	.974	1.29	February	5.04	2.56	3.16
March	3.29	1.30	1.69	March	1.88	.485	.717
April	3.32	1.16	1.43	April	.677	.144	.177
May	8.42	4.36	4.95	May	.702	.144	.236
June	4.68	.454	.558	June	.915	.201	.294
July	1.84	.595	.731	July	.462	.101	.129
August	.769	.183	.223	August	.380	.081	.106
September	.544	.123	.157	September	.479	.110	.177
Water year 1993				Water year 1994			
October	0.284	0.061	0.075	October	.839	.329	.534
November	1.81	.710	.880	November	.471	.093	.123
December	2.27	1.13	1.56	December	.569	.110	.146
January	6.40	4.95	6.45	January	1.76	.710	1.10
February	1.41	.275	.377	February	.553	.111	.141
March	4.37	1.83	2.28	March	1.07	.119	.317
April	1.58	.304	.418	April	.934	.169	.273
May	5.75	3.66	4.90	May	.511	.109	.143
June	1.34	.296	.400	June	1.74	.779	1.22
July	1.06	.229	.299	July	2.77	1.22	1.54
August	.707	.143	.186	August	.478	.094	.134
September	.738	.159	.208	September	.275	.062	.074
Water year 1995				Water year 1996			
October	0.481	0.102	0.157	October	2.72	1.65	2.06
November	.388	.080	.127	November	1.73	.797	1.08
December	1.01	.385	.615	December	11.0	10.5	12.7
January	1.72	.620	.877	January	2.83	1.23	1.54
February	.801	.155	.230	February	2.77	1.13	1.56
March	2.30	.811	1.20	March	3.63	1.56	2.12
April	2.68	.964	1.37	April	4.11	1.71	2.31
May	14.2	11.6	14.1	May	.869	.187	.231
June	1.40	.378	.606	June	.814	.174	.232
July	.739	.149	.198	July	1.16	.288	.370
August	3.55	2.22	2.91	August	1.39	.423	.548
September	.454	.096	.121	September	.693	.172	.228
Water year 1997				Water year 1998			
October	0.444	0.108	0.127	October	1.77	.870	1.14
November	.414	.105	.123	November	4.39	2.80	3.25
December	1.43	.559	.751	December	2.05	.888	1.13
January	2.01	.787	1.02	January	13.1	9.19	10.2
February	2.31	.772	.989	February	3.25	1.24	1.47
March	2.37	.875	1.18	March	9.51	6.64	8.13
April	1.41	.381	.568	April	2.35	.733	.909
May	3.93	2.07	2.69	May	1.26	.346	.454
June	5.80	3.00	3.47	June	.838	.226	.302
July	14.2	10.1	11.1	July	2.23	.884	1.07
August	1.86	.586	.672	August	.948	.292	.369
September	.758	.201	.233	September	20.6	22.0	24.8

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

Total nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	31.5	2.01	2.12	October	33.3	1.33	1.52
November	31.0	1.91	2.04	November	36.4	1.44	1.69
December	35.8	1.83	2.02	December	36.5	1.66	1.85
January	81.5	6.57	7.13	January	51.9	2.79	3.07
February	45.5	2.20	2.48	February	58.3	2.92	3.37
March	46.6	2.09	2.37	March	42.5	1.70	1.97
April	53.4	2.33	2.72	April	34.5	1.17	1.40
May	74.6	5.53	6.02	May	32.5	1.30	1.49
June	44.3	1.85	2.11	June	40.8	1.50	1.78
July	46.2	1.99	2.26	July	35.4	1.35	1.56
August	41.1	1.70	1.92	August	31.4	1.41	1.58
September	39.2	1.59	1.81	September	32.2	1.41	1.61
	Water year 1993				Water year 1994		
October	27.7	1.46	1.58	October	31.0	1.64	1.82
November	41.8	2.18	2.44	November	32.8	1.82	1.96
December	39.3	1.99	2.25	December	31.2	1.74	1.87
January	65.0	11.5	12.0	January	34.1	1.92	2.08
February	39.5	2.10	2.30	February	27.8	1.52	1.65
March	58.5	4.09	4.53	March	36.3	1.84	2.02
April	42.7	1.94	2.18	April	35.0	1.57	1.77
May	47.6	2.47	2.80	May	28.7	1.47	1.60
June	36.3	1.48	1.70	June	48.3	4.59	4.93
July	38.6	1.77	1.97	July	38.6	1.96	2.16
August	33.0	1.51	1.67	August	28.7	1.52	1.65
September	31.0	1.49	1.65	September	26.8	1.57	1.68
	Water year 1995				Water year 1996		
October	30.5	1.67	1.83	October	48.5	4.75	5.10
November	29.5	1.72	1.89	November	39.1	2.38	2.58
December	31.5	1.83	1.98	December	82.3	27.5	28.1
January	37.9	2.31	2.51	January	40.5	2.52	2.72
February	30.6	1.68	1.83	February	42.9	2.65	2.98
March	39.4	2.14	2.35	March	47.5	3.40	3.74
April	48.1	3.00	3.31	April	57.9	4.34	4.70
May	82.2	20.6	21.0	May	32.3	1.37	1.55
June	36.6	1.67	1.89	June	38.9	1.82	2.08
July	35.1	1.59	1.77	July	35.6	1.53	1.73
August	43.4	3.07	3.37	August	39.0	1.81	2.02
September	25.1	1.60	1.70	September	32.1	1.49	1.65
	Water year 1997				Water year 1998		
October	28.8	1.48	1.61	October	38.4	2.23	2.45
November	27.8	1.57	1.69	November	52.9	3.83	4.14
December	33.2	1.89	2.07	December	41.0	2.88	3.02
January	31.0	1.84	1.97	January	92.4	20.0	20.4
February	34.6	1.97	2.15	February	40.6	2.91	3.08
March	34.8	1.98	2.18	March	74.8	18.8	19.2
April	31.5	1.79	1.95	April	36.5	2.66	2.80
May	41.7	3.00	3.24	May	33.3	2.53	2.63
June	52.7	3.86	4.17	June	28.9	2.59	2.68
July	94.0	19.2	19.7	July	35.9	2.76	2.88
August	37.1	1.87	2.04	August	28.3	2.52	2.60
September	35.1	1.88	2.03	September	165	99.8	100

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

Total Kjeldahl nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	8.44	1.17	1.29	October	9.51	.940	1.12
November	7.83	.994	1.19	November	11.8	1.25	1.72
December	11.1	1.28	1.74	December	10.3	1.07	1.29
January	53.9	18.4	19.8	January	22.6	3.05	3.75
February	18.0	2.11	2.80	February	30.2	5.49	6.66
March	20.1	2.38	2.98	March	16.2	1.63	2.14
April	30.6	4.53	5.61	April	10.9	.998	1.23
May	58.3	17.2	18.9	May	10.7	1.05	1.33
June	22.4	2.67	3.15	June	18.7	2.02	2.53
July	24.9	3.14	3.73	July	13.5	1.33	1.63
August	17.8	2.03	2.34	August	10.1	1.03	1.27
September	15.1	1.68	1.97	September	10.5	1.13	1.50
	Water year 1993				Water year 1994		
October	6.08	0.753	0.849	October	9.07	1.25	1.70
November	16.4	2.49	3.09	November	8.35	1.06	1.20
December	13.7	1.99	2.68	December	7.01	.870	.992
January	28.5	19.3	20.3	January	9.23	1.18	1.49
February	12.5	1.45	1.76	February	5.47	.720	.810
March	32.8	9.94	11.1	March	11.1	1.30	1.59
April	17.6	2.05	2.53	April	11.3	1.24	1.50
May	26.3	5.08	6.14	May	7.77	.945	1.10
June	14.1	1.50	1.81	June	30.7	11.4	12.6
July	16.2	1.94	2.25	July	17.1	2.37	2.82
August	11.0	1.22	1.44	August	7.75	.961	1.08
September	6.80	1.01	1.18	September	6.09	.836	.926
	Water year 1995				Water year 1996		
October	8.65	1.20	1.58	October	26.0	10.4	11.4
November	7.50	1.12	1.54	November	13.1	2.04	2.45
December	8.04	1.13	1.47	December	23.8	19.9	20.4
January	12.1	1.89	2.34	January	12.9	1.97	2.40
February	6.83	.837	.963	February	15.5	3.62	4.38
March	13.9	1.91	2.33	March	21.2	6.32	7.14
April	24.3	5.34	6.16	April	31.6	9.13	10.0
May	47.1	36.8	37.7	May	9.69	1.03	1.21
June	14.5	1.76	2.21	June	16.9	2.38	2.99
July	12.7	1.41	1.65	July	13.2	1.47	1.78
August	23.0	6.35	7.39	August	15.5	1.93	2.27
September	5.23	.760	.838	September	9.17	1.07	1.24
	Water year 1997				Water year 1998		
October	6.51	0.819	0.922	October	13.1	2.28	2.79
November	5.51	.747	.831	November	22.0	5.57	6.20
December	8.75	1.25	1.58	December	11.6	1.98	2.15
January	6.88	.935	1.07	January	34.9	18.3	18.8
February	9.32	1.25	1.51	February	12.0	2.09	2.31
March	10.9	1.74	2.18	March	24.9	16.1	16.6
April	9.40	1.27	1.58	April	11.6	2.07	2.29
May	20.4	4.84	5.54	May	10.0	1.83	1.95
June	29.7	7.64	8.47	June	8.75	1.70	1.91
July	55.9	29.8	30.6	July	12.9	2.39	2.58
August	13.2	1.75	1.97	August	7.75	1.52	1.63
September	10.8	1.51	1.68	September	38.6	30.7	31.3

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

Total inorganic nitrogen

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				Water year 1992		
October	19.6	0.734	0.815	October	20.8	.544	.660
November	20.0	.744	.830	November	21.9	.549	.682
December	22.4	.737	.843	December	24.5	.659	.793
January	27.8	.899	1.03	January	28.0	.843	.983
February	27.2	.854	.998	February	27.7	.781	.937
March	26.3	.792	.924	March	25.6	.645	.794
April	25.3	.766	.896	April	22.2	.563	.694
May	25.6	.873	.988	May	19.4	.572	.672
June	22.7	.690	.806	June	21.5	.579	.701
July	22.4	.697	.806	July	19.7	.523	.632
August	22.0	.675	.782	August	17.8	.501	.596
September	22.0	.650	.765	September	18.1	.501	.604
	Water year 1993				Water year 1994		
October	17.7	0.547	0.633	October	18.3	.580	.670
November	22.7	.655	.779	November	22.2	.698	.808
December	23.4	.637	.765	December	22.4	.676	.787
January	24.3	.655	.790	January	23.3	.689	.809
February	25.9	.732	.883	February	20.9	.684	.790
March	25.5	.731	.864	March	24.0	.683	.809
April	24.5	.690	.824	April	22.5	.639	.761
May	22.6	.656	.772	May	18.4	.640	.722
June	20.6	.585	.697	June	18.8	.661	.748
July	20.9	.641	.744	July	20.0	.635	.732
August	19.1	.559	.656	August	17.6	.565	.648
September	18.8	.557	.656	September	17.2	.587	.665
	Water year 1995				Water year 1996		
October	19.0	0.609	0.700	October	20.1	.652	.747
November	19.2	.651	.741	November	24.1	.803	.917
December	21.6	.682	.786	December	23.3	.718	.835
January	23.9	.739	.858	January	26.4	.827	.954
February	23.3	.695	.824	February	25.8	.755	.896
March	24.2	.712	.837	March	24.6	.716	.843
April	23.1	.723	.839	April	25.3	.789	.916
May	20.7	.686	.783	May	21.9	.606	.723
June	21.0	.617	.727	June	21.5	.616	.732
July	20.9	.623	.728	July	21.1	.597	.709
August	19.7	.623	.719	August	22.3	.683	.793
September	16.7	.612	.684	September	21.4	.622	.735
	Water year 1997				Water year 1998		
October	21.1	0.629	0.735	October	24.2	.850	.956
November	21.8	.681	.789	November	26.4	.993	1.10
December	23.8	.737	.854	December	29.3	1.17	1.28
January	24.7	.771	.892	January	28.7	1.20	1.31
February	25.3	.780	.918	February	29.0	1.16	1.28
March	23.5	.786	.895	March	27.3	1.13	1.23
April	21.7	.787	.884	April	25.7	1.10	1.20
May	20.6	.818	.900	May	24.0	1.06	1.15
June	23.1	.788	.895	June	19.9	1.04	1.10
July	23.9	.967	1.06	July	22.8	1.04	1.12
August	23.2	.765	.872	August	20.0	1.01	1.07
September	23.6	.809	.917	September	19.3	1.08	1.14

Appendix 2. Monthly mean load tables for selected surface-water sites in the J.B. Converse Lake watershed, Mobile County, Alabama, 1990–98—Continued

[kg/d, kilograms per day]

Hamilton Creek at Snow Road near Semmes, 02480002 (site HAM)

Total phosphorus

Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)	Month	Daily mean constituent discharge (kg/d)	Standard error (kg/d)	Standard error of prediction (kg/d)
	Water year 1991				**Water year 1992**		
October	0.637	0.176	0.206	October	.744	.184	.221
November	.595	.154	.207	November	.972	.242	.364
December	.902	.232	.352	December	.823	.184	.237
January	5.766	3.41	4.08	January	2.04	.618	.822
February	1.56	.418	.611	February	2.97	1.18	1.59
March	1.78	.485	.647	March	1.45	.334	.478
April	2.91	1.05	1.36	April	.931	.204	.258
May	6.56	3.66	4.59	May	.941	.210	.283
June	1.99	.551	.677	June	1.72	.426	.567
July	2.23	.663	.821	July	1.18	.271	.347
August	1.51	.386	.464	August	.853	.196	.258
September	1.25	.313	.384	September	.899	.209	.311
	Water year 1993				**Water year 1994**		
October	0.479	0.123	0.147	October	.821	.200	.363
November	1.49	.446	.642	November	.713	.160	.205
December	1.25	.368	.598	December	.596	.136	.172
January	5.19	4.14	5.66	January	.846	.186	.301
February	1.12	.231	.333	February	.470	.117	.142
March	3.83	1.92	2.61	March	1.06	.221	.325
April	1.68	.390	.551	April	1.09	.224	.314
May	2.79	1.04	1.49	May	.732	.158	.210
June	1.31	.281	.376	June	3.98	2.23	3.10
July	1.53	.342	.444	July	1.75	.447	.612
August	.984	.212	.276	August	.710	.161	.200
September	.763	.170	.218	September	.540	.134	.161
	Water year 1995				**Water year 1996**		
October	0.821	0.199	0.345	October	3.43	2.08	2.73
November	.716	.184	.348	November	1.37	.416	.575
December	.765	.190	.319	December	8.92	8.77	11.1
January	1.24	.359	.537	January	1.40	.435	.604
February	.638	.152	.191	February	1.89	.778	1.19
March	1.47	.389	.551	March	2.87	1.40	1.97
April	2.89	1.16	1.54	April	4.20	2.11	2.66
May	11.1	9.47	11.5	May	1.05	.252	.307
June	1.56	.377	.549	June	2.02	.623	.866
July	1.31	.290	.371	July	1.50	.378	.483
August	2.86	1.35	1.95	August	1.75	.483	.606
September	.490	.130	.155	September	.970	.252	.305
	Water year 1997				**Water year 1998**		
October	0.661	0.184	0.215	October	1.63	.627	.858
November	.550	.163	.188	November	3.00	1.52	1.85
December	.967	.306	.431	December	1.38	.472	.539
January	.734	.214	.260	January	8.67	7.02	8.46
February	1.06	.316	.410	February	1.51	.526	.624
March	1.34	.450	.644	March	7.95	6.80	8.58
April	1.14	.330	.453	April	1.54	.504	.612
May	2.84	1.28	1.65	May	1.32	.403	.463
June	4.28	2.06	2.58	June	1.18	.371	.493
July	13.0	10.3	12.2	July	1.75	.568	.664
August	1.59	.458	.537	August	1.00	.314	.374
September	1.26	.370	.430	September	33.3	39.4	44.2

Appendix 3. Methods and results for *Giardia* and *Cryptosporidium* analyses for October 1996 to May 1998

[na, not applicable; —, no results for this assay; gal/min, gallons per minute; >, greater than; ICR, Information Collection Rule]

Sample date	Sample location	Treatment characteristics of sample	Gallons sampled	Liters sampled	Other conditions	Volume assayed (gallons)	Volume assayed (liters)	*Giardia lamblia* cysts	*Giardia* sp. cysts	*Cryptosporidium* oocysts	Method
06/02/93	Pumping station	Raw	250	na	SC=25	125.00	473.13	0	—	0	SM18;9711B, Biovir modification
06/02/93	U.S. Highway 98 bridge	Raw	200	na	na	100.00	378.50	0	—	0	SM18;9711B, Biovir modification
06/03/93	H.E. Myers Filtration Plant	Raw	210	na	na	105.00	397.43	0	—	0	SM18;9711B, Biovir modification
06/03/93	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	300	na	na	150.00	567.75	0	—	0	SM18;9711B, Biovir modification
08/03/93	Pumping station	Raw	247	na	na	123.50	467.45	0	1	0	SM18;9711B, Biovir modification
08/04/93	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	406.3	na	na	203.00	768.36	0	—	0	SM18;9711B, Biovir modification
08/04/93	Mouth of Crooked Creek	Raw	195.5	na	Clogged filter	97.50	369.04	0	—	0	SM18;9711B, Biovir modification
08/04/93	H.E. Myers Filtration Plant	Raw	126	na	Clogged filter	63.00	238.46	0	—	0	SM18;9711B, Biovir modification
11/03/93	U.S. Highway 98 bridge	Raw	212	na	na	106.00	401.21	0	—	0	SM18;9711B, Biovir modification
11/03/93	H.E. Myers Filtration Plant	Raw	220	na	na	110.00	416.35	0	—	0	SM18;9711B, Biovir modification
11/04/93	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	225	na	na	112.50	425.81	0	—	0	SM18;9711B, Biovir modification
11/04/93	Pumping station	Raw	200	na	na	100.00	378.50	0	—	0	SM18;9711B, Biovir modification
02/02/94	Pumping station	Raw	200	na	na	100.00	378.50	0	—	0	SM18;9711B, Biovir modification
02/02/94	Boat Landing—Mouth of Crooked Creek	Raw	210	na	na	105.00	397.43	0	—	0	SM18;9711B, Biovir modification
02/03/94	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	260	na	na	130.00	492.05	0	—	0	SM18;9711B, Biovir modification
02/03/94	Myers Filtration Plant Holding Reservoir	Raw	241	na	na	120.50	456.09	0	—	0	SM18;9711B, Biovir modification
05/23/94	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	310	na	na	154.95	586.5	0	—	0	SM18;9711B, Biovir modification
05/23/94	U.S. Highway 98 bridge	Raw	203	na	na	101.45	384	0	—	0	SM18;9711B, Biovir modification
05/24/94	Pumping station	Raw	265	na	na	132.50	501.5	0	—	0	SM18;9711B, Biovir modification
05/24/94	H.E. Myers Filtration Plant	Raw	160	na	Filter was clogging. Filter rate = 0.75gal/min at end.	80.05	303	0	—	0	SM18;9711B, Biovir modification
08/11/94	H.E. Myers Filtration Plant	Raw	250	na	na	124.97	473	0	—	0	SM18;9711B, Biovir modification
08/11/94	Mouth of Crooked Creek	Raw	210	na	na	105.15	398	0	—	0	SM18;9711B, Biovir modification
08/03/94	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	343	na	na	171.47	649	0	—	0	SM18;9711B, Biovir modification
08/02/94	Pumping station	Raw	201	na	na	100.66	381	0	—	0	SM18;9711B, Biovir modification
11/01/94	U.S. Highway 98 bridge	Raw	160.6	na	na	80.32	304	0	—	0	SM18;9711B, Biovir modification
11/02/94	H.E. Myers Filtration Plant	Raw	250.3	na	na	125.23	474	0	—	0	SM18;9711B, Biovir modification
11/02/94	Pumping station	Raw	240	na	na	119.95	454	0	—	0	SM18;9711B, Biovir modification
11/03/94	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	210.3	na	na	105.15	398	0	—	0	SM18;9711B, Biovir modification
02/27/95	H.E. Myers Filtration Plant	Raw	205	na	na	49.93	189	0	—	0	SM18;9711B, Biovir modification
02/28/95	Pumping station	Raw	244	na	na	61.03	231	0	—	0	SM18;9711B, Biovir modification

Appendix 3. Methods and results for *Giardia* and *Cryptosporidium* analyses for October 1996 to May 1998—Continued

[na, not applicable; —, no results for this assay; gal/min, gallons per minute; >, greater than; ICR, Information Collection Rule]

Sample date	Sample location	Treatment characteristics of sample	Gallons sampled	Liters sampled	Other conditions	Volume assayed (gallons)	Volume assayed (liters)	*Giardia lamblia* cysts	*Giardia* sp. cysts	*Cryptosporidium* oocysts	Method
02/28/95	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	209	na	na	49.93	189	0	—	0	SM18;9711B, Biovir modification
03/01/95	Mouth of Crooked Creek	Raw	200	na	na	49.93	189	0	—	0	SM18;9711B, Biovir modification
05/22/95	H.E. Myers Filtration Plant	Raw	146	na	na	36.72	139	0	—	0	SM18;9711B, Biovir modification
05/22/95	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	263	na	na	118.36	448	0	—	0	SM18;9711B, Biovir modification
05/23/95	U.S. Highway 98 bridge	Raw	147	na	na	36.72	139	0	—	0	SM18;9711B, Biovir modification
05/23/95	Pumping station	Raw	169	na	na	42.27	160	0	—	0	SM18;9711B, Biovir modification
09/12/95	Pumping station	Raw	300	na	na	na	na	—	0	0	SM18;9711B, Biovir modification
09/13/95	U.S. Highway 98 bridge	Raw	>113	na	Dial malfunctioned/could not reengage by backflushing	na	na	—	0	0	SM18;9711B, Biovir modification
09/13/95	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	?	na	na	na	na	—	0	0	SM18;9711B, Biovir modification
09/14/95	H.E. Myers Filtration Plant	Raw	146	na	Filter clogged	na	na	—	0	0	SM18;9711B, Biovir modification
01/25/96	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	580	na	na	115.98	439	0	—	0	SM18;9711B, Biovir modification
01/24/96	Pumping station	Raw	371	na	na	11.10	42	0	—	0	SM18;9711B, Biovir modification
01/24/96	U.S. Highway 98 bridge	Raw	288	na	na	11.62	44	0	—	0	SM18;9711B, Biovir modification
01/25/96	H.E. Myers Filtration Plant	Raw	278	na	na	27.74	105	0	—	1	SM18;9711B, Biovir modification
03/14/96	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	231	na	na	115.46	437	0	—	0	SM18;9711B, Biovir modification
03/13/96	Pumping station	Raw	455	na	na	13.74	52	0	—	0	SM18;9711B, Biovir modification
03/13/96	H.E. Myers Filtration Plant	Raw	232	na	na	9.25	35	0	—	0	SM18;9711B, Biovir modification
03/14/96	Mouth of Crooked Creek	Raw	222	na	na	8.98	34	0	—	0	SM18;9711B, Biovir modification
06/06/96	Pumping station	Raw	321	na	na	16.12	61	6	—	0	SM18;9711B, Biovir modification
06/06/96	U.S. Highway 98 bridge	Raw	150	na	na	7.40	28	6	—	1	SM18;9711B, Biovir modification
06/07/96	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	200	na	na	80.05	303	0	—	0	SM18;9711B, Biovir modification
06/07/96	H.E. Myers Filtration Plant	Raw	150	na	na	6.08	23	0	—	0	SM18;9711B, Biovir modification
08/05/96	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	221	na	na	176.75	669	0	—	0	SM18;9711B, Biovir modification
08/06/96	Mouth of Crooked Creek	Raw	200	na	na	3.96	15	0	—	0	SM18;9711B, Biovir modification
08/06/96	Pumping station	Raw	829	na	na	8.19	31	0	—	0	SM18;9711B, Biovir modification
08/07/96	Myers Filtration Plant Holding Reservoir	Raw	97	na	na	1.85	7	0	—	0	SM18;9711B, Biovir modification
10/29/96	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	200	na	Dechlorination	16.12	61	0	—	0	SM18;9711B, Biovir modification
10/29/96	Myers Filtration Plant Holding Reservoir	Raw	140	na	na	2.91	11	0	—	0	SM18;9711B, Biovir modification
10/31/96	Pumping station	Raw	279	na	na	5.55	21	0	—	0	SM18;9711B, Biovir modification
10/30/96	U.S. Highway 98 bridge	Raw	214	na	na	4.23	16	0	—	0	SM18;9711B, Biovir modification

Appendix 3. Methods and results for *Giardia* and *Cryptosporidium* analyses for October 1996 to May 1998—Continued

[na, not applicable; —, no results for this assay; gal/min, gallons per minute; >, greater than; ICR, Information Collection Rule]

Sample date	Sample location	Treatment characteristics of sample	Gallons sampled	Liters sampled	Other conditions	Volume assayed (gallons)	Volume assayed (liters)	*Giardia lamblia* cysts	*Giardia* sp. cysts	*Cryptosporidium* oocysts	Method
01/07/97	Pumping station	Raw	282	na	na	14.00	53	0	—	0	SM18;9711B, Biovir modification
01/08/97	Mouth of Crooked Creek	Raw	232	na	na	6.87	26	0	—	0	SM18;9711B, Biovir modification
01/06/97	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	190	na	Dechlorination	151.92	575	0	—	0	SM18;9711B, Biovir modification
01/07/97	Myers Filtration Plant Holding Reservoir	Raw	238	na	na	7.13	27	0	—	0	SM18;9711B, Biovir modification
04/16/97	U.S. Highway 98 bridge	Raw		540	Meter inoperable	4.23	16	0	—	0	SM18;9711B, Biovir modification
04/14/97	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	202	763	Dechlorination	80.58	305	0	—	0	SM18;9711B, Biovir modification
04/15/97	Myers Filtration Plant Holding Reservoir	Raw	136	515	na	2.64	10	0	—	0	SM18;9711B, Biovir modification
04/15/97	Pumping station	Raw	403	1523	na	7.93	30	0	—	0	SM18;9711B, Biovir modification
07/22/97	Myers Filtration Plant Holding Reservoir	Raw	181	na	na	3.70	14	0	—	0	SM18;9711B, Biovir modification
07/22/97	Outside spigot at Howard Johnson Hotel	Filtered and disinfected	279	na	Dechlorination	111.49	422	0	—	0	SM18;9711B, Biovir modification
07/24/97	Mouth of Crooked Creek	Raw	200.2	na	na	3.96	15	0	—	0	SM18;9711B, Biovir modification
07/21/97	Pumping station	Raw	306.9	na	na	6.08	23	0	—	0	SM18;9711B, Biovir modification
10/16/97	Myers Filtration Plant Holding Reservoir	Raw	200	757	na	11.89	45	0	—	0	Biovir Modification of *Giardia* and *Cryptosporidium* methods.
10/16/97	Outside spigot at Howard Johnson Hotel	Treated	235.1	890	Dechlorination	28.27	107	0	—	0	Biovir Modification of *Giardia* and *Cryptosporidium* methods.
10/15/97	U.S. Highway 98 bridge	Raw	229.1	867	na	16.12	61	0	—	0	Biovir Modification of *Giardia* and *Cryptosporidium* methods.
10/15/97	Pumping station	Raw	201	761	na	12.15	46	0	—	0	Biovir Modification of *Giardia* and *Cryptosporidium* methods.
01/15/98	H.E. Myers Filtration Plant	Raw	93.5	354	na	9.35	35.4	0	—	0	SM18;9711B, Biovir modification
01/16/98	Outside spigot at Howard Johnson Hotel	Treated	225	852	No dechlorination	117.04	443	0	—	0	SM18;9711B, Biovir modification
01/16/98	Mouth of Crooked Creek	Raw	200	757	na	8.01	30.3	0	—	0	SM18;9711B, Biovir modification
01/15/98	Pumping station	Raw	281	1064	na	14.06	53.2	0	—	0	SM18;9711B, Biovir modification
05/19/98	U.S. Highway 98 bridge	Raw	56	212	na	na	na	—	0	0	Information Collection Rule Method 600/R-95/178 ICR ID # CA200
05/20/98	Pumping station	Raw	75.4	285	na	na	na	—	0	0	Information Collection Rule Method 600/R-95/178 ICR ID # CA200
05/20/98	Myers Filtration Plant Holding Reservoir	Raw	91.3	346	na	na	na	—	0	0	Information Collection Rule Method 600/R-95/178 ICR ID # CA200
05/21/98	Myers Filtration Plant Sink	Treated	392.3	1485	No dechlorination	na	na	—	0	0	Information Collection Rule Method 600/R-95/178 ICR ID # CA200

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