Quality of Water and Bottom Sediments, and Nutrient and Dissolved-Solids Loads in the Apopka-Beauclair Canal, Lake County, Florida, 1986-90

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CONTENTS

Abstract 1
Introduction 2
- Purpose and Scope 3
- Background 3
- Previous Studies 6

Approach 6
- Data Collection 6
  - Lake-Outflow Site 8
  - Lock and Dam 9
- Measurement of Discharge 11

Hydrology and Flow Description 12
Quality of Water and Bottom Sediments 16
- Summary of Water Quality at the Lake-Outflow and Lock-and-Dam Sites 16
- Storm Sampling 21
- Reconnaissance Sampling 33
- Bottom Sediments 37
  - Thickness of Organic Bed Material 37
  - Constituent Concentrations in Sediments 38

Nutrient and Dissolved-Solids Loads 42
- Loads from Lake Apopka and at the Apopka-Beauclair Canal Lock and Dam 42
- Effective Loads in the Apopka-Beauclair Canal 49

Summary 56
Selected References. 58
Appendix I 63
Appendix II 75

FIGURES

1. Map showing location of study area 4
2. Map showing location of sampling sites 7
3. Photograph showing lake-outflow site 9
4. Photograph showing Apopka-Beauclair Canal lock-and-dam control structure 10

5-7. Graphs showing:
- 5. Index velocity at the lake-outflow site, March 20, 1990 11
- 6. Discharge at the lake-outflow site, the Apopka-Beauclair Canal lock-and-dam site, and rainfall at the lock-and-dam site, October 1988 through September 1990 13
- 7. Mean differences in daily mean discharge between the lock-and-dam and lake-outflow sites, for selected time periods 15

8-12. Graphs showing temperature, specific conductance, and dissolved oxygen concentrations at the lake-outflow site and the Apopka-Beauclair Canal lock-and-dam site:
- 8. January 15-18, 1990 19
- 9. June 14-17, 1990 20
- 10. July 26-31, 1990 21
- 11. June 21-30, 1990 22
- 12. December 15-31, 1989 23

13. Graphs showing total ammonia-plus-organic nitrogen and nitrate-plus-nitrite nitrogen concentrations at the lake-outflow site and the Apopka-Beauclair Canal lock-and-dam site, and discharge at site 13, October 1986 through September 1990 24
14. Graphs showing total phosphorus and orthophosphorus concentrations at the lake-outflow site and the Apopka-Beauclair Canal lock-and-dam site, and discharge at site 13, October 1986 through September 1990 25

15. Diagram showing ionic composition of water at the Apopka-Beauclair Canal lock and dam during a period of changes in gate openings, March 29 to April 30, 1987 26
16. Map showing ionic composition of water at selected sampling sites from Lake Apopka to Lake Beauclair, March 31, 1987 27
17-25. Graphs showing nutrient concentrations at selected sampling sites from Lake Apopka to Lake Beauclair:
17. March 31, 1987 28
18. April 2, 1987 29
19. September 9, 1988 30
20. September 12, 1988 31
21. June 27, 1990 32
22. July 13, 1990 33
23. May 4, 1988 34
24. June 15, 1989 35
25. August 29, 1990 36
26-29. Graphs showing:
26. Thickness of muck and organic material at selected sampling sites from Lake Apopka to Lake Beauclair, June 15, 1989 37
27. Nutrient and carbon concentrations in bottom sediments at selected sampling sites from Lake Apopka to Lake Beauclair, May 4, 1988 39
28. Nutrient and carbon concentrations in bottom sediments at selected sampling sites from Lake Apopka to Lake Beauclair, June 15, 1989 40
29. Nutrient and carbon concentrations in bottom sediments at selected sampling sites from Lake Apopka to Lake Beauclair, August 29, 1990 41
30-34. Graphs showing monthly total loads at the lake-outflow site and the Apopka-Beauclair Canal lock-and-dam site, and difference in loads, October 1988 through September 1990:
30. Total nitrogen 43
31. Total ammonia-plus-organic nitrogen 44
32. Total phosphorus 45
33. Total organic carbon 46
34. Dissolved-solids, based on continuous record of specific conductance 47
35-39. Graphs showing monthly total load at the Apopka-Beauclair Canal lock and dam (site 13) and canal-effective load, October 1986 to September 1990:
35. Nitrogen and ammonia-plus-organic nitrogen 52
36. Nitrate-plus-nitrite nitrogen 53
37. Phosphorus 53
38. Dissolved-solids 54
39. Organic carbon 54

TABLES

1. Sampling sites along the Apopka-Beauclair canal 8
2. Statistical summary of water-quality data for the lake-outflow site and Apopka-Beauclair Canal lock-and-dam site 17
3. Nitrogen, phosphorus, and carbon concentrations in bottom sediments at the lake-outflow site and the Apopka-Beauclair Canal lock-and-dam site 42
4. Loads of selected constituents in the Apopka-Beauclair Canal, water years 1987-90 55

CONVERSION FACTORS, VERTICAL DATUM, ADDITIONAL ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Mass	
ton	0.9072	megagram
	Area	
acre	0.4047	hectare
square foot (ft^3)	0.09290	square meter
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot per second (ft/s)	0.3048	meter per second

Equations for temperature conversion between degrees Celsius (°C) and degrees Fahrenheit (°F):

$$°C = 5/9\ (°F - 32)$$
$$°F = (9/5°C) + 32$$

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.

Additional Abbreviations

µS/cm at 25 °C	=	microsiemens per centimeter at 25 °C
g/kg	=	grams per kilogram
mg/L	=	milligrams per liter
mg/kg	=	milligrams per kilogram
Pt-Co units	=	Platinum-Cobalt units
µm	=	micron

Acronyms

FEL	=	Farm effective load
FWPCA	=	Florida Water Pollution Control Agency
IFAS	=	Institute of Food and Agricultural Sciences of the University of Florida
MSE	=	Mean square error
NTU	=	Nephelometric turbidity units
SJRWMD	=	St. Johns River Water Management District
SR	=	State Road
SWIM	=	Surface Water Improvement and Management Act
USGS	=	U.S. Geological Survey
WATSTORE	=	U.S. Geological Survey's National Water Data Storage and Retrieval System

Quality of Water and Bottom Sediments, and Nutrient and Dissolved-Solids Loads in the Apopka-Beauclair Canal, Lake County, Florida, 1986-90

By Donna M. Schiffer

Abstract

The water entering Lake Beauclair, in the Ocklawaha River chain of lakes in central Florida, has high concentrations of the nutrients nitrogen and phosphorus . Major sources of the nutrients entering Lake Beauclair are Lake Apopka outflow and drainage from farming operations adjacent to the Apopka-Beauclair Canal. The U.S. Geological Survey began a study in 1986 to determine the relative contribution of nutrient loads from these two sources.

Two flow and water-quality monitoring sites were established to obtain data needed to calculate loads leaving Lake Apopka and at a control structure (the Apopka-Beauclair Canal lock and dam) between the two lakes. Water samples were collected at those sites biweekly for analysis of nutrients and monthly for analysis of major ions during 4 years of the study. The study, which was originally scheduled to end in 1989, was extended to 1991 to provide an additional 2 years of data collection at a constriction built at the lake-outflow gaging site. Prior to 1988, discharge could not be gaged at the site because of low velocities. The constriction increased velocities in the canal and made it possible to gage discharge at the site. Regression analysis of discharge data collected at the gaged sites indicated that 64 percent of the variation in discharge at the lake-outflow site is explained by discharge at the lock and dam, and other hydrologic variables (rainfall, water-surface slope) explained 8 percent of the variation.

The quality of water in the Apopka-Beauclair Canal is relatively uniform during periods between storms. Analysis of water samples collected 1 to 2 days after storms, however, indicated that water quality is much more variable during these periods because of the effects of farm inflow (to the canal) at both the lake-outflow and lock-and-dam sites.

Sand, silt, and clay account for most of the native materials in the bed sediments of the canal, but muck (the highly organic fraction of the bottom sediments characterized by a high water content) and organic material are deposited downstream from Lake Apopka to a distance of about 0.5 mile (the location of the lake-outflow site). Higher median concentrations of carbon, and nitrogen and phosphorus species (except ammonia nitrogen) were measured in bottom sediments at the lake-outflow site than at the lock-and-dam site, an indication that much of the nutrient load leaving the lake is not being transported downstream to Lake Beauclair.

Nutrient and dissolved-solids loads were computed for the two monitoring sites based on daily mean discharge and water-quality data linearly interpolated between samples. Loads at the lock and dam were fairly constant (a reflection of the controlled discharge at the site) except during periods of increased discharge (when gates were opened). Loads at the lake-outflow site were much more variable (a reflection of the more variable discharge at that site).

An alternative approach for determining the relative nutrient-load contribution was derived using water-quality data for both locations and discharge data for the lock and dam. This approach involved the computation of a "canal-effective load," which is a measure of the effect on the total load measured at the lock and dam from farm activities along the canal and physical and chemical processes occurring in the canal between the two monitored sites. The canal-effective load represents the net increase (or decrease) in load at the lock and dam, above (or below) the load that would have been received from Lake Apopka if there were no farm discharge to the canal.

The maximum monthly nitrate-plus-nitrite nitrogen load at the lock and dam during the study was 41 tons in April 1987, and the maximum monthly canal-effective nitrate-plus-nitrite nitrogen load was 6.44 tons in September 1988. The canal-effective total nitrogen load generally was less than 10 percent of the total nitrogen load at the lock and dam. The annual phosphorus load ranged from 33 tons in the 1987 water year to 9.1 tons in the 1990 water year; canal-effective phosphorus load accounted for 11.4 percent of the annual phosphorus load in 1987 and 33 percent in 1990.

Much of the constituent load transported through the lock and dam on the Apopka-Beauclair Canal was transported during periods of high discharge. In April 1987 when discharges were as high as 589 cubic feet per second, loads transported through the lock and dam accounted for 59 percent of the ammonia-plus-organic nitrogen load, 61 percent of the total nitrogen load, 59 percent of the phosphorus load, 51 percent of the total organic carbon load, and 47 percent of the dissolved-solids load transported during the 1987 water year.

The canal-effective nitrogen load accounted for less than 10 percent of the total nitrogen load at the lock and dam, but most of the total phosphorus load was attributable to the canal-effective load. In December 1987 and January 1990, 69 and 73 percent of the total phosphorus load, respectively, was due to the canal-effective load. During the summer months of 1989, both load calculation methods indicated large inflows to the canal. In June and July 1989, 50 and 60 percent, respectively, of the total phosphorus load was attributable to the canal-effective load.

Load computations using the canal-effective load approach indicated that, with the exception of phosphorus, nutrient and dissolved-solids loads due to farm activity along the canal account for 10 percent or less of the total load at the Apopka-Beauclair Canal lock and dam.

INTRODUCTION

There has been concern in recent years that outflow from Lake Apopka, one of the more eutrophic lakes in Florida, has accelerated eutrophication of downstream lakes. Agricultural and treated-sewage discharges to the lake since 1922 have changed Lake Apopka from a prime fishing and recreational lake to a highly eutrophic lake populated by gizzard shad and other fish species that are able to tolerate low dissolved oxygen conditions (St. Johns River Water Management District, 1988). Although downstream lakes receive water from Lake Apopka, there is some uncertainty as to whether the principal source of the nutrients entering these lakes is outflow from Lake Apopka or discharge from agricultural areas adjacent to the Apopka-Beauclair Canal. Much attention has been directed toward Lake Apopka in an effort to restore the quality of the lake water. However, little information is available describing the outflow from the lake and its effect on lakes downstream.

Mean concentrations of total nitrogen and phosphorus in Lake Apopka are 4.5 mg/L and 0.22 mg/L, respectively (Lowe and others, 1992). Samples collected from 165 Florida lakes from September 1979 to September 1980 had a median total nitrogen concentration of 0.60 mg/L, and a median total phosphorus concentration of 0.02 mg/L (Canfield, 1981). Mean nitrogen concentrations in Lake Apopka reported by Lowe and others (1992) were 7 times greater, and phosphorus concentrations were 11 times greater than the median concentrations reported by Canfield. In a ranking of 580 Florida lakes from worst to best water quality (by trophic state index), Lake Apopka ranked 17th (Myers and Edmiston, 1983).

Lake Apopka and Lake Beauclair are part of a chain of lakes located in the upper Ocklawaha River drainage basin in central Florida (fig. 1). Lake Apopka and Lake Beauclair (the next downstream lake in the chain) are connected by an engineered drainage feature named the Apopka-Beauclair Canal. Flow between the lakes is controlled by a structure in the canal about 3 mi downstream from Lake Apopka.

To address the effects of Lake Apopka outflow and farm discharge water entering the Apopka Beauclair canal on water quality, the U.S. Geological Survey (USGS) began a study of nutrient loads and sources of these loads in the Apopka-Beauclair Canal in 1986 in cooperation with the St. Johns River Water Management District (SJRWMD). Originally a 3-year investigation, the study was extended 2 years to 1991. Data collection began in 1986 and continued through September 1990. The extension of the project allowed for 2 years of data collection at a constriction built in the canal during the summer of 1988, approximately 0.5 mi downstream from Lake Apopka.

Purpose and Scope

This report describes the relative contributions of nutrient loads to the total load measured at the Apopka-Beauclair Canal lock and dam from two sources: (1) Lake Apopka outflow, and (2) inflow from farms adjacent to the canal. The quality and quantity of water in the canal during the study also are described. Data presented include concentrations of major ions and nutrients in water; values for physical properties (temperature, specific conductance, and dissolved oxygen concentrations) of lake and canal waters; concentrations of nutrients in bottom sediments; and nitrogen, phosphorus, and dissolved-solids loads transported through the canal.

Constituent concentrations in reconnaissance samples collected during wet and dry seasons under steady-state conditions (little or no pumping to the canal and no rainfall) are presented to characterize the general quality of water in the canal. Also described are changes in canal water quality as a result of rainfall; typically, the hydraulics in the canal are more dynamic after a storm (because of pumping) than during between-storm periods. Bottom sediments, which were cored at selected sites in the canal between Lake Apopka and Lake Beauclair, are qualitatively described. Net loads between the lake-outflow and the lock-and-dam sites and the estimated effective increase (or decrease) in nutrient loads due to farm discharge to the canal and physical, chemical, and biological processes in the canal are also presented.

Background

The Apopka-Beauclair Canal is located in Lake County, northwest of Orlando, in central Florida. It connects two lakes in the Ocklawaha River drainage basin: Lake Apopka and Lake Beauclair. Prior to the construction of the canal, the direction of outflow from Lake Apopka during periods of high water was to the northwest, toward Little Lake Harris (fig. 1). Originally, the lands north of Lake Apopka were covered with water and sawgrass. In 1893, these lands were drained by the Delta Canal Company by dredging a waterway from Lake Apopka through Lakes Dora and Eustis to the Ocklawaha River. The Apopka Canal Company had started dredging the canal in 1880 but was unable to complete the canal because of the difficulty experienced in excavating the clayey native materials and financial problems. The Apopka Canal Company abandoned its efforts in 1890 and the canal was then purchased by the Delta Canal Company.

The original purpose of the canal was to create a navigable waterway for steamboats and to drain about 30,000 acres on the north shore of Lake Apopka for agricultural use. Draining of the area was accomplished, and the water surface of Lake Apopka and the surrounding area was lowered about 4 ft by 12 mi of canal and 32 mi of lateral drainage ditches. The canal was not used for transportation to the degree that its proponents had envisioned because the railroads had already become well established by the time the canal was completed (Shofner, 1982).

The newly drained lands were to be used for agriculture, but the land was difficult to work and water-table fluctuations caused problems. In an effort to alleviate the water-table fluctuations, the Zellwood Produce Company did further work on the canal in 1915, which lowered the lake level to 63 ft above sea level (the original lake level is not known). World War I prompted the planting of potatoes, which proved unsuccessful because the low potash and phosphorus contents of the lake bottom sediments resulted in potatoes that rotted shortly after harvesting. By 1917, the land was no longer used for farming and in 1926 rains from a hurricane resulted in much of the area reverting to sawgrass marsh, a condition that lasted about 15 years.

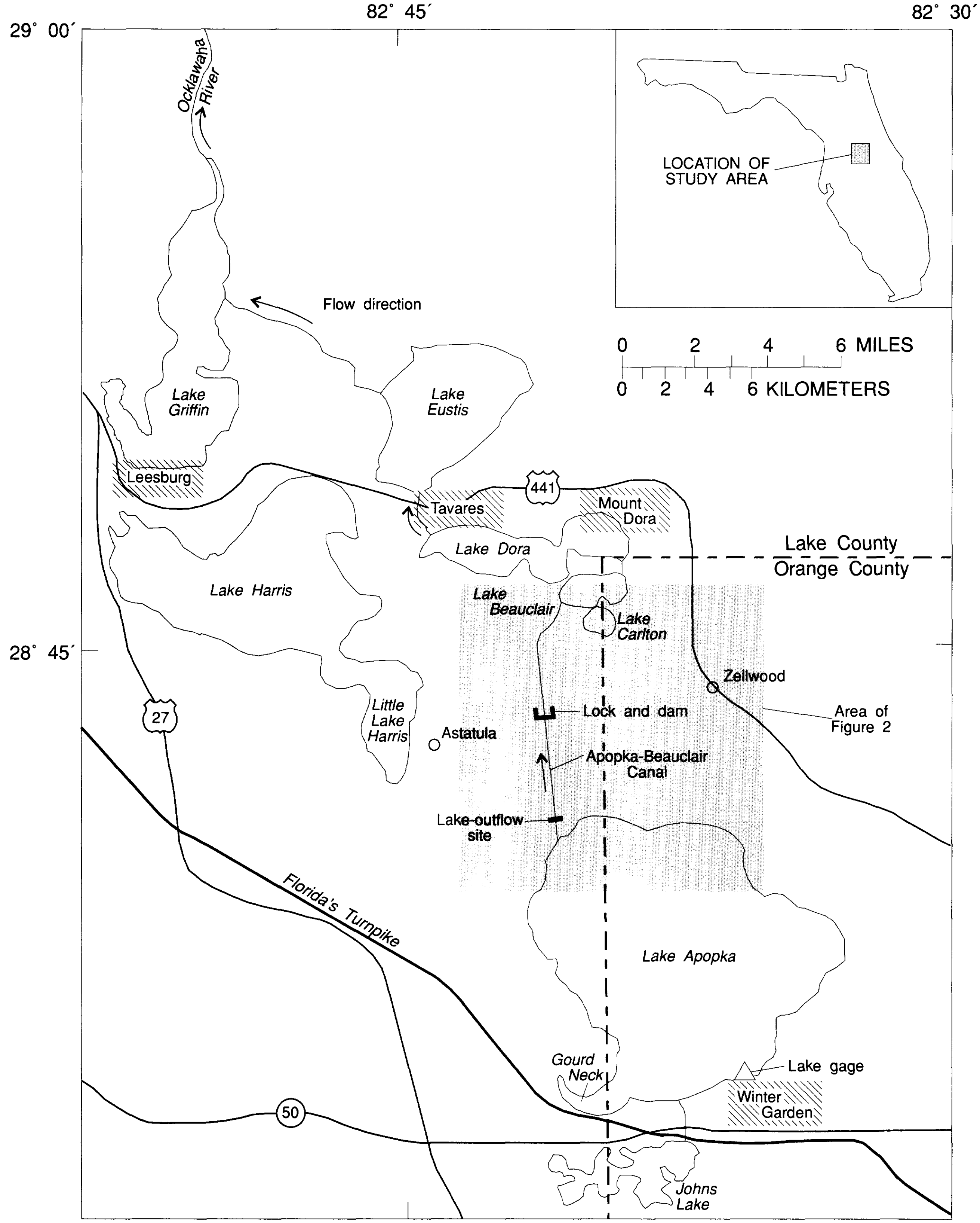


Figure 1. Location of study area.

Farming resumed during World War II (1941). The land was drained and a network of canals was built so that the water level in each tract of land could be independently controlled. Water was brought in by gravity flow and pumped through the canal network. Excess water was pumped back into the lake. During the 1940's, the land was used to grow celery, beans, carrots, spinach, and cabbage. Corn, for which the area is now well known, was first grown in 1948.

Lake Apopka had become a world-renowned sport-fishing lake by the 1920's. Fishing in the Ocklawaha chain of lakes reached a peak in the early 1950's when there were 21 fish camps on the shores of Lake Apopka. The quality of water had already begun to decline because of inflow of irrigation water from farms, citrus processing plant wastes, and sewage treatment plant discharges. A major change in the water quality of the lake was caused by a hurricane in September 1947 that uprooted much of the aquatic vegetation. The decay of the uprooted vegetation resulted in the first recorded algal bloom in Lake Apopka in October 1947. In the years that followed, the eutrophication of the lake was accelerated by the spraying of hyacinths with herbicides and poisoning of undesirable species of fish. Plant and fish tissues were not removed, so nutrients formerly bound in the living tissues became available, increasing algal growth. By 1965, only nine fish camps remained on the shores of Lake Apopka and, by 1974, only four remained (St. Johns River Water Management District, 1988). Once the second-largest lake in Florida, Lake Apopka is now the fourth largest because of the draining of outlying areas for farming.

A timber control structure was placed in the Apopka-Beauclair Canal in 1950 and a lake-level stabilization program was begun in 1952. A new lock-and-dam control structure, featuring two Tainter lift gates, was completed in 1956 and the canal was further deepened in 1958.

Discharge in the Apopka-Beauclair Canal is controlled at the lock and dam. Water is pumped from farms to the canal to control flooding in the low-lying farm lands adjacent to the canal. Numerous pumps along the canal allow farmers to control the amount of water in irrigation ditches in their fields. Outflow from Lake Apopka is decreased because of the backwater condition that occurs when the volume of water being pumped into the canal from adjacent farms is equal to or greater than the volume of water being released at the lock and dam. During these periods, flow in the canal can reverse and the flow direction is toward Lake Apopka.

Outflow from Lake Apopka is controlled by the lock and dam and discharges from farms to the canal. The maximum potential outflow from the lake at any point in time is the discharge at the lock and dam minus the net discharge entering the canal from the farms downstream from the lake. When farms along the canal are discharging, outflow from the lake is reduced by a volume equivalent to the farm discharge. Farm discharge to the canal can increase or decrease constituent loads being transported to the lock and dam by displacing discharge from the lake. When farm discharge contains less nitrogen than lake-outflow water, the effect is a reduction in the nitrogen load at the lock and dam. Similarly, when farm discharge contains more nitrogen, the effect is an increase in loads. The "effect" of the farms is not the load from the farms, but the difference between the load from the farms and the load contained in the displaced discharge from the lake. If the farms discontinued discharging to the canal, the effect on the constituent load at the lock and dam would be equal to the difference between the constituent concentration in the lake outflow and the constituent concentration in the farm discharge multiplied by the volume of (discontinued) discharge water from the farms.

Though farm discharge was not measured directly in this study, the effects of farm discharge on loads at the lock and dam can be estimated indirectly by measuring changes in water quality from the lake-outflow site to the lock-and-dam site. However, these effects cannot be separated from the effects resulting from natural processes such as sedimentation, adsorption, absorption, and uptake by aquatic vegetation that is occurring in the canal between the lake and the lock and dam. The effect from farm discharges and processes in the canal on loads transported to Lake Beauclair through the lock and dam can be expressed in terms of a load, referred to as "canal-effective load" in this report. The canal-effective load is a measure of the magnitude of the change in the load at the lock and dam that has resulted from farm discharges and canal processes.

Previous Studies

Previous reports about Lake Apopka and its water-quality problems are the result of efforts to clean up the lake and reclaim it for recreation. Because this report primarily is concerned with loads in the Apopka-Beauclair Canal and not Lake Apopka, the reader interested in more information on Lake Apopka is referred to several reports which are described below, and listed in the reference section of this report.

Schneider and Little (1969) reported on bottom sediment, and nitrogen and phosphorus sources in Lake Apopka. Their study was one of several conducted by the Florida Water Pollution Control Agency (FWPCA, now Department of Environmental Protection) to review the eutrophication problem in Lake Apopka. Anderson (1971) evaluated the potential hydrologic effects of draining Lake Apopka, one of several methods proposed to clean the lake water. The FWPCA published a project plan (1972), based on the results of the two studies, that described cleaning the lake water using a controlled drawdown. The drawdown project never took place. The U.S. Environmental Protection Agency (1979) published a report on their Environmental Impact Study of the Lake Apopka Restoration project.

The Surface Water Improvement and Management Act (SWIM), which became law in 1987, states "The Legislature finds that the declining quality of the state's surface waters has been detrimental to the public's right to enjoy these surface waters and that it is the duty of the state through the state's agencies and subdivisions, to enhance the environmental and scenic value of surface water" (McSweeney, 1991). Lake Apopka is one of six water bodies in the State selected for funding under this act. The SJRWMD, which has the responsibility of planning, implementing, and coordinating the restoration strategies for Lake Apopka, released a report on the Interim SWIM plan for Lake Apopka in 1988 (St. Johns River Water Management District, 1988).

Additional reports have been written on the results of studies done in cooperation with the SJRWMD as part of the Lake Apopka Restoration project. One report, prepared by the Institute of Food and Agricultural Sciences (IFAS) of the University of Florida (1989), characterized sediments in Lake Apopka with respect to total storage of nutrients. The report described the first phase of a multiphase investigation of the role of sediments in the eutrophication of Lake Apopka.

APPROACH

Continuously recorded stage, velocity, and water-quality data were collected at two sites on the Apopka-Beauclair Canal: a lake-outflow site (site 5), 0.5 mi downstream from Lake Apopka; and a site at the lock-and-dam control structure (site 13), about 7 mi downstream from the lake as shown in figure 2. The quality of water leaving Lake Apopka is represented by samples collected at the lake-outflow site, and the quality of water being discharged to lakes downstream from farming operations along the canal is represented by samples collected at the lock-and-dam site. Between these two sites, farms on either side of the canal have numerous small channels that either contribute flow (from pumps discharging water from these channels) or receive water from the Apopka-Beauclair Canal by gravity flow. Because flow to the canal from adjacent farms is sporadic, direct measurement of farm discharge and routine water-quality sampling of these point discharges was not attempted. Supplemental sampling during the study included annual sampling of water and bottom sediments, and some sampling of point discharges following storms.

Data Collection

Water-quality samples from the lock-and-dam and lake-outflow sites were collected biweekly for nutrient analyses and monthly for major-ion analyses. Temperature, specific conductance, and dissolved oxygen data were recorded every hour at the lake-outflow site and every half-hour at the lock-and-dam site, using USGS water-quality minimonitors connected to a datalogger. Minimonitor probes were located about 1.5 ft below the water surface. Water-level, rainfall, and gate-opening data were also recorded every half-hour at the lock and dam. Water-level and point-velocity data were recorded every 15 minutes at the lake-outflow site.

Minimonitors were calibrated biweekly to ensure the quality of the data collected. Dissolved oxygen data occasionally were not valid because of membrane fouling caused by heavy algae growth; however, temperature and conductance probes were not affected. Dissolved oxygen data considered invalid were deleted from the data base.

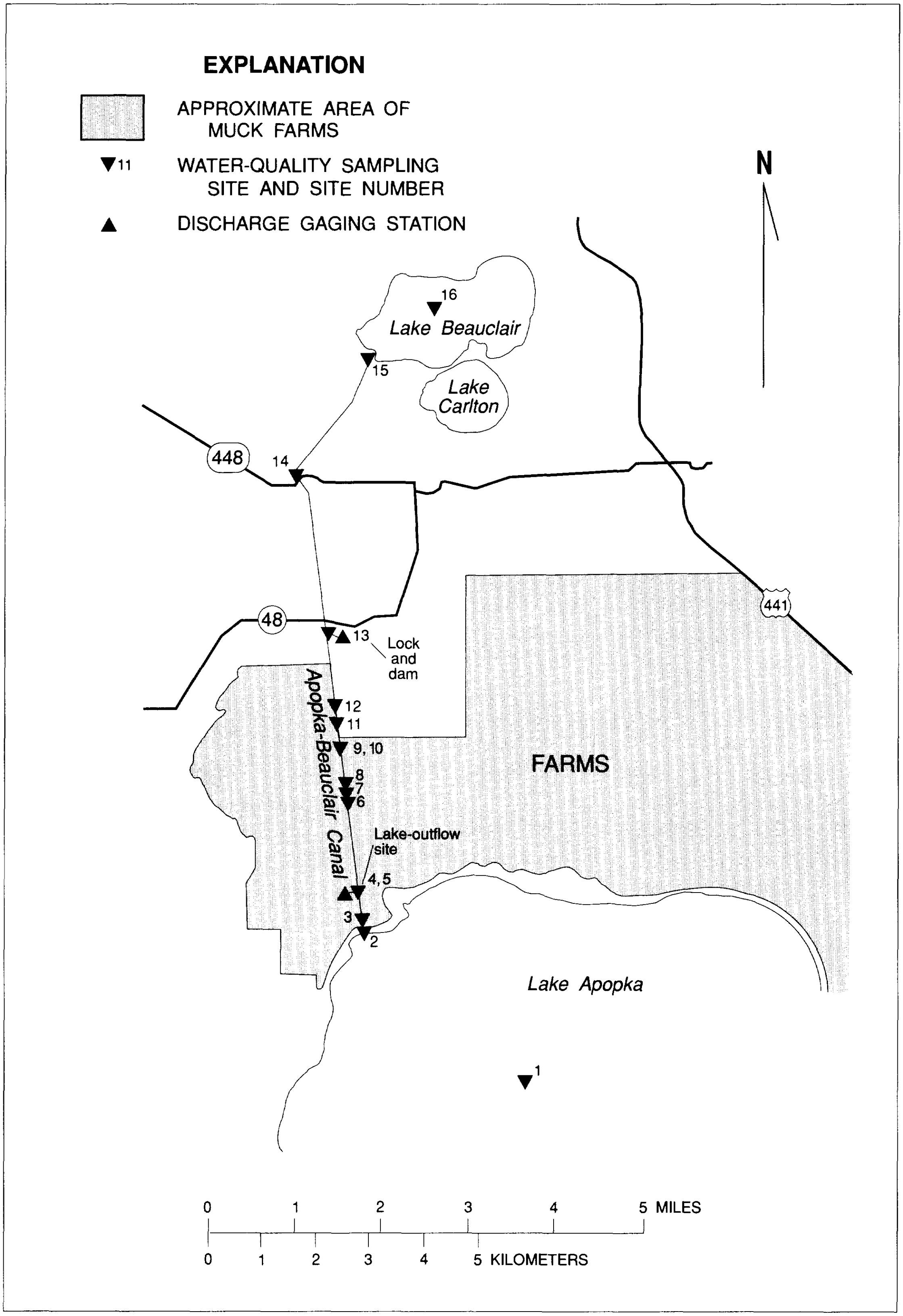


Figure 2. Location of sampling sites.

Water samples were processed at the time of collection using standard USGS procedures (Brown and others, 1970). Samples collected to determine dissolved-constituent concentrations were filtered through a 0.45-micron membrane filter. All water samples were analyzed at a USGS laboratory using analytical procedures described by Wershaw and others (1983) and by Fishman and Friedman (1985). Bed sediment samples were collected using an Eckman dredge in 1988 and 1990, and a 2-in. diameter coring-type sampler in 1989 (to determine depth of organic material in canal). Sediment samples were analyzed for nutrient concentrations by a USGS laboratory.

USGS laboratories maintain quality assurance programs to ensure data validity. Field quality-assurance methods used in this study included replicate sampling and measurement of specific conductance across the canal at sampling sites to ensure that samples collected at one point in the cross section represented water quality across the section.

In addition to routine sample collection, samples were collected annually at selected locations along the canal between Lake Apopka and Lake Beauclair and analyzed for nutrients and major ions in water, and for nutrients in bottom sediments. Samples were also collected periodically at selected farm-discharge points after storm events, when farms typically would discharge to the canal. These storm samples provided additional information on the quality of water entering the canal from adjacent farms. Sampled locations along the canal are listed in table 1.

Lake-Outflow Site

Prior to the building of the constriction in 1988, discharge measurements of Lake Apopka outflow could only be made during times when the gates at the lock and dam were opened enough to produce increased velocities at the lake-outflow site (fig. 2, site 4, renumbered site 5 after constriction was built). No continuous record of flow at the lake-outflow site was available prior to the installation of the constriction because velocities were less than the lowest threshold of measurement for the equipment in use (less than about 0.10 ft/s). The constriction, constructed of sheet-metal piling, reduced the canal width from about 200 ft to about 30 ft. The 30-ft opening was formed

Table 1. Sampling sites along the Apopka-Beauclair Canal
[USGS, U.S. Geological Survey; mi, mile; in., inch; SR, state road]

USGS site identification number	Site number	Site name and description
283730081373000	1	Lake Apopka near center.
284021081404400	2	Apopka-Beauclair Canal inlet at Lake Apopka.
284026081404400	3	Apopka-Beauclair Canal - pump near Lake Apopka.
284046081404600	4	Apopka-Beauclair Canal lake outflow (before constriction).
284046081404601	5	Apopka-Beauclair Canal lake outflow (after constriction).
284140081405401	6	Apopka-Beauclair Canal at Duda bridge, south pond.
284140081405400	7	Apopka-Beauclair Canal at Duda Farms bridge.
284140081405402	8	Apopka-Beauclair Canal at Duda bridge, north pond.
284209081405701	9	Apopka-Beauclair Canal at flywheel pump, west bank.
284209081405700	10	Apopka-Beauclair Canal, 1.4 mi above lock and dam (pump upstream of flywheel pump).
284235081410000	11	Apopka-Beauclair Canal - 60-in. culvert, west bank, above lock and dam.
281240081405900	12	Apopka-Beauclair Canal 1 mi above lock and dam (two 24-in. culverts).
02237700	13	Apopka-Beauclair Canal near Astatula.
284419081412100	14	Apopka-Beauclair Canal at SR448 bridge.
284557081403300	15	Apopka-Beauclair Canal outlet at Lake Beauclair.
284623081394700	16	Lake Beauclair at center, near Mt. Dora.

by cutting the sheet metal 5 to 6 ft below the water surface and approximately 1 ft above the canal bottom. The constriction was intended to increase flow velocities to at least 0.10 ft/s for measurement purposes; however, velocities frequently were below 0.10 ft/s even with the constriction in place.

Daily mean discharge at the lake-outflow site (site 5, figs. 2 and 3) was computed based on index velocity (measured using a Marsh-McBirney electromagnetic current meter) and stage data recorded every 15 minutes. The velocity probes were mounted approximately 1.1 and 2.1 ft above the bottom of the opening in the sheet-metal piling, which corresponded to 0.8 and 0.6 times the total depth of the opening. Index-velocity and stage measurements were made every 5 minutes (meter recorded mean velocity during a 60-second time interval), and the average of three 5-minute measurements were recorded at 15-minute intervals. Each recorded index-velocity and stage measurement thus represents an average over the previous 15 minutes. Mean velocity in the cross section for each 15-minute period was computed from a rating curve. Average daily discharge was computed from the 15-minute velocity and stage data.

Lock and Dam

Discharge at the lock and dam was computed using equations for flow through Tainter gates plus estimates of discharge caused by lockages. There are two gates at the site, each 12 ft wide, and a lock at the west side of the structure for passage of boats (fig. 4). Periodic discharge measurements have been made at the bridge (State Road 48) just downstream from the site since July 1958. Digital recorders upstream and downstream from the structure are used to monitor and record water levels. Records of gate-setting changes and lockages are kept by the lock operator and sent to the USGS for use in computation of discharge.

Figure 3. Lake-outflow site, looking north from south side of constriction. (Site 5, shown in fig. 22.)

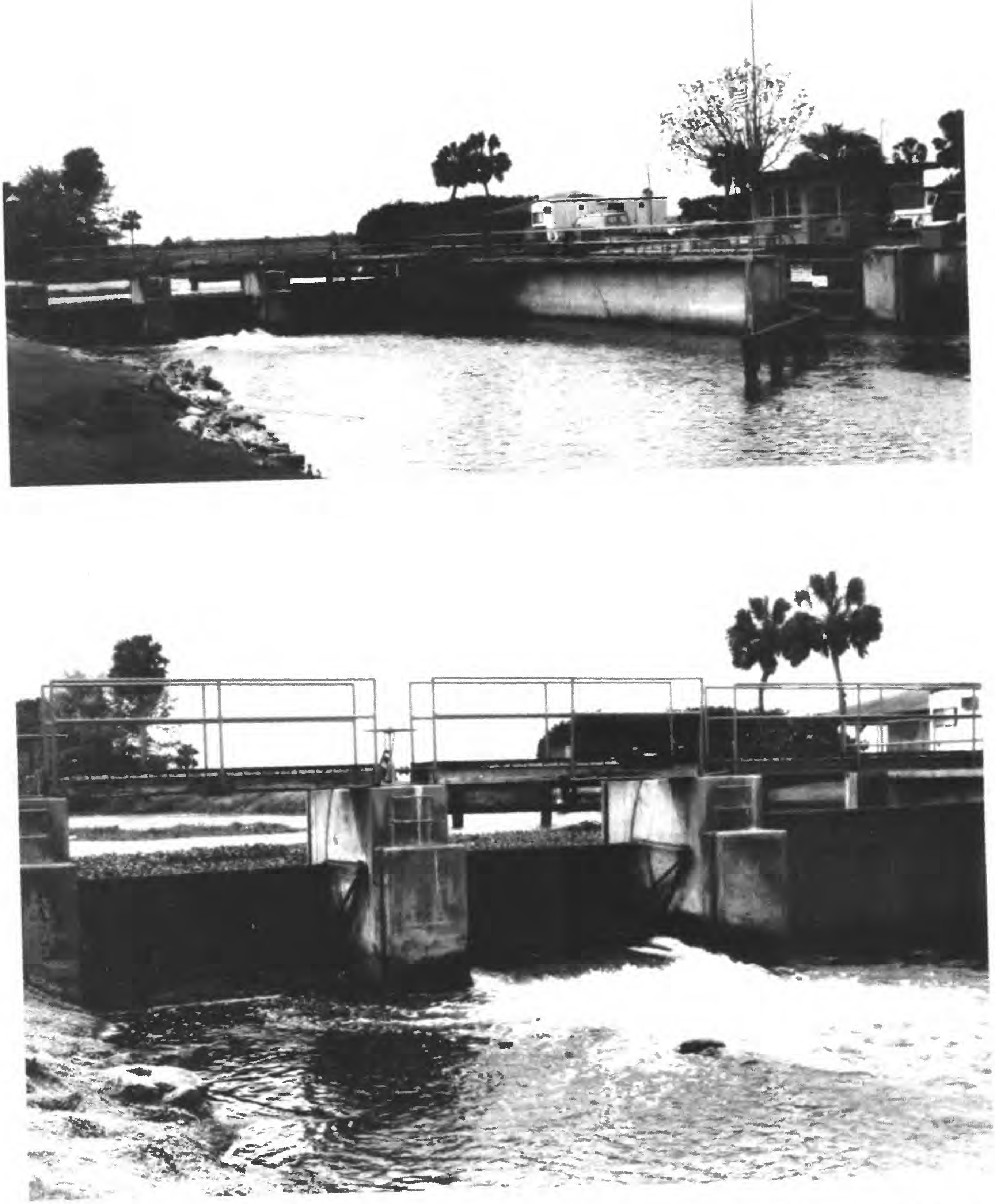


Figure 4. Apopka-Beauclair Canal lock-and-dam control structure, looking upstream from the east bank, towards the south. (Site 13, shown in fig. 2.)

Measurement of Discharge

Discharge was gaged at the lake-outflow and lock-and-dam sites (fig. 2, sites 5 and 13, respectively). Discharge at the lake-outflow site (site 5) after the installation of the constriction was computed based on a rating curve that related index velocity at a point (determined using directional-velocity flowmeters) to average velocity in the cross section (Rantz and others, 1982). At the lock-and-dam site, computation of discharge through the control structure was based on equations for flow through Tainter gates (Collins, 1977). These data are stored in the USGS National Water Data Storage and Retrieval (WATSTORE) System.

Discharge was gaged from September 14, 1988, through September 1990. Discharge measurements were made approximately monthly to develop the rating curve, which describes the relation between the index velocity from the electromagnetic directional-velocity current meter and the mean velocity in the cross section (obtained from the discharge measurement). Shifts in the rating were made when justified by discharge measurements.

After several discharge measurements were made at the lake-outflow site, a different method was used because of observed seiche effects at the section. Discharge at the constriction varied greatly and sometimes reversed during the measurement in a cyclical, tidal fashion. The variability in velocity is shown in the trace of 1-minute index-velocity data in figure 5. This variable flow pattern is characteristic of the site; a steady flow pattern was observed only when the gates downstream were opened, increasing discharge at the site in the downstream direction. The method implemented for measurement of discharge at the lake-outflow site is that used to measure rapidly changing discharge described by Rantz and others (1982).

Another improvement for measurement of discharge was made during March 1989 when the low-velocity current meter in use was replaced with an optic-head current meter that had been rated for velocities as low as 0.08 ft/s. The low-velocity meter used prior to that time had been rated from 0.2 to 2.5 ft/s (Rantz and others, 1982, p. 86). Although the constriction was built to increase velocity, typically the velocities at the site were still low (0.1 - 0.2 ft/s).

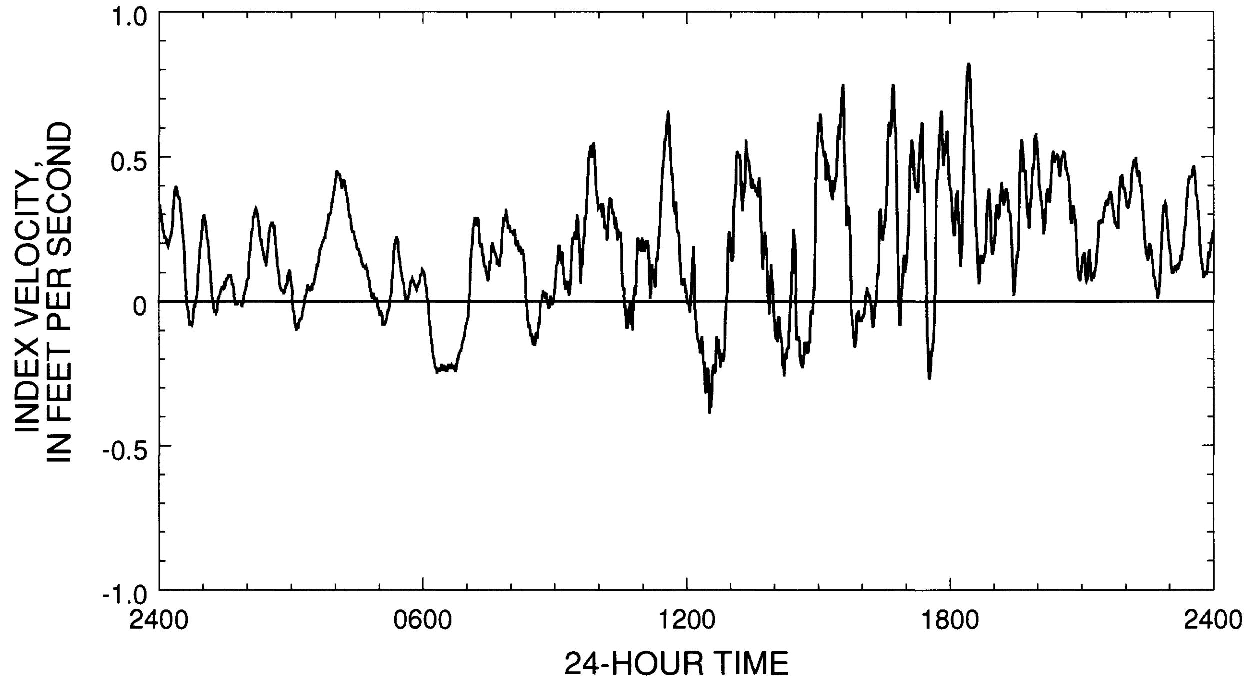


Figure 5. Index velocity at the Lake Apopka outflow site (site 5), March 20, 1990.

HYDROLOGY AND FLOW DESCRIPTION

Lake Apopka is a broad, shallow depression underlain by clay, sandy clay, and sand of Miocene and younger age. These materials constitute the surficial aquifer system and the Hawthorn Formation. The clayey materials under the lake retard the exchange of water between the lake and the underlying Upper Floridan aquifer, a highly productive limestone aquifer, which is under artesian conditions in the vicinity of Lake Apopka. The top of the Floridan aquifer system in the Lake Apopka area is less than 100 ft below land surface (Tibbals, 1990). The only known breach in the confining materials beneath the lake is at Apopka Springs, located in the southwest corner of the lake referred to as the Gourd Neck (fig. 1).

Other inflows to Lake Apopka include rainfall directly on the lake surface, stormwater from communities along the southern lake shore, lateral seepage from the surficial aquifer system beneath adjacent sand hills, and discharge from pumps located on muck farms along the northern and eastern shores. During unusually wet periods such as 1959-60, when many lakes and streams reached record high water levels (Anderson, 1971), overflow from Johns Lake (south of Lake Apopka) enters the lake. The primary outflow from Lake Apopka is through the Apopka-Beauclair Canal on the north side of the lake. Other water losses include evaporation and gravity drainage to the muck farms.

Outflow from Lake Apopka, pump discharges, and water from adjacent feeder channels and ponds enter the Apopka-Beauclair Canal between the lake and the lock and dam. Downstream from the lock and dam the canal passes through primarily residential areas, pasture, and undeveloped land. The next lake downstream from Lake Apopka in the Ocklawaha chain of lakes is Lake Beauclair, followed by Lakes Dora, Eustis, and Griffin (fig. 1).

The Apopka-Beauclair Canal lock and dam controls outflow from, and the level of, Lake Apopka. Daily mean discharge at the structure was about 35ft ^{3}/s during most of the study and only varied slightly from this value except when the gate openings were increased. During periods when the gates remained open at higher settings for several days, flows generally were stable from day to day, varying by only a few cubic feet per second until the gate opening was again altered. The maximum discharge during the study was 589 ft^3/s (April 1987) and the minimum was 15 ft^3/s (July 1987).

Streamflow velocities generally are low (less than 0.10 ft/s) in the Apopka-Beauclair Canal for the normal gate opening (allowing 35 ft^3/s discharge at the lock and dam). The depth of water in the canal generally is 6 to 8 ft, but sedimentation from pumps discharging sediment-laden farm water can create deltas in the canal. This sedimentation process has caused numerous deltas and islands in the canal between Lake Apopka and site 11 (fig. 2).

Equipment installed to gage discharge 0.5 mi downstream from Lake Apopka was initially ineffective because of low velocities. The building of the constriction in the canal in 1988 increased velocities somewhat, but the seiche effect at the section and reverse flow during pumping from farms caused highly variable flow conditions. Variations in velocity due to wind and seiche effects are evident in the plot of index velocity (fig. 5).

The highly variable flow at the lake-outflow site presented a challenge in measuring and gaging discharge. Several rating curves were used during the study. The rating curve used from March 15, 1990, to September 30, 1990, had a 95-percent confidence limit for the prediction of mean section velocity within +/- 0.05 ft/s (mean square error (MSE), 0.024). When multiplied by an average cross-sectional area of 155 ft^2, the flow could be predicted to +/- 8 ft^3/s. For the average flow in the channel of 35 ft^3/s, the predicted flow ranges from 27 to 43 ft^3/s. For two earlier ratings used in the study (effective from September 1988 to March 1990), the 95-percent confidence interval ranged from +/- 0.12 to +/- 0.14 ft/s. Discharge predicted with these ratings could be off by as much as +/- 22 ft^3/s (MSE, 0.072).

To better understand the hydrology of the canal system, discharge data for the lake-outflow and the lock-and-dam sites were related to other hydrologic variables thought to affect discharge. Daily mean discharge data for both sites were used in the analyses because the seiche effects at the lake-outflow site were not considered to have a substantial effect on the mean velocity for a 24-hour period. Data used in the analyses were collected during the period from October 1988 to September 1990. Other hydrologic variables included in the analyses are rainfall, water-surface elevation differences between a gage in Winter Garden (fig. 1) on the south side of Lake Apopka and a gage at the lake-outflow site (representing the head that would drive flow into the canal), and water-surface elevation differences between the lake-outflow site and the lock and dam.

The daily discharge record at the lake-outflow site indicated much greater variation than that at the lock and dam (fig. 6) because of pumping effects. Discharge computed at the lake-outflow site during the summer months of 1989 indicated numerous days of reverse flow, and showed greater variability from day to day than for any other time period during the study. Reverse flow was observed during routine site visits within this time period. Although reverse flow was observed during the summer of 1990, the number of days with negative daily mean discharge was much smaller in 1990 than in 1989. This variability in the discharge record prompted the further analysis of other hydrologic factors that might explain the variability.

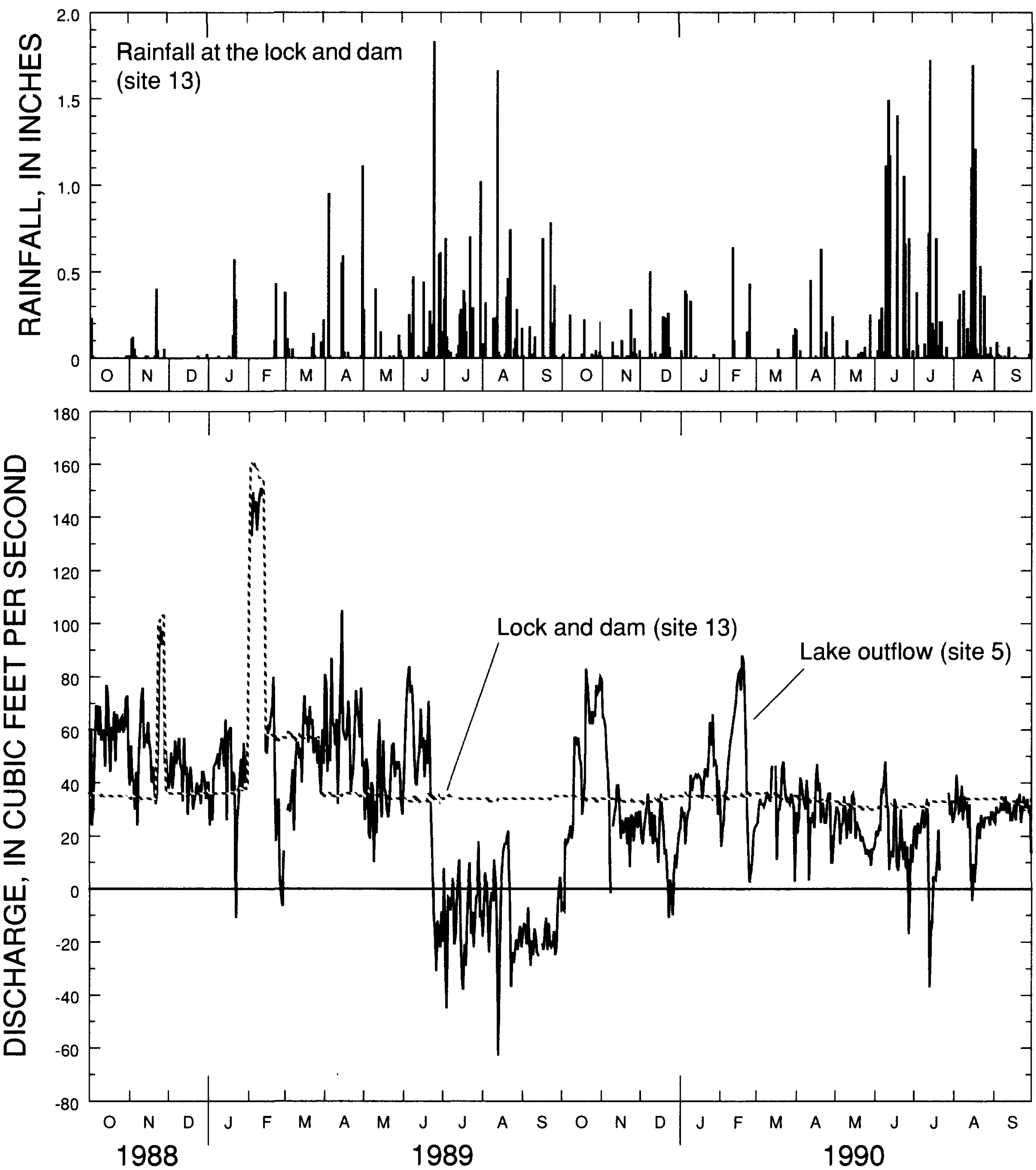


Figure 6. Discharge at the lake-outflow site (site 5), the Apopka-Beauclair Canal lock-and-dam site (site 13), and rainfall at the lock and dam site, October 1988 through September 1990.

Discharge records considered to be accurate are available for the period from September 14, 1988, through June 14, 1989 (period 1), and from November 11, 1989, through September 1990 (period 3). For the intervening period, from approximately June 15, 1989, through November 10, 1990 (period 2), there was a higher level of uncertainty in the computation of discharge because of reverse-flow conditions and equipment problems. Two electromagnetic velocity meters were installed in August 1988 at the site, providing a backup in case of equipment failure. Analysis of the discharge and other hydrologic data was done for each of these three periods of time and for periods 1 and 3 combined.

The difference in discharge between the lake-outflow and lock-and-dam sites (flow at the lock and dam minus lake outflow) represents the inflow from farms (or outflow from the canal to the farms) between the two sites. A positive difference represents water being added to the canal, whereas a negative difference represents water being withdrawn from the canal. A positive difference in discharge can result from both downstream (positive) and reverse flow at the lake-outflow site. When discharge at the lake-outflow site is reversed (flowing toward Lake Apopka), the difference between the two gaging sites is positive (subtraction of the negative flow yields a positive result), indicating inflow from farms.

Results of the analysis of discharge data computed for the two sites during the study is graphically depicted in figure 7. For the periods 1 and 3 together (September 14, 1988, through September 30, 1990, excluding the period from June 15, 1989, through November 9, 1989), the mean difference in flow between the lake-outflow and the lock-and-dam sites was -1.02 ft^3/s. However, when periods 1 and 3 are considered individually, the mean difference in flow is much greater. For time period 1 (September 14, 1988, to June 14, 1989) the mean difference in discharge is -8.10 ft^3/s, and for period 3 (November 10, 1989, through September 30, 1990) the mean difference is 5.1 ft^3/s. For period 2, from June 15, 1989, through November 9, 1989, the mean difference in flow was 27.0 ft^3/s, nearly 27 times greater than the other two periods (1 and 3) together.

Period 3 was further subdivided into two time periods: 3A (November 10, 1989, to March 13, 1990) and 3B (March 14, 1990, to September 30, 1990). Period 3A is the period from the time of reinstallation of the original electromagnetic velocity meter, to the time the monitoring equipment at the lake-outflow site was rewired in March 1990. Rewiring of the equipment at the lake-outflow site corrected a grounding problem that had caused more erratic readings. The mean difference in discharge for period 3A was 1.36 ft^3/s. Period 3B is the period following the rewiring of the monitoring equipment, from March 15, 1990, through September 30, 1990. For period 3B, the mean difference in discharge was 7.51 ft^3/s. A new rating curve was developed based on the data for period 3B.

The anomaly of the discharge data for period 2 may be the result of different agricultural practices that were not repeated in the summer growing season of 1990. Another possible explanation is a gradual deterioration of the electromagnetic velocity meter before its failure in August 1989 and again in October 1989. Because of the uncertainty in the data for period 2, an attempt was made to develop a predictive equation for discharge at the lake-outflow site (using data from periods 1 and 3) as a function of discharge at the lock and dam and other hydrologic variables.

Daily mean discharge at the lake-outflow site was correlated with daily rainfall with lagtimes of as much as 30 days. The highest correlation was between discharge and rainfall lagged by 1 day (coefficient of correlation of 0.166). Rainfall data lagged by 2 days were also correlated with discharge (coefficient of 0.158).

Regressions were tried using periods 1 and 3 together, representing 587 days of record. Hydrologic variables used in the regression analysis for the site included the following: difference in stage between the Winter Garden gage (fig. 1) and the gage at the lake-outflow site, difference in stage between the lake-outflow and the lock-and-dam sites, rainfall at the lock and dam, rainfall data lagged 1 or 2 days, discharge at the lock and dam, the number of days since 1900 (to account for trends with time during the study period), and a variable to account for seasonality of the data (sine and cosine functions of Julian day). All possible prediction equations were attempted and the best subset of predictor variables was identified by the amount of "improvement" in the value of R-squared, and Mallow's Cp (Gunst and Mason, 1980, p. 268). These variables were used in stepwise regression to obtain a regression equation.

The best-fit regression using data from periods 1 and 3 resulted in the following equation:

$$Q = 0.78\ LOKQ - 0.03\ NUMDAY - 15.26\ RAIN.1 - 12.42\ RAIN.2 - 3.20\ SCOS + 23.29\ DEL2 + 993.87$$

where Q is daily discharge, in cubic feet per second, at the lake-outflow site,
LOKQ is daily discharge, in cubic feet per second, at the lock and dam,
NUMDAY is number of days since 1900 (indicator of time trend),
RAIN.1 is rainfall, in inches, lagged 1 day,
RAIN.2 is rainfall, in inches, lagged 2 days,
SCOS is a variable measuring seasonality (cosine of Julian day), and
DEL2 is the difference in water-surface elevation between the lake-outflow and lock-and-dam sites, in feet.

The above regression explains 72 percent of the variation in the discharge data with 64 percent of the variation dependent on the discharge at the lock and dam. The other five variables together explained less than 10 percent of the variation in discharge. This result confirms that the lock and dam is the primary hydraulic control in the canal. The standard error of estimate for the regression was 16.23 ft^3/s. The largest residuals (difference between predicted and actual

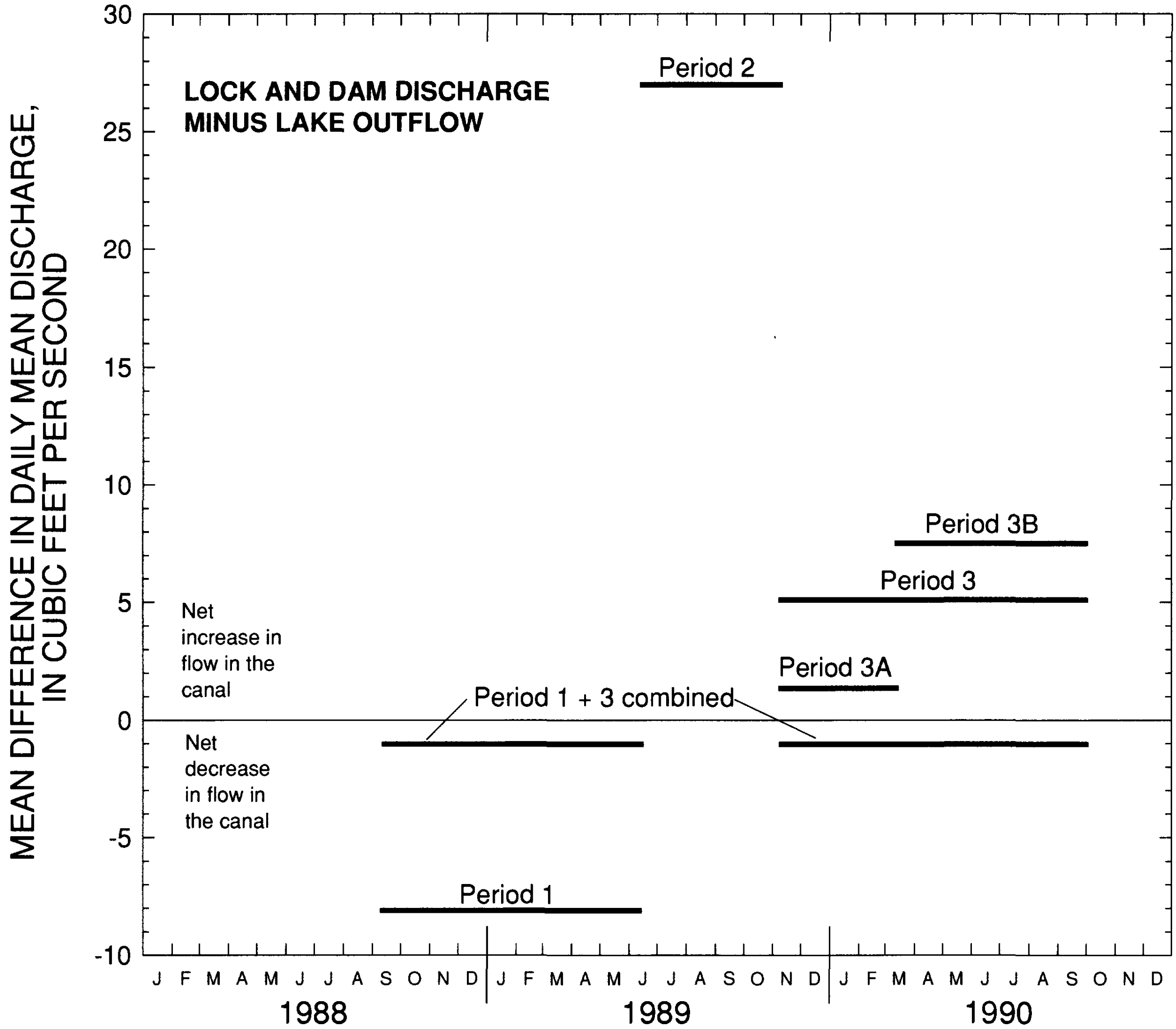


Figure 7. Mean differences in daily mean discharge between the lock-and-dam (site 13) and lake outflow (site 5) sites for selected time periods.

values) were associated with negative discharge values or values very close to zero, typically 1 to 2 days after a rainfall event. Thus, the prediction equation fit the actual discharge best for periods of no rainfall and worst for periods when farms were pumping to the canal.

The results of the regression analysis indicate that the discharge data from periods 1 and 3 (fig. 7, September 14, 1988, through June 14, 1989, and November 10, 1989, through September 30, 1990) seem to be accurate within the limitations previously discussed for the rating equations. The data from period 2 (June 15 through November 9, 1989) have a greater degree of uncertainty and cannot be substantiated with the other hydrologic data available. Pumping during this period cannot be quantified because records generally are not kept by the farmers along the canal (oral commun., David Stites, St. Johns River Water Management District, December 1990). Net loads computed for this study are considered to have a greater amount of uncertainty for time period 2, but are considered to be reasonably accurate (within the limitations of measurement of discharge and concentrations) for periods 1 and 3.

QUALITY OF WATER AND BOTTOM SEDIMENTS IN THE APOPKA-BEAUCLAIR CANAL

Nutrient data for water samples collected biweekly at the lake-outflow and lock-and-dam sites provided most of the data used for load computations. Water samples collected monthly at these sites were analyzed for major ion concentrations to provide information about conservative constituents in the canal water. Continuous collection of temperature, specific conductance, and dissolved oxygen data (at 30-minute intervals) provided information about variations in water quality for a smaller time interval than that obtained from biweekly or monthly samples.

Samples also were collected during selected storms to assess the effects of farm discharge, rainfall, and changes in gate openings at the lock and dam on canal water quality. Water samples from discharge points along the canal and at selected sites in the canal typically were collected the day after a storm. Samples at discharge points were collected directly from the discharge pipe or structure. Nutrient concentrations in, and ionic composition of, water samples collected after storm events are presented in the following section.

Reconnaissance sampling provided a synoptic survey of the quality of water and bottom sediments during non-storm periods, or "steady-state" conditions. These reconnaissance samples were collected in the canal, not from specific discharge points as were the storm samples. Three sets of reconnaissance samples were collected: two during the dry season and one at the end of the summer rainy season. Nutrient concentrations in reconnaissance samples are presented in a later section.

Summary of Water Quality at the Lake-Outflow and Lock-and-Dam Sites

Concentrations of nutrients and major ions at both gaging sites are summarized in table 2. Qualified values (concentrations less than the detection limit) were set equal to the detection limit to calculate mean concentrations. Mean and median concentrations for most constituents were similar between the two sites, because many of the samples were collected during average flow conditions. Therefore, minimum, median, and mean values in table 2 are associated with, and biased toward, the "average" flow of 35 ft^3/s at the lock and dam.

Nearly 80 samples were collected for analysis of nutrients and water-quality characteristics, and about 42 samples were collected for analysis of major ions at each of the two major sampling sites. These samples, collected during various hydrologic conditions during 4 years of the study, probably are sufficient for generally characterizing the quality of water leaving Lake Apopka and leaving the lock and dam. Water in the Apopka-Beauclair Canal generally is a calcium-bicarbonate type. Mean hardness of water at the lake-outflow site was 159 mg/L as $CaCO_3$, and at the lock-and-dam site, 174 mg/L as $CaCO_3$, which is within the classification of hard water (hardness ranging from 61 to 120 mg/L as $CaCO_3$ classified as hard by Hem, 1986). Specific conductance of the water from both sites ranged from 280 μS/cm to 630 μS/cm, an indication of the high dissolved-solids content of the water. The pH of water ranged from a low of 7.4 (at the lock-and-dam site) to a high of 9.4 standard units (at the lake-outflow site), indicating an alkaline environment, probably as a result of metabolic processes of the large algal population which exists in water in Lake Apopka and in the canal.

Table 2. Statistical summary of water-quality data for the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13)

[Concentrations are in milligrams per liter, unless otherwise noted. °C, degrees Celsius; NTU, nephelometric turbidity units; Pt-Co units, Platinum Cobalt units; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; <, less than]

Constituent or physical measure	Lake outflow (site 5)					Apopka-Beauclair Canal Lock and Dam (site 13)				
	No. of samples	Minimum	Maximum	Median	Mean	No. of samples	Minimum	Maximum	Median	Mean
Temperature (°C)	70	11.0	31.0	25.0	23.5	69	12.0	32.0	25.5	24.0
Turbidity (NTU)	47	.60	29	11	12	50	.65	25	10	11
Color (Pt-Co units)	45	15	240	50	65	49	20	200	60	75
Specific conductance (µS/cm at 25 °C)	73	280	510	400	405	76	290	630	430	440
Dissolved oxygen	60	1.9	12.2	6.8	6.7	58	1.2	10.8	6.2	6.0
pH, (standard units)	28	7.5	9.4	8.8	8.6	28	7.4	9.2	8.0	8.1
Nitrogen, as N:										
Organic, total	72	2.4	10.7	4.3	4.5	77	2.1	7.5	3.9	4.2
Ammonia, total	79	<.01	0.61	.02	.05	82	<.01	.93	.02	.09
Ammonia plus organic, dissolved	68	1.2	3.6	2.0	2.1	71	1.5	4.3	2.0	2.2
Ammonia plus organic, total	79	2.6	11	4.4	4.6	82	2.1	7.8	4.0	4.4
Nitrate plus nitrite, total	79	<.02	3.6	<.02	.26	82	<.02	4.4	<.02	.41
Nitrate plus nitrite, dissolved	68	<.02	3.6	<.02	.24	71	<.02	4.4	<.02	.38
Phosphorus, as P										
Total	78	.04	.91	.22	.26	82	.10	1.8	.27	.39
Dissolved,	68	<.02	.71	<.02	.07	71	<.02	1.6	.03	.18
Ortho, total	78	<.01	.76	.06	.11	82	<.01	1.6	.08	.22
Ortho, dissolved	68	<.01	.69	<.01	.05	71	<.01	1.5	<.01	.16
Total organic carbon	42	13	57	25	26	45	1.7	59	26	28
Hardness, as $CaCO_3$	42	135	187	156	159	45	140	226	172	174
Calcium, dissolved	42	26	47	34	35	45	28	58	41	40
Magnesium, dissolved	42	15	20	17	17	45	16	21	18	18
Sodium, dissolved	42	11	33	16	17	45	10	29	15	15
Potassium, dissolved	42	7.4	13	11	11	45	8.7	19	11	12
Chloride, dissolved	42	25	45	38	37	44	24	52	38	37
Sulfate, dissolved	42	10	34	24	24	44	19	59	24	28
Alkalinity	40	109	149	122	123	45	101	154	130	129

Nutrient concentrations generally were high, although the median nitrate-plus-nitrite nitrogen concentration at both sites was less than detection limit. The primary form of nitrogen in the canal water is organic nitrogen, which ranged from a minimum of 2.1 mg/L at the lock-and-dam site to a maximum of 4.5 mg/L at the lake-outflow site. Total phosphorus concentrations ranged from 0.04 mg/L at the lake-outflow site to 1.8 mg/L at the lock-and-dam site.

Nearly all the maximum values in table 2 represent extreme conditions (high discharges) associated with storm periods or changes in gate openings. Maximum values observed generally were from March 29 (discharge of 101 ft^3/s) through April 2, 1987 (discharge of 589 ft^3/s), with a few exceptions. For example, the maximum concentration of total phosphorus at the lake-outflow site, 0.91 mg/L, was measured on August 1, 1989, and again on August 15, 1989. During this period, discharge at the lock and dam was 34 ft^3/s, but reverse flow was recorded and observed at the lake-outflow site, an indication that water was being pumped into the canal from farms. Thus, this maximum phosphorus concentration probably is not representative of the lake outflow.

Median specific conductance values were higher at the lock-and-dam site than at the lake-outflow site, an indication of an increase in dissolved solids between the two sites on the canal. Medians of other constituents also varied slightly between the two sites and are summarized below:

Constituents or physical properties for which medians are higher at lock-and-dam site	Constituents or physical properties for which medians are higher at lake-outflow site
total and dissolved nitrate -plus-nitrite nitrogen	pH
total ammonia	dissolved oxygen
total orthosphosphorus	total organic nitrogen
calcium, sulfate, color	dissolved sodium
total phosphorus	
hardness and alkalinity	

These differences in medians are slight. However, examination of data from sampling after specific storm events or data recorded at a frequent time interval (hourly, for example) may indicate greater differences in water quality.

Temperature, specific conductance, and dissolved oxygen vary seasonally and with rainfall, and can be indicators of physical, chemical, and biological processes in the canal. Several time periods were selected from the hourly data recorded at each site to represent varying seasonal and hydrologic conditions. Temperature, specific conductance, and dissolved oxygen concentrations at the lake-outflow and lock-and-dam sites during several relatively dry periods, when little or no rainfall was recorded, are shown in figures 8-10. Figures 11 and 12 show these water-quality characteristics for periods when rain was recorded during summer (fig. 11) and winter (fig. 12).

Temperature, specific conductance, and dissolved oxygen concentrations at both sites tended to vary less during winter months (fig. 8) than during summer months (figs. 9 and 10), largely because of the reduction in biological activity and farm pumping during winter. The decline in dissolved oxygen concentrations at the lake-outflow site January 17 and 18 (fig. 8) may have resulted from farms pumping to the canal downstream from the site. The daily mean discharge at the lake-outflow site decreased from 41 ft^3/s on the 17th to 34 ft^3/s on the 18th; this indicates pumping downstream. This could also be the reason for the brief rise in conductance at the lake-outflow site on January 17, 1990 (fig. 8). The sudden decrease in specific conductance at the lock-and-dam site on June 17 (fig. 9) probably was the result of rainfall (1.40 inches) on that date. Dissolved oxygen concentrations tended to be more stable and generally higher in winter, although concentrations sometimes exceeded 15 mg/L for brief periods during the summer (observed in the continuous record for the lake-inflow site).

Specific conductance and dissolved oxygen concentrations were more variable during summer months, particularly at the lake-outflow site. The variations in dissolved oxygen concentration generally were greater at the lake-outflow site than at the lock-and-dam site (fig. 9) because of the dynamic flow conditions in the canal (seiche effects, flow reversals at the lake-outflow site, and pumping into the canal). Plots of temperature, specific conductance, and dissolved oxygen concentrations during two relatively dry periods in June and July 1990 (figs. 9 and 10) indicate that these characteristics can vary substantially within the same summer growing season. Specific conductance and dissolved oxygen concentrations varied more during July (fig. 10) than during June (fig. 9), whereas temperature varied more in June. The overall pattern observed in dissolved oxygen concentrations in figures 9 and 10 is typical of a eutrophic water body during hot summer months, with high concentrations during the late afternoon and low concentrations at night and in the early morning (Wetzel, 1975, p. 135). Dissolved oxygen concentrations are stratified with depth. The highly variable pattern in dissolved oxygen concentrations at the lake-outflow site on July 31 (fig. 10) probably is the result of changes in flow direction at the site due to more pronounced seiche effects from higher wind speeds, or effects due to pumping into the canal. The pattern in dissolved oxygen concentrations is similar to the pattern that was observed in the short-term variations in the index-velocity data shown in figure 5.

Variations in temperature, specific conductance, and dissolved oxygen concentrations were most evident during periods of rainfall (figs. 11 and 12), regardless of season. The extreme fluctuations in dissolved oxygen concentrations at the lake-outflow site that were evident during June 14-17, 1990, (fig. 9) also were present in the data for June 28, 1990, 2 days after it rained on June 26 (0.69 inch, fig. 11); however, these patterns are not consistent. For example, in data shown in figure 11, erratic variations in dissolved oxygen concentrations were not evident on June 24 and 25 after 1.05 in. of rain on June 22 and another 0.66 in. on June 23, 1990. Temperature values at both monitoring sites followed similar patterns; however, specific conductance values did not. For example, the gradual increase in specific conductance at the lock-and-dam site in figure 11 was not reflected in the data for the lake-outflow site. The specific conductance of water discharged into the canal from adjacent farms usually is much higher than that of the receiving canal water, so this increase at the lock and dam could be an indication of discharge from farms along the canal.

Record-breaking cold temperatures in December 1989 caused a major fish kill in Lake Apopka and in the Apopka-Beauclair Canal. Plots of temperature,

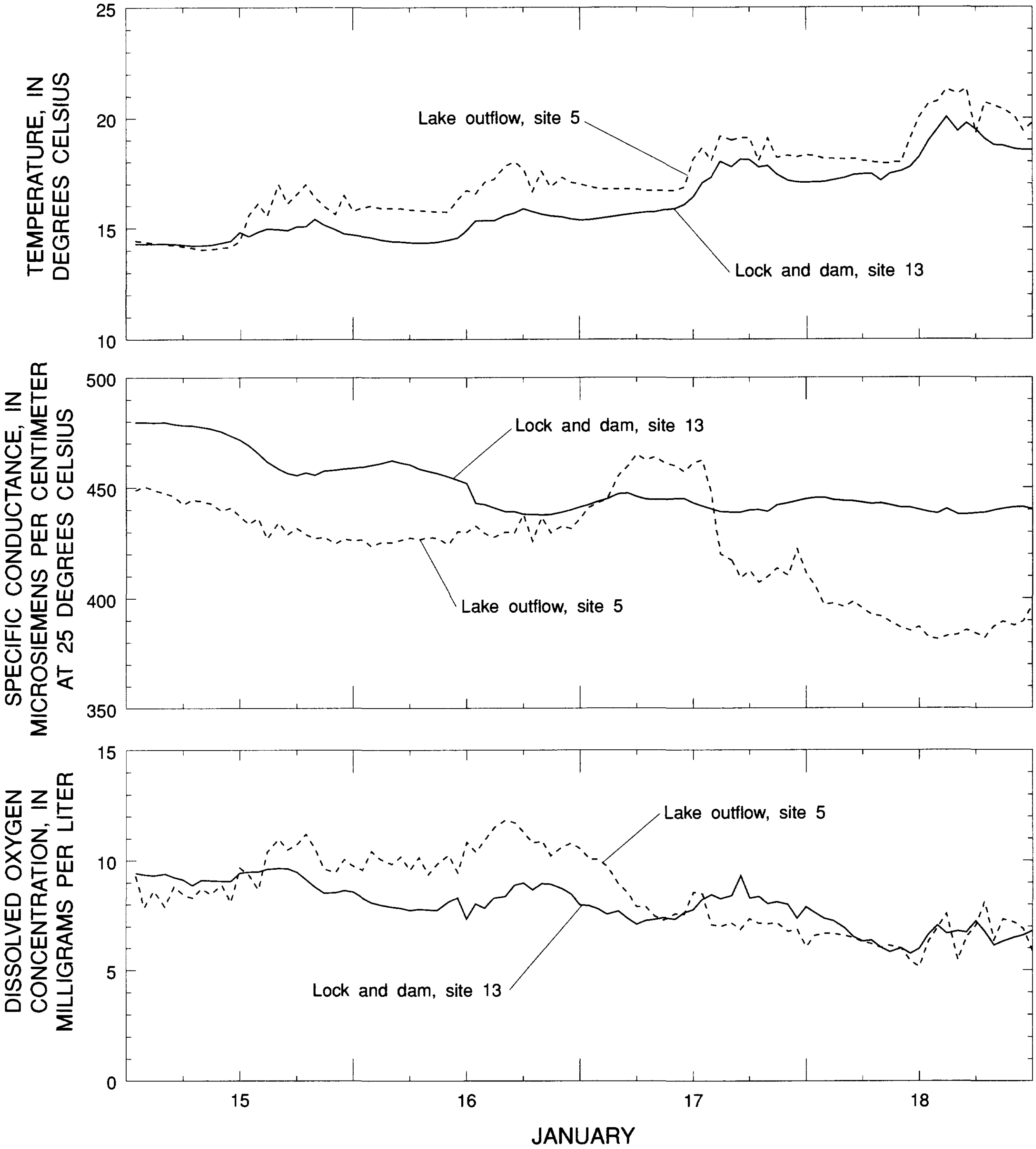


Figure 8. Temperature, specific conductance, and dissolved oxygen concentrations at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), January 15-18, 1990.

specific conductance, and dissolved oxygen for this period (fig. 12) show the effect of the extreme temperature and the fish kill on dissolved oxygen concentrations. The decline in dissolved oxygen concentrations at the lake-outflow site during December 27-31 probably was due to the decomposition of dead fish. This decline in dissolved oxygen concentrations was not evident in the data for the lock-and-dam site.

Nitrogen and phosphorus concentrations in water from the two gaging sites on the canal were variable (figs. 13 and 14), with higher concentrations associated with higher discharges at the lock and dam. Total ammonia-plus-organic nitrogen had the greatest seasonal variation of the nutrient species analyzed. High concentrations of total phosphorus and orthophosphorus were measured at

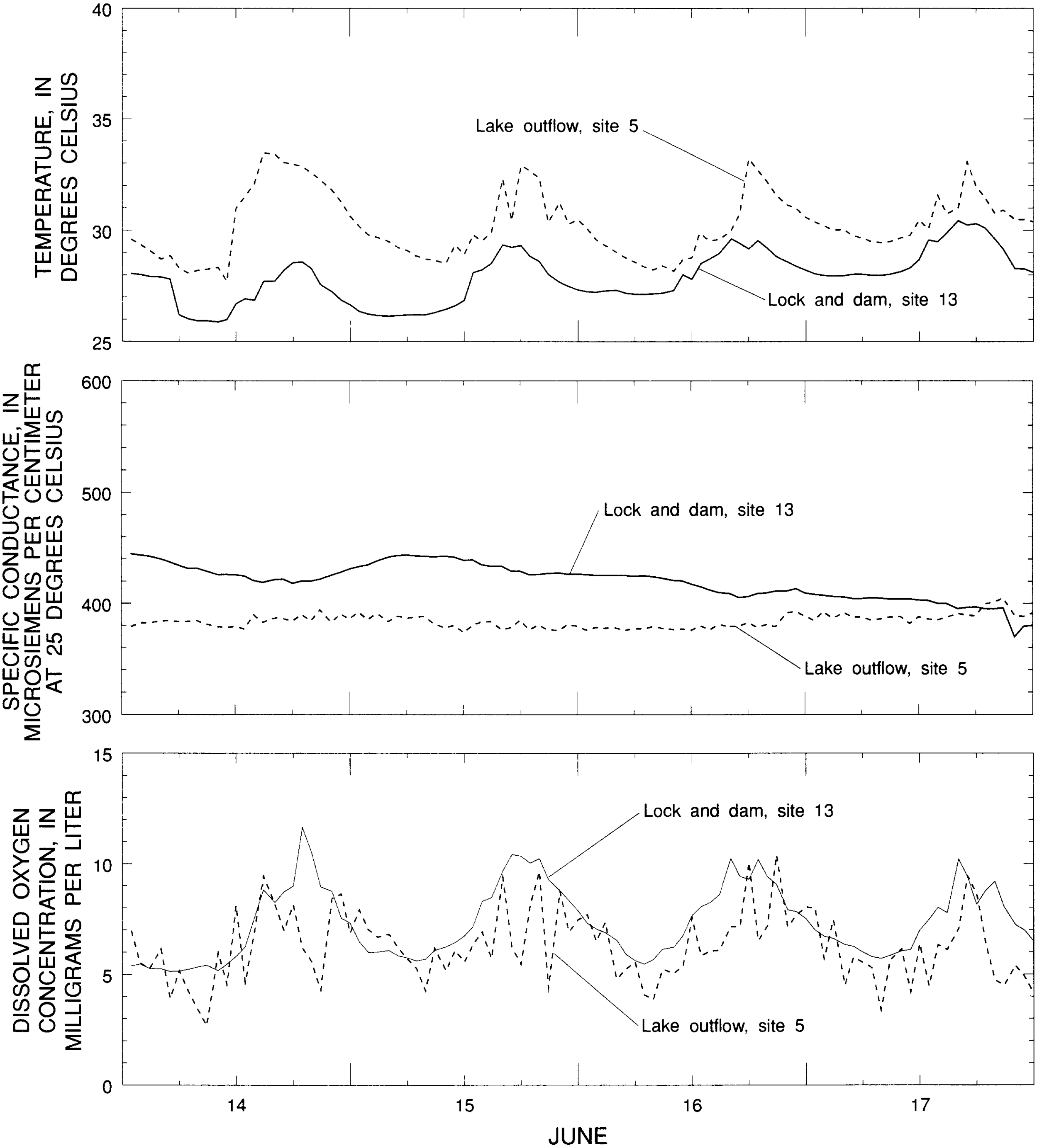


Figure 9. Temperature, specific conductance, and dissolved oxygen concentrations at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), June 14-17, 1990.

both sites in August 1989. During August, reverse flow was gaged at the lake-outflow site, but discharge at the lock and dam remained constant. These extremes in phosphorus concentrations, particularly in orthophosphorus, support the hypothesis that farm discharge to the canal during this period was great enough to cause the flow at the lake-outflow site to be reversed.

Storm Sampling

Water-quality samples were collected from discharge points along the canal and at selected sites in the canal after several storms during the study to evaluate the effects of rainfall, gate opening, and inflow from discharge points on quality of water in the canal.

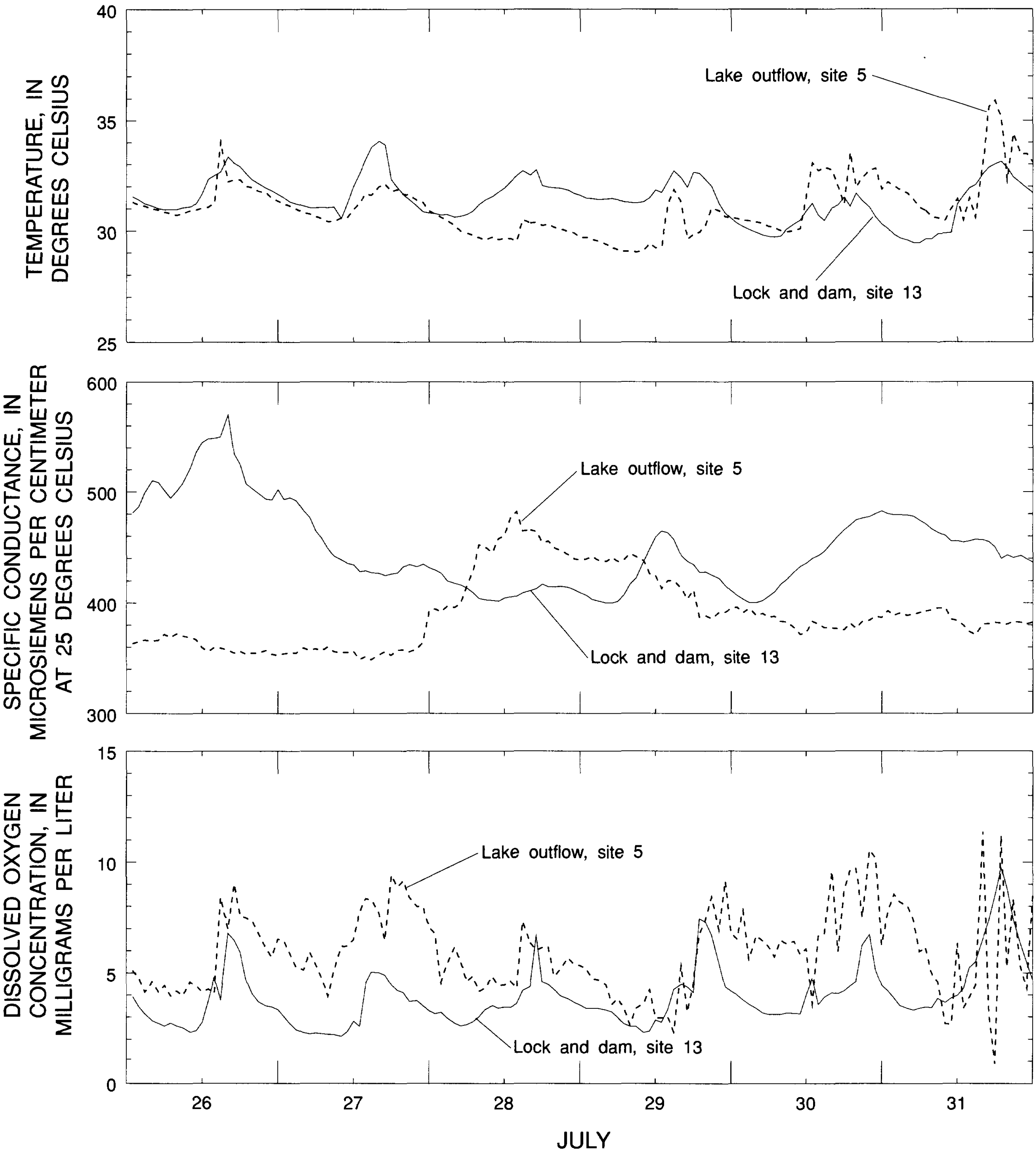


Figure 10. Temperature, specific conductance, and dissolved oxygen concentrations at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), July 26-31, 1990.

Changes in canal water quality after several storms are presented in this section and in figures 15-22.

The gate openings at the Apopka-Beauclair Canal lock and dam were increased to discharge excess water after more than 10 in. of rain fell in March 1987. Daily mean discharge at the lock and dam increased to 101 ft^3/s on March 29, to 457 ft^3/s on March 30, to 577 ft^3/s on March 31, and to 589 ft^3/s on April 1-2. The discharge remained high during much of the month of April, but decreased to approximately 210 ft^3/s on April 25, 1987. During March and April 1987, numerous samples were collected at the lake-outflow site, at discharge points along the canal, and at the lock-and-dam site. No discharge data are available at the lake-outflow site

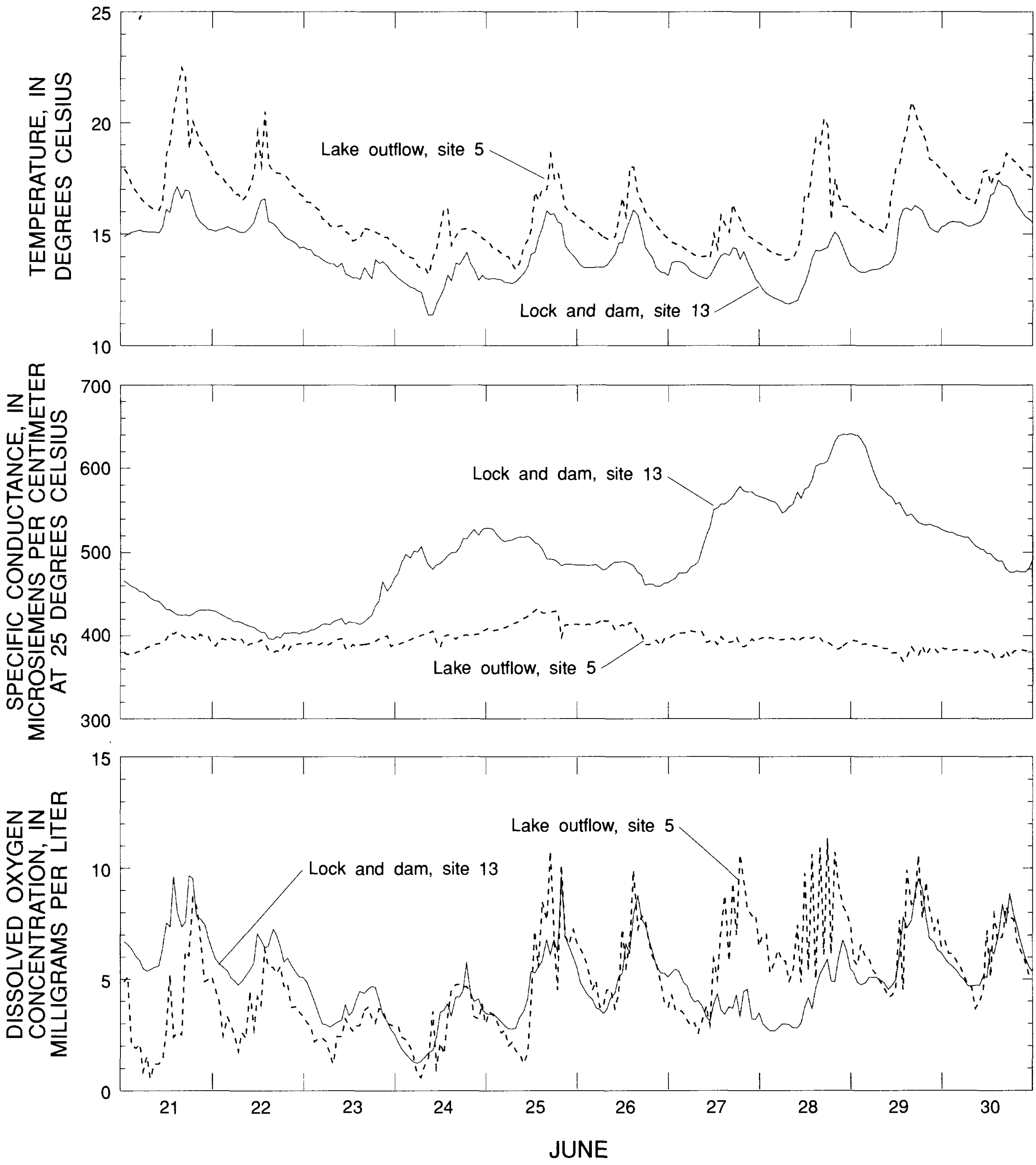


Figure 11. Temperature, specific conductance, and dissolved oxygen concentrations at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), June 21-30, 1990.

for this time period, but two discharge measurements were made at site 7, downstream from the lake-outflow site. Discharge at site 7 was 486 ft^3/s on April 2, 1987, and 559 ft^3/s on April 6, 1987. Discharges at the lake-outflow and the lock-and-dam sites were about equal during periods of high flow when the gates were open.

The evolution of the ionic composition of water at the lock-and-dam site during this high-flow period is represented by Stiff diagrams (Hem, 1986, p. 175) in figure 15. The sample collected on March 29, 1987, when the discharge was 101 ft^3/s, contained relatively high concentrations of calcium, magnesium, bicarbonate, sulfate, and nitrate nitrogen. In subsequent samples,

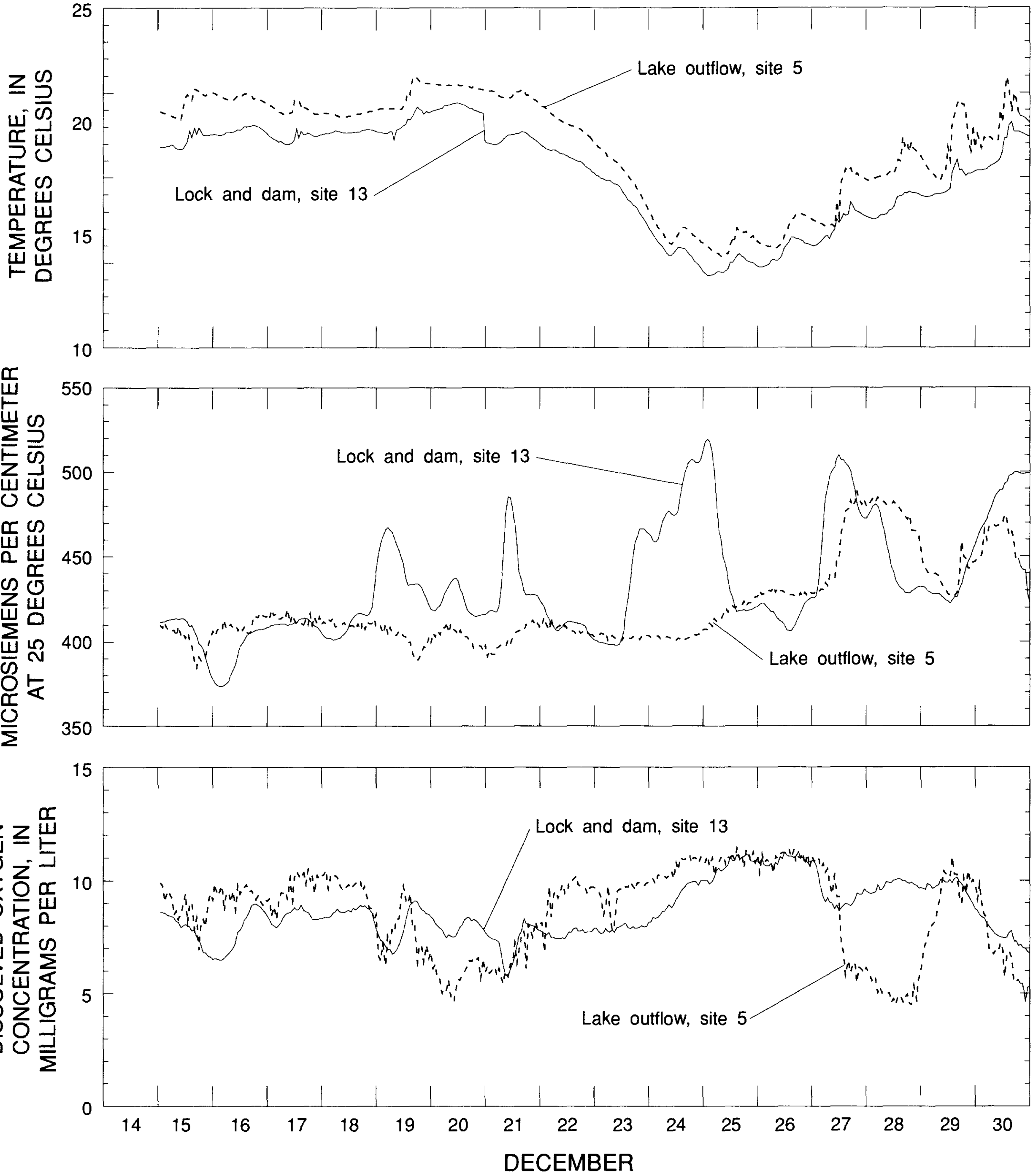


Figure 12. Temperature, specific conductance, and dissolved oxygen concentrations at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), December 15-31, 1989.

collected during April, relative concentrations of bicarbonate and chloride ions slightly increased and relative concentrations of nitrate and sulfate decreased.

Nitrate nitrogen concentrations typically do not comprise a large part of the anion portion of the ionic composition of surface waters. However, probably as a result of the heavy rainfall, high nitrate concentrations were detected in water from both the lake-outflow and the lock-and-dam sites following the opening of the gates. Nitrate concentrations on March 31, 1987, were 3.6 mg/L at the lake-outflow site, and 4.4 mg/L at the lock-and-dam site. By the end of April 1987, concentrations had decreased to 0.02 and 0.03 mg/L at the lake-outflow and lock-and-dam sites, respectively.

Diagrams showing the ionic composition of water from selected sites 2 days after the gates were opened (March 31, 1987) indicate little difference in the composition of water between Lake Apopka and Lake Beauclair (fig. 16). Noticeable differences are increased calcium and magnesium concentrations between Lake Apopka and the lock-and-dam site, with much of the increase occurring just downstream from Lake Apopka. The nitrate nitrogen concentration increased from site 2 (just downstream from Lake

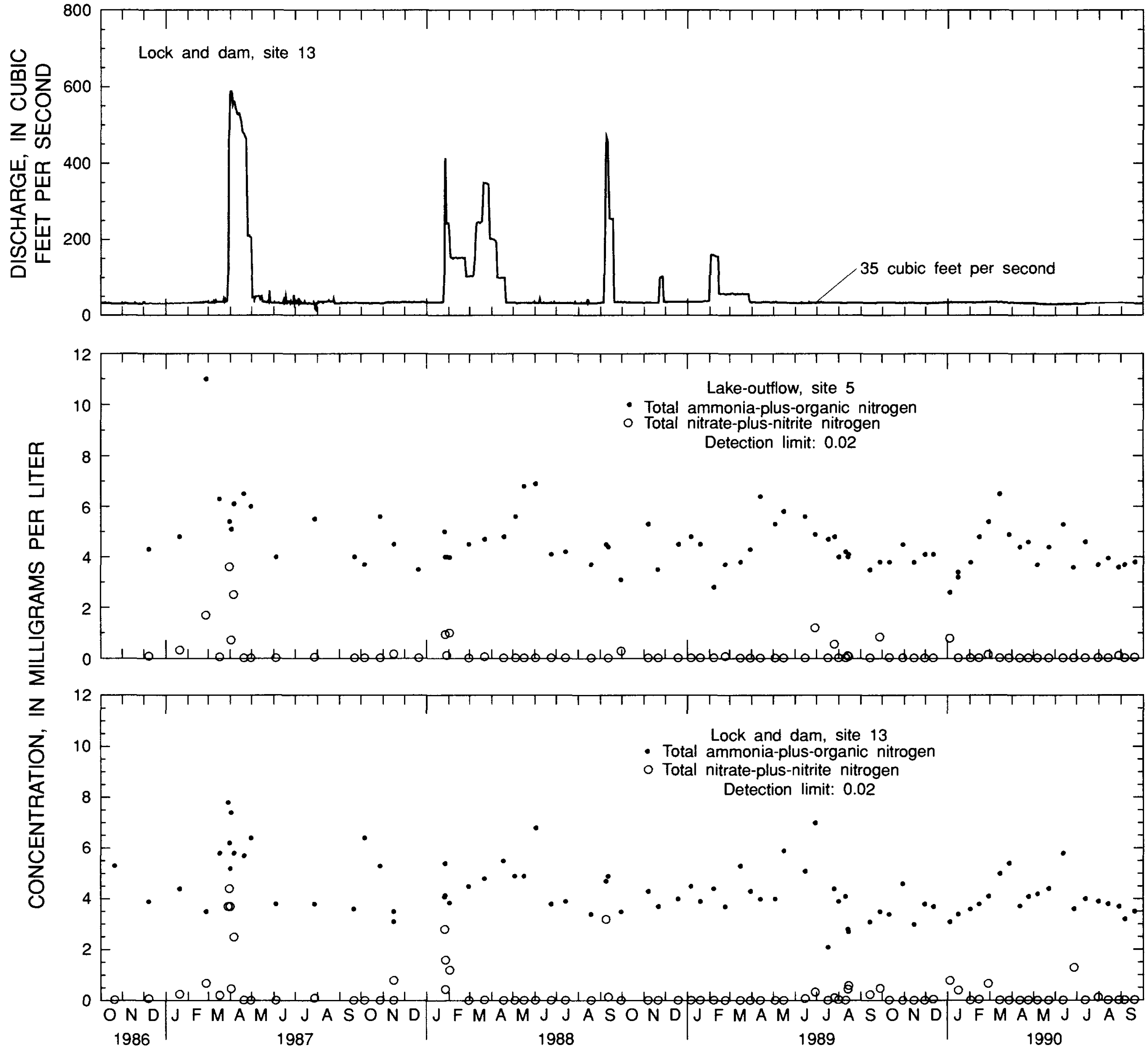


Figure 13. Total ammonia-plus-organic nitrogen and nitrate-plus-nitrite nitrogen concentrations at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), and discharge at site 13, October 1986 through September 1990.

Apopka), to site 8 (halfway to the lock-and-dam site) and then seemed to remain nearly constant from site 8 to Lake Beauclair. The increased nitrate nitrogen concentration between sites 2 and 8 might have been caused by pump discharge at site 3; the relatively high nitrate nitrogen concentrations along the canal from site 3 to Lake Beauclair could indicate the presence of other nitrate sources along the canal. Samples collected from pond discharge pipes (sites 6 and 8) on April 2, 1987, had relatively high concentrations of nitrate nitrogen. There are few sources for nitrate nitrogen below the lock and dam because the area adjacent to the canal in this reach is mostly residential or undeveloped land. It is probable that most of the nitrate reaching Lake Beauclair was contributed by Lake Apopka outflow and outflow from farms adjacent to the canal between Lake Apopka and the lock and dam.

Some contributions from farm discharge points are indicated by the ionic composition of water in the canal during other storm periods (and non-storm periods), but generally the canal water seemed to have an ionic composition similar to that of water in Lake Apopka. Alkalinity and concentrations of calcium, sodium, and chloride increased between some sites along the canal but generally these increases were small.

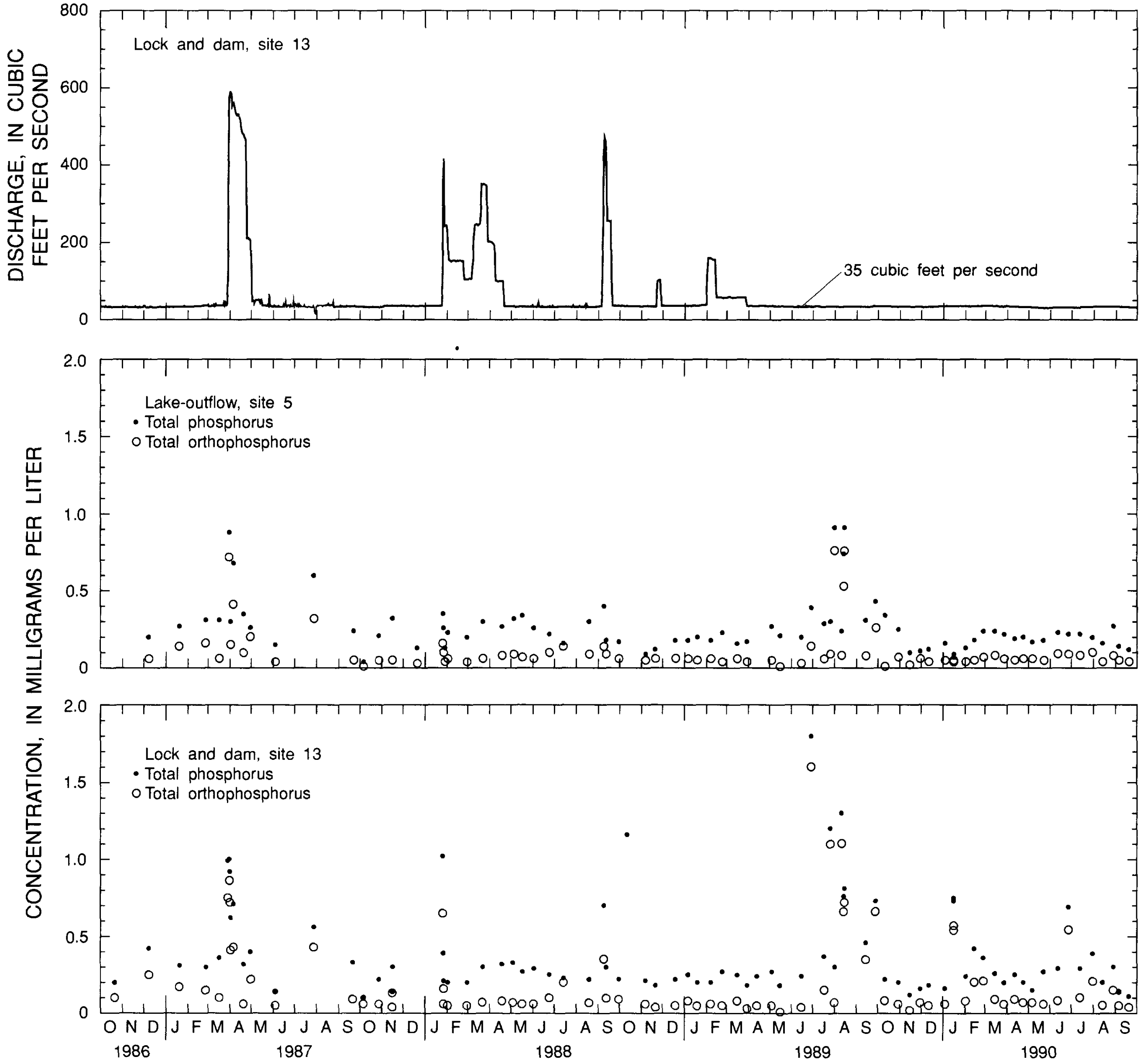


Figure 14. Total phosphorus and orthophosphorus concentrations at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), and discharge at site 13, October 1986 through September 1990.

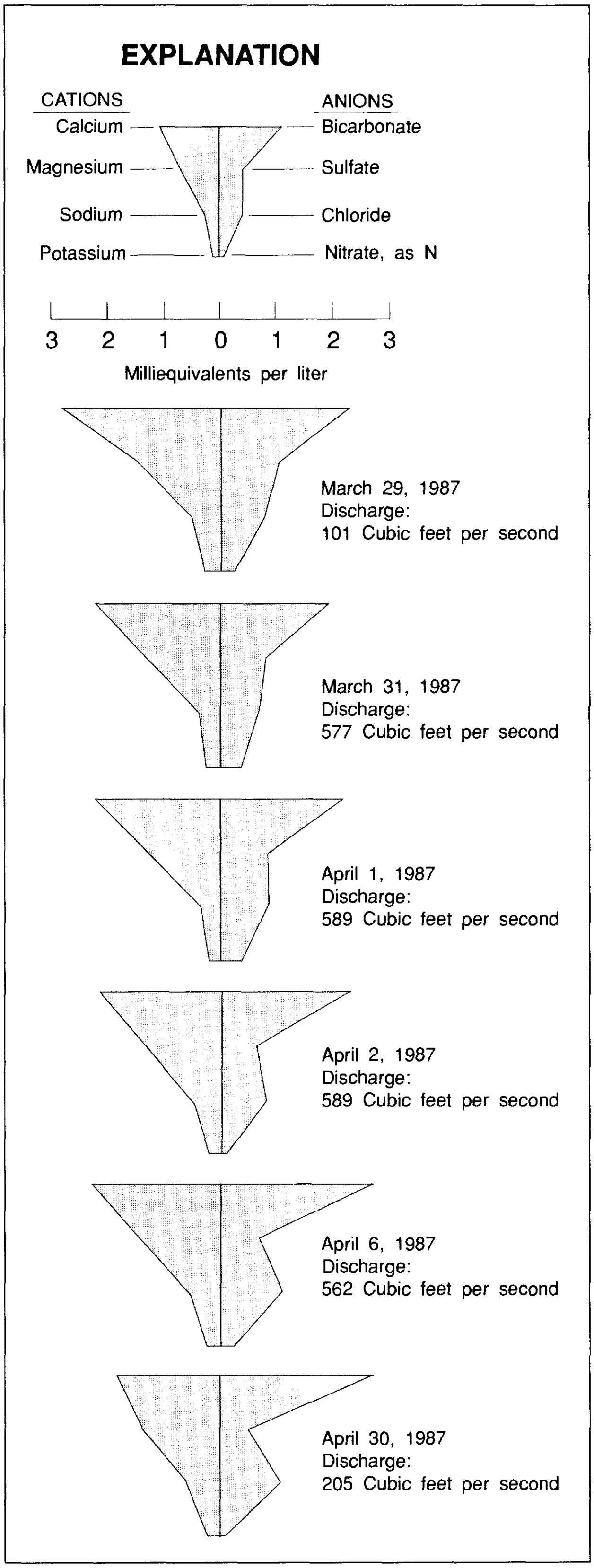


Figure 15. Ionic composition of water at the Apopka-Beauclair Canal lock and dam (site 13) during a period of changes in gate openings, March 29 to April 30, 1987.

Nitrogen and phosphorus concentrations in samples collected during selected storms are shown in figures 17-22 for sites within the canal, in Lakes Apopka and Beauclair, and in point discharges from farms along the canal. In these figures, concentrations are plotted against distance from the Lake Apopka site (site 1, approximately in the center of the lake). Although lines are shown connecting the data points in these illustrations, they do not represent variations in concentrations between the sampling sites.

High concentrations of nitrate-plus-nitrite nitrogen were measured in samples collected at sites in the canal (figs. 17 and 18) during the period of high discharge in March and April 1987 when the gates were open at the lock and dam. These concentrations are associated with the highest discharge recorded during the study. Analysis of samples collected on March 31, 1987, indicated that nitrate-plus-nitrite nitrogen concentrations increased from near the detection level in Lake Apopka to 3.6 mg/L at the lake-outflow site (site 4) and to 5.2 mg/L at site 7 (fig. 17). Nitrate-plus-nitrite concentrations in the canal remained elevated at canal sites downstream from site 7, but decreased sharply in Lake Beauclair. Ammonia-plus-organic nitrogen concentrations were relatively high (5 to 7 mg/L) but more uniform than concentrations of nitrate-plus-nitrite nitrogen (fig. 17). Variations in the concentrations of nitrogen species indicate the possible conversion from organic nitrogen to nitrate-plus-nitrite nitrogen in the reach upstream from site 7, and the biological uptake of nitrate-plus-nitrite nitrogen downstream from site 7 and in Lake Beauclair. Biological uptake could also be responsible for the sharp decrease in phosphorus concentrations between site 15 and site 16 in Lake Beauclair, although dilution and sedimentation in the lake might also affect nitrogen and phosphorus concentrations.

On April 2, 1987, at a similar but slightly higher discharge (589 ft^3/s), ammonia-plus-organic nitrogen concentrations at sites in the canal were similar or slightly higher than concentrations measured on March 31, 1987, but nitrate-plus-nitrite nitrogen and phosphorus concentrations were much lower (fig. 18). Concentrations of phosphorus and nitrate-plus-nitrite nitrogen at sites in the canal were less than concentrations in discharge from point sources along the canal (sites 6, 8, and 12). The low nitrate-plus-nitrite nitrogen and high ammonia-plus-organic nitrogen concentrations in the canal water at the lock and dam indicate that nitrate-plus-nitrite nitrogen from point sources along the canal apparently was being assimilated by biota in the canal.

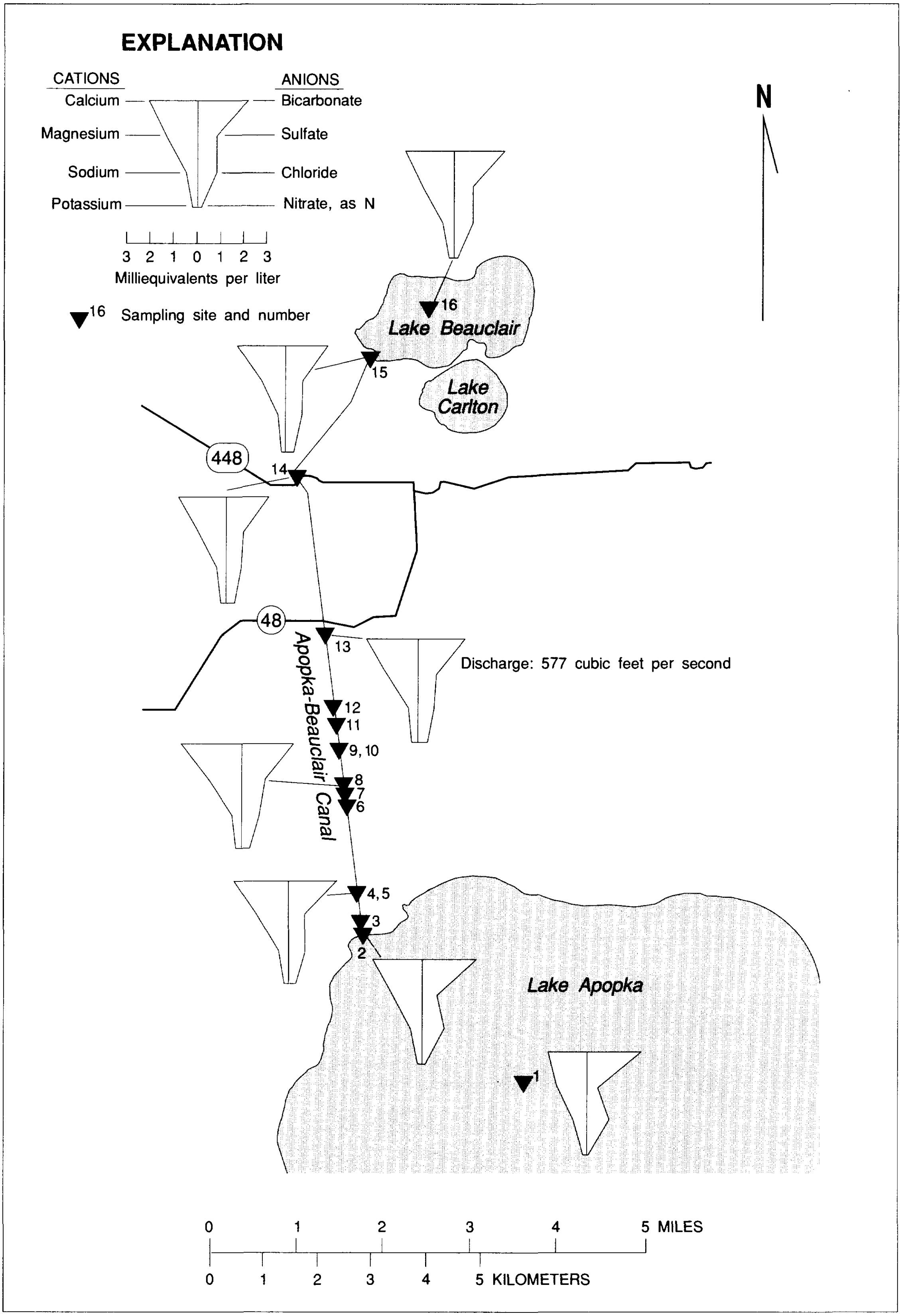


Figure 16. Ionic composition of water at selected sampling sites along the Apopka-Beauclair Canal, March 31, 1987.

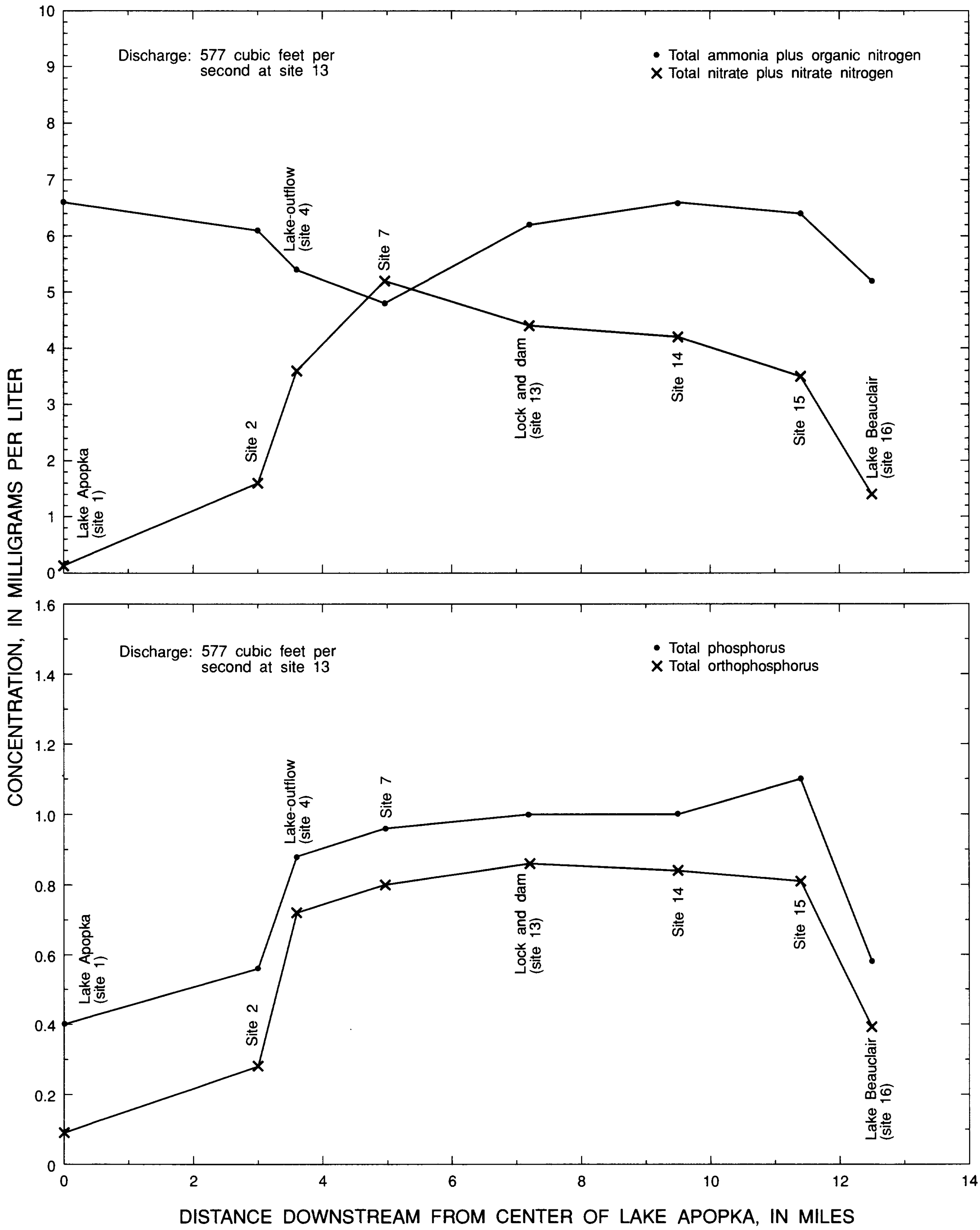


Figure 17. Nutrient concentrations at selected sampling sites from Lake Apopka to Lake Beauclair, March 31, 1987.

Nutrient concentrations in water at selected sampling sites on September 9, 1988 (discharge, 471 ft^3/s), and September 12, 1988 (discharge 360 ft^3/s), are shown in figures 19 and 20. On September 9, 1988, nitrate-plus-nitrite nitrogen concentrations increased from less than the detection level at site 2 to 3 mg/L at the lock and dam because of inflows to the canal (fig. 19). The same pattern was observed for phosphorus. Total phosphorus and orthophosphorus concentrations were higher in water at the lock and dam than in water at site 2. Ammonia-plus-organic nitrogen concentrations were high (more than 4 mg/L) at all but one site downstream from Lake Apopka on September 9 and 12, 1988 (figs. 19 and 20). However, phosphorus concentrations decreased by more than half from September 9 to September 12, 1988, from 0.40 to 0.18 mg/L at the lake-outflow site (site 5) and from 0.70 to 0.30 mg/L at the lock and dam (site 13). Nitrate-plus-nitrite nitrogen concentrations were significantly lower on September 12 (0.15 mg/L) than on September 9, 1988, (3.2 mg/L) at the lock and dam. During this time, the concentration of nitrate-plus-nitrite nitrogen at the lake-outflow site decreased from 1.9 to 0.02 mg/L. Increases in nutrient concentrations between site 2 and the lake-outflow site (site 5) could be the result of a point discharge (site 3), where relatively high concentrations of these nutrients were measured (fig. 19 and 20).

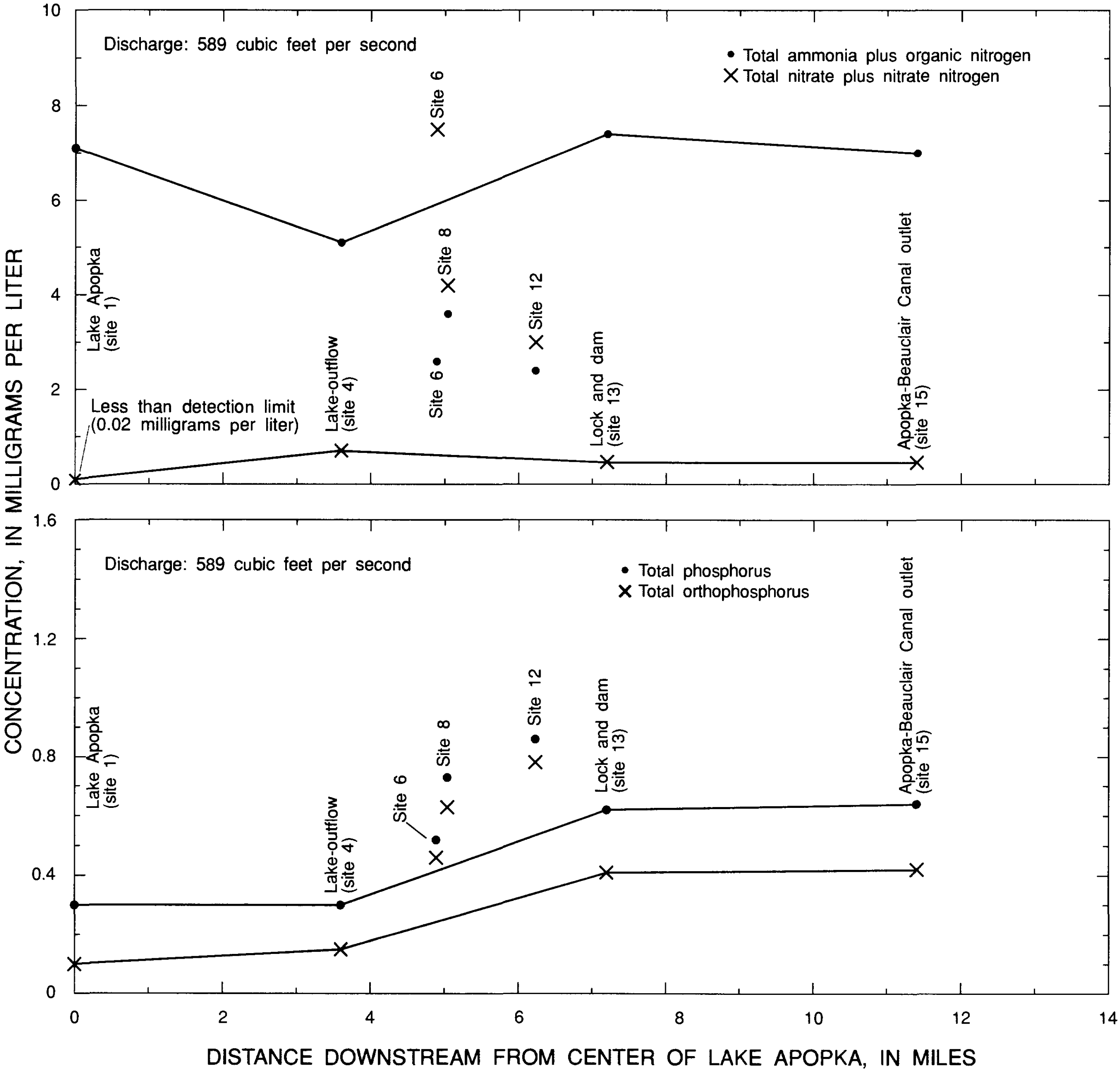


Figure 18. Nutrient concentrations at selected sampling in Lake Apopka and the Apopka-Beauclair Canal, April 2, 1987.

The descriptions of water quality in the canal presented thus far have been for high-flow periods, when the discharge at the lock and dam exceeded 300 ft^3/s and discharge at the lake-outflow site was approximately equal to the discharge at the lock and dam. Water quality under more normal flow conditions, when discharge is about 35 ft^3/s can be expected to differ from water quality during the conditions of high flow, because discharges to or withdrawals from the canal by farms and seiche effects from Lake Apopka can significantly affect water quality at lower discharges.

To examine water quality during more normal flow conditions, samples were collected at selected sites following two storms during June and July 1990. These samples were collected during periods when the gates at the lock and dam were set to release 35 ft^3/s. Flow reversals typically were observed at the lake-outflow site 1 to 2 days following storms.

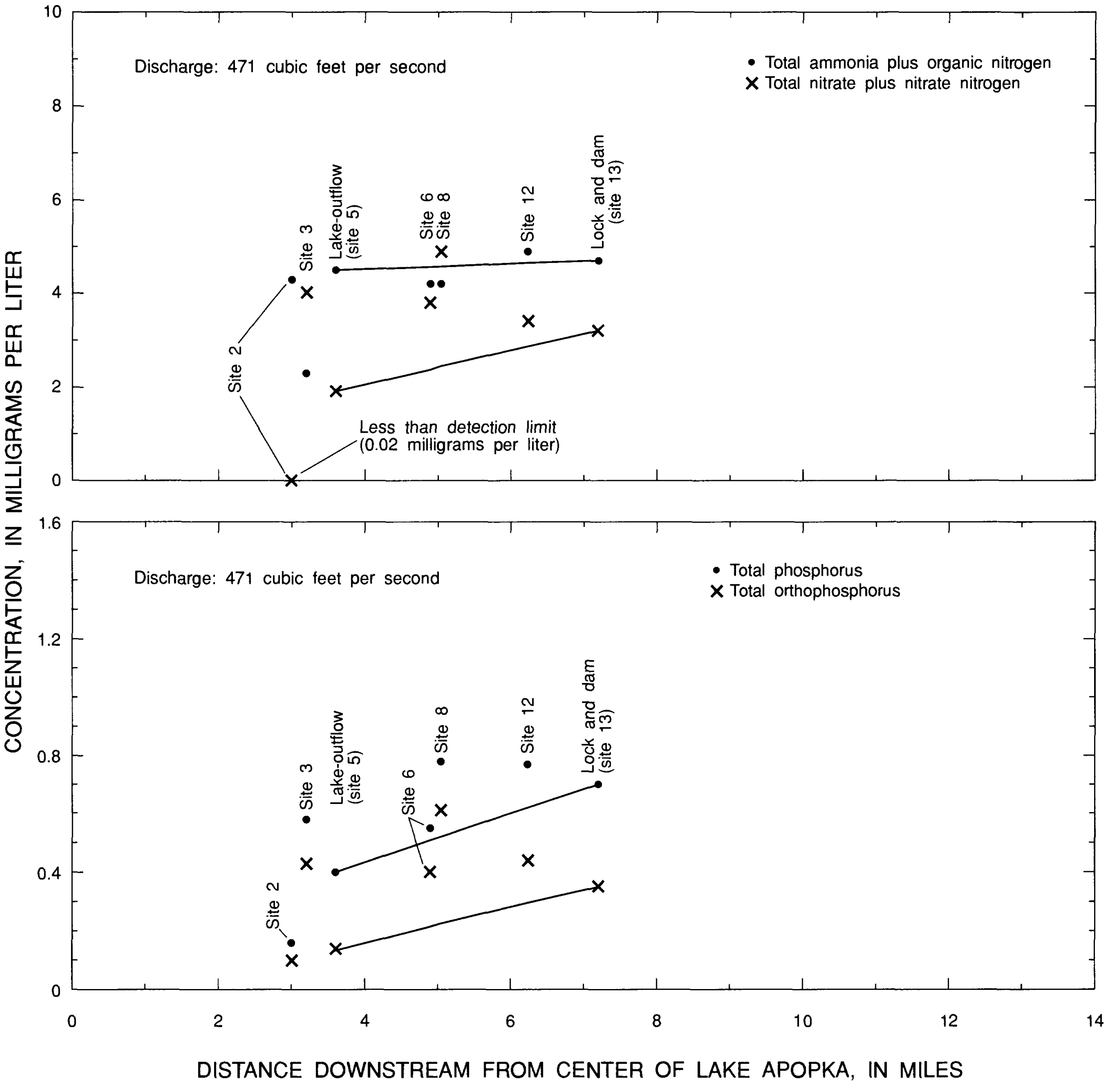


Figure 19. Nutrients concentrations at selected sampling sites on the Apopka-Beauclair Canal, September 9, 1988.

Rainfall amounts and daily mean discharge at the lake-outflow and lock-and-dam sites for several days in June and July 1990, are listed in the following table. In June 1990, 0.69 in. of rainfall on the 26th resulted in a reverse flow of 17 ft^3/s (daily mean) on the 27th. In July 1990, 2 days of heavy rainfall (0.72 and 1.72 in. on the 11th and 12th, respectively) resulted in reverse flows of 37, 16, and 13 ft^3/s on the 13th, 14th, and 15th, respectively, although flow at the lock and dam remained nearly constant at about 33 ft^3/s. The difference in the duration and magnitude of reverse flow in July (in response to nearly 2.5 in. of rain) compared to June (in response to 0.69 in. of rain) indicates the relation between rainfall and discharge at the lake-outflow site.

Date	Rainfall (inches)	Daily mean discharge at the lake-outflow site (ft^3/s)	Daily mean discharge at the lock-and-dam site (ft^3/s)
June 26, 1990	0.69	16	32
27	0	-17	32
28	0	2	32
29	.04	17	32
July 11, 1990	.72	34	31
12	1.72	26	31
13	.05	-37	33
14	.20	-16	33
15	0	-13	33

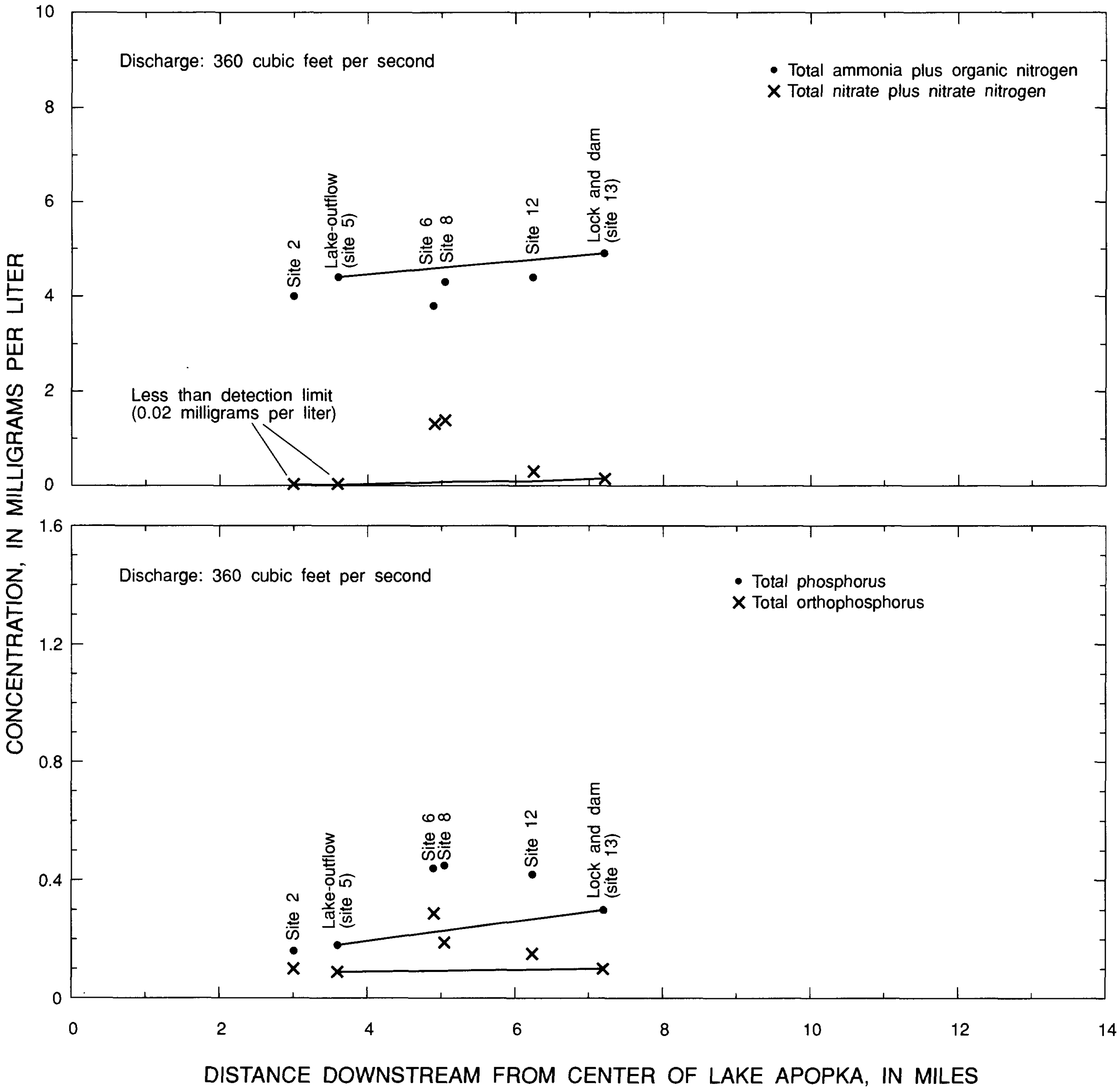


Figure 20. Nutrient concentrations at selected sampling sites on the Apopka-Beauclair Canal, September 12, 1988.

Although daily mean discharges and rainfall amounts differ for the June and July 1990 storm periods, the nutrient concentrations in water samples collected on June 27 and July 13, 1990, were similar (figs. 21 and 22). Total phosphorus and orthophosphorus concentrations were higher in water samples collected June 27, 1990, from the lock and dam than in water from site 2 or from the lake-outflow site (site 5), probably as a result of the inflow of farm-discharge water with high phosphorus concentrations at site 12 (fig. 21). Ammonia-plus-organic nitrogen concentrations did not change significantly from site 2 to the lock and dam. Nitrate-plus-nitrite nitrogen was detected at three sites including the lock and dam in the June 1990 sampling, possibly because of the inflow of farm-discharge water with higher nitrate-plus-nitrite nitrogen concentrations at site 12. The lack of a similar rise in nitrate-plus-nitrite nitrogen concentration in the July sampling (fig. 22) indicates the effect of point discharge at site 12 on the concentration of nitrate-plus-nitrite nitrogen downstream at the lock and dam (nitrate-plus-nitrite nitrogen was below the detection level at site 12 on July 27, 1990).

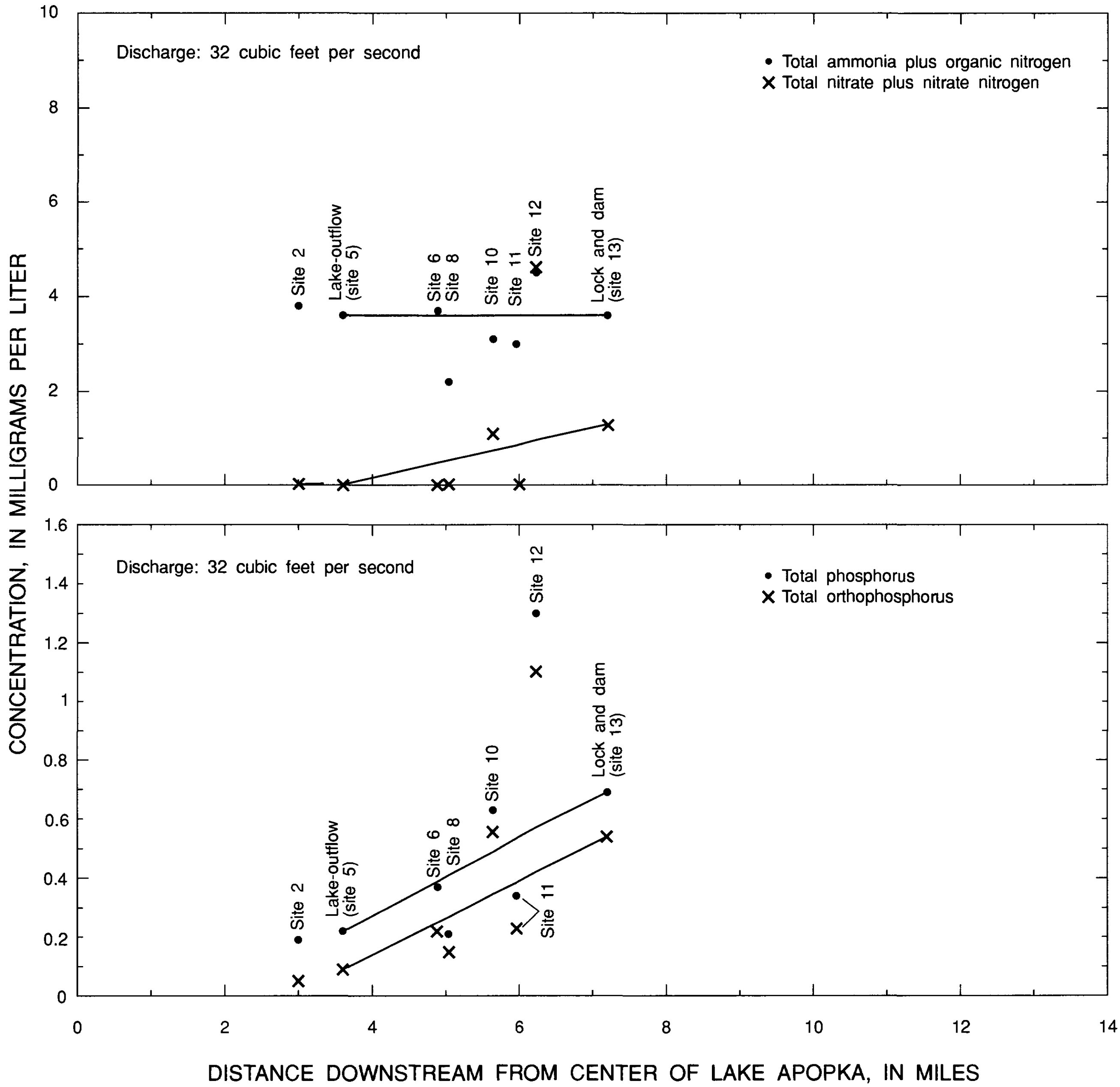


Figure 21. Nutrient concentrations at selected sampling sites on the Apopka-Beauclair Canal, June 27, 1990.

Reconnaissance Sampling

Reconnaissance samples were collected three times during the study: twice during the dry season (May 4, 1988 and June 15, 1989) and once toward the end of the wet season (August 29, 1990). Reconnaissance samples, in contrast to the storm samples discussed previously, were collected during steady-state conditions, when no rainfall had fallen within the previous few days and discharge at the lock and dam was about 35 ft^3/s. All reconnaissance samples were collected from the canal or from Lakes Apopka and Beauclair. No samples were collected from point sources discharging to the canal, but samples were collected from the canal near those point-discharge sites (sites 3, 6, 12). Site numbers of point sources were used in the figures in this section only for identification of distance downstream from Lake Apopka. Sediment samples were collected at the same time and are discussed in a later section.

Results of reconnaissance sampling of the Apopka-Beauclair Canal indicate little variation in nutrient concentrations during non-storm periods (figs. 23-25).

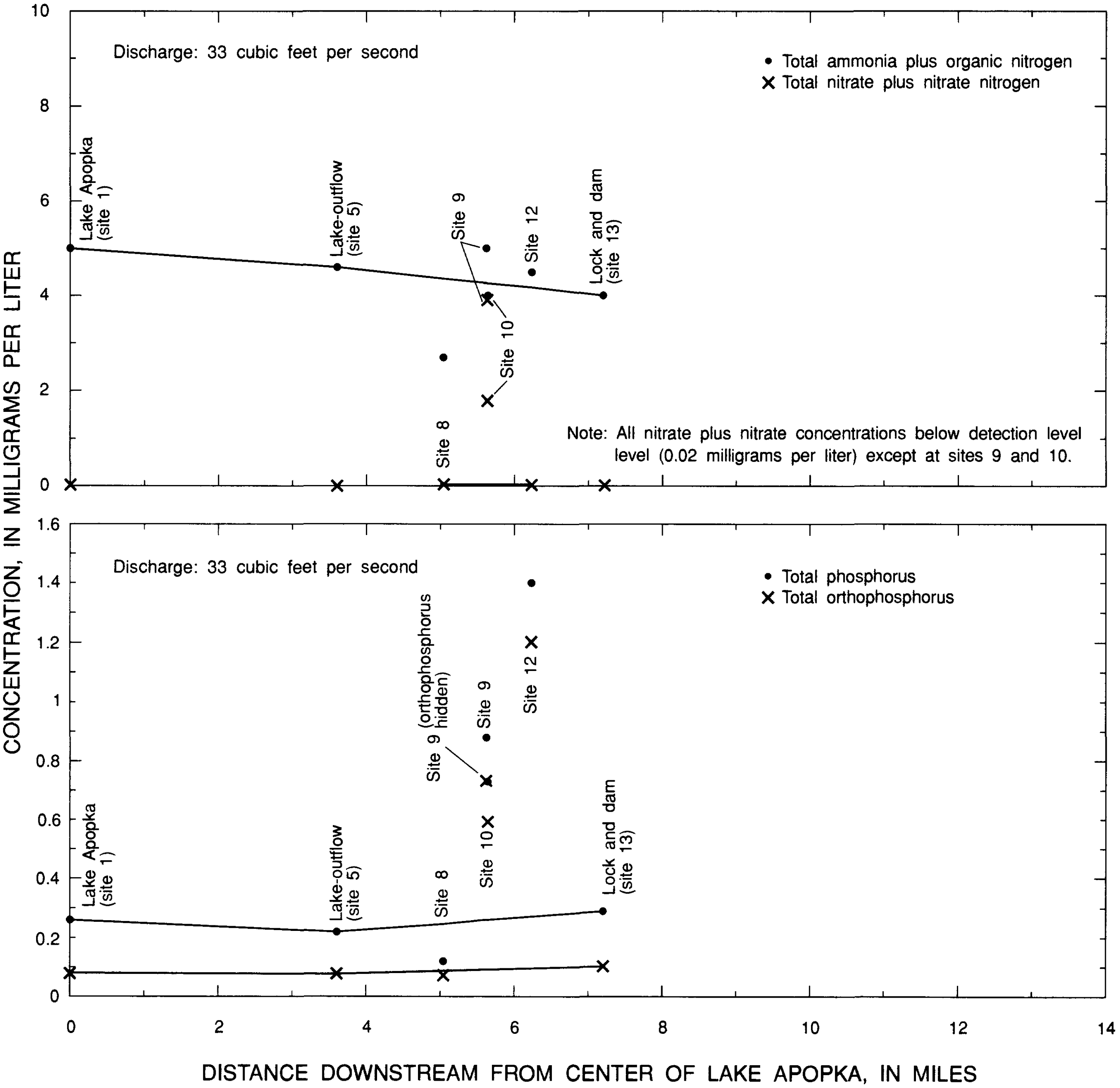


Figure 22. Nutrient concentrations at selected sampling sites on the Apopka-Beauclair Canal, July 13, 1990.

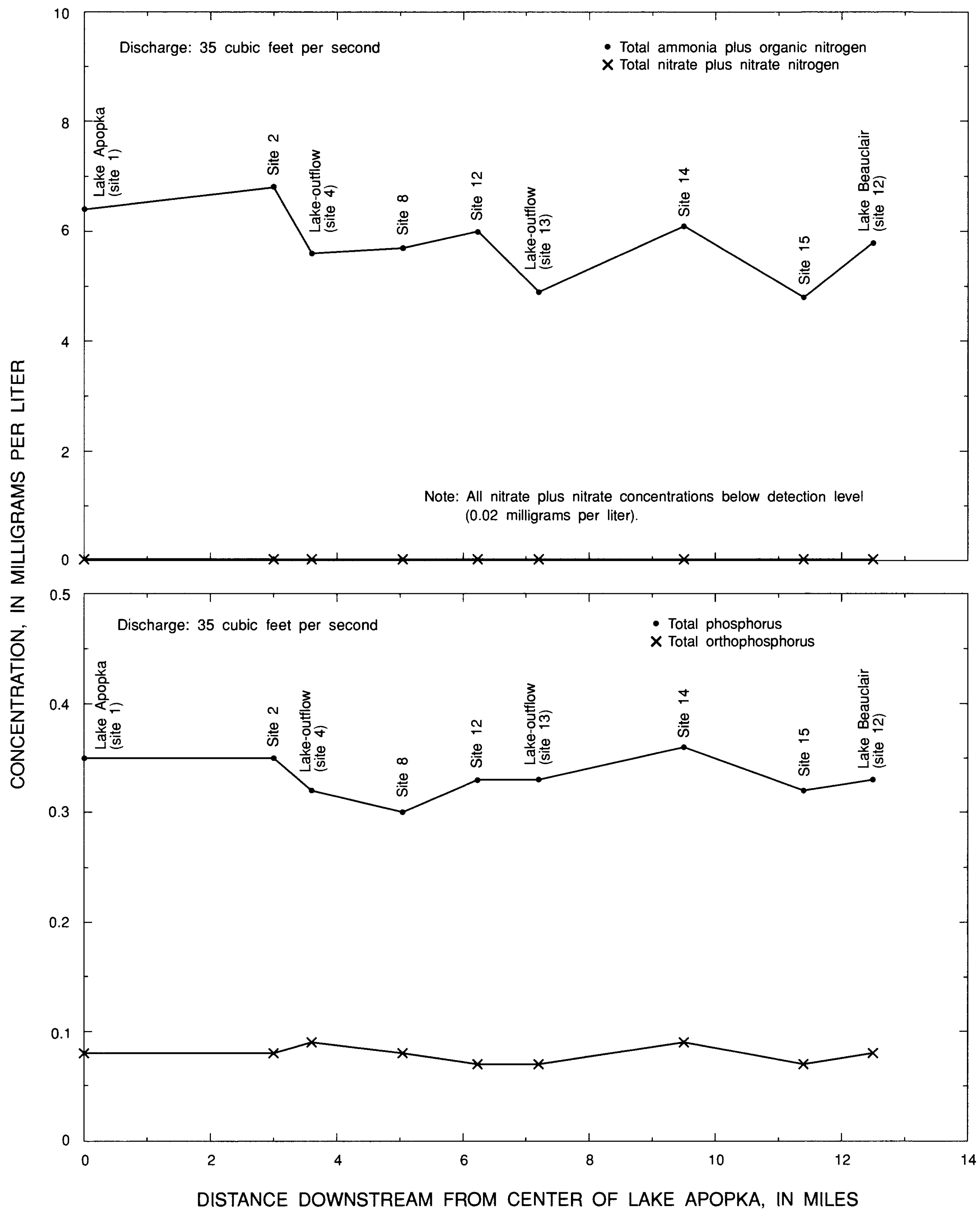


Figure 23. Concentration of nutrients at selected sampling sites on the Apopka-Beauclair Canal, May 4, 1988.

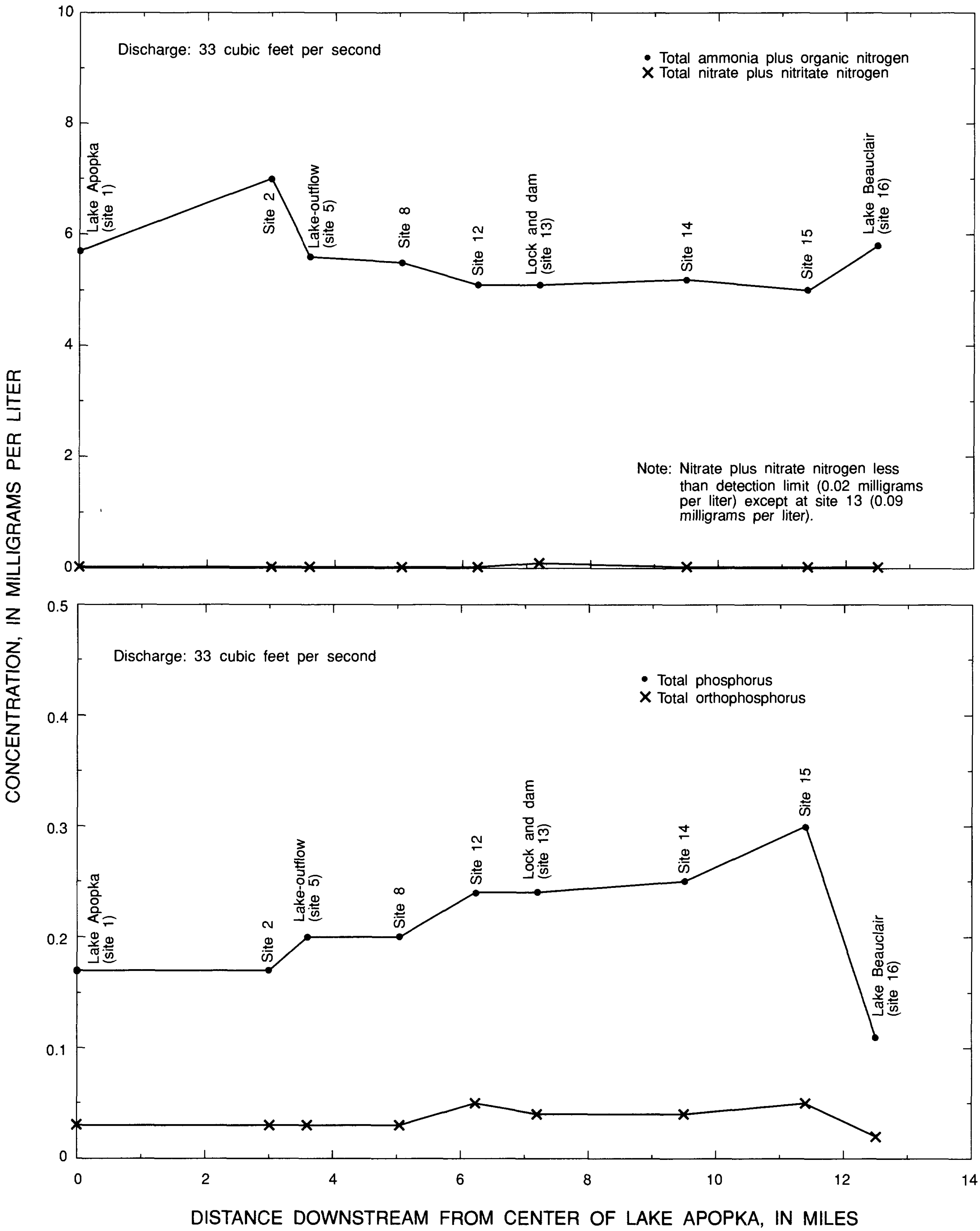


Figure 24. Concentration of nutrients at selected sampling sites on the Apopka-Beauclair Canal, June 15, 1989.

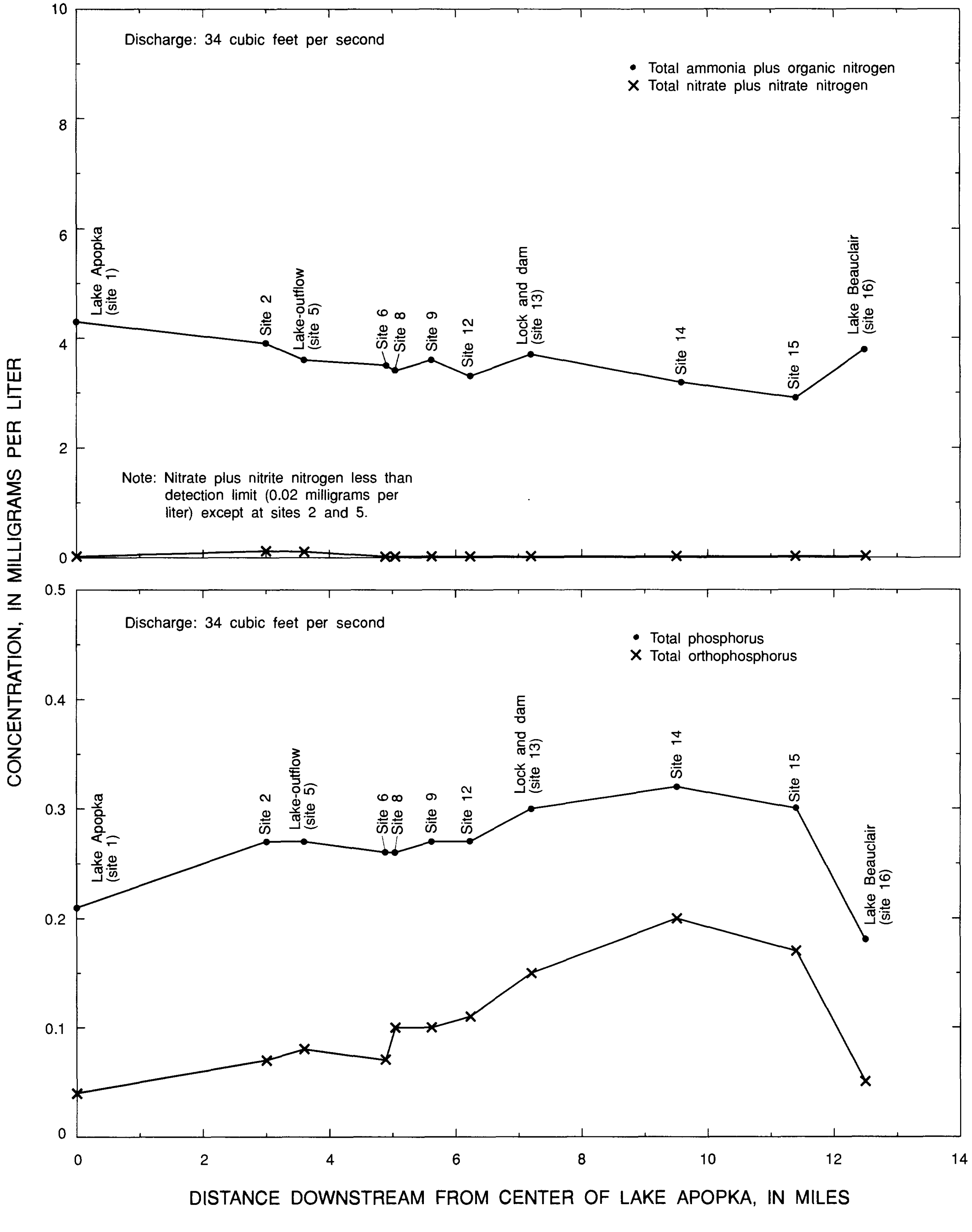


Figure 25. Concentration of nutrients at selected sampling sites on the Apopka-Beauclair Canal, August 29, 1990.

Ammonia-plus-organic nitrogen concentrations increased from Lake Apopka to site 2 (canal inlet) in samples collected during the dry season, but not in samples collected during August 1990 at the end of the rainy season. Nitrate-plus-nitrite nitrogen concentrations were at or below the analytical detection limit (0.02 mg/L) in most of the samples, probably because of reduced nitrogen input from farm discharges and increased biological uptake. Nitrate-plus-nitrite nitrogen concentrations were 0.12 mg/L during the August sampling at site 2 and at the lake-outflow site (site 5) but concentrations were 0.02 mg/L or less downstream. No substantial increase in nutrient concentrations with distance down the canal are evident from figures 23-25, but ammonia-plus-organic nitrogen concentrations seem to be higher during dry months (5 to 7 mg/L, figs. 23 and 24) than in wet months (3.5 to 4.2 mg/L, fig. 25).

Phosphorus concentrations were slightly higher in reconnaissance samples collected in May 1988 than in the samples collected in June 1989 and August 1990, but were relatively uniform at sites along the canal on all three sampling dates. Another difference between the total phosphorus concentrations in May 1988 and those on the other sampling dates is the lack of a decrease in concentration from the canal outlet (site 15) to Lake Beauclair (site 16) that was observed in samples collected in June 1989 and August 1990.

The minor differences among nutrient concentrations on the three reconnaissance sampling dates indicate that between-storm constituent concentrations are relatively constant from Lake Apopka to Lake Beauclair. The canal system is much more dynamic during periods of rainfall (typically for several days following rainfall), as shown in figures 15-22.

Bottom Sediments

Bottom-sediment samples were collected at sites in Lake Apopka and Beauclair and in the Apopka-Beauclair Canal at the time the reconnaissance samples were collected (May 4, 1988; June 15, 1989; and August 29, 1990). An Eckman dredge was used to collect samples in May 1988 and August 1990. A 2-inch diameter coring device was used to collect sediment cores in June 1989 to measure the depth of organic material deposited on the canal and lake bottom. Approximately the top 6 in. of sediment in the cores was analyzed for concentrations of nutrients and organic carbon, as were the samples collected using the Eckman dredge, which typically collects samples from only the top few inches of the bottom sediments.

Thickness of Organic Bed Material

Deposition of organic material on the bottom of Lake Apopka and in the Apopka-Beauclair Canal varies with distance downstream from the lake (fig. 26) largely because of the hydraulics of the system. In this report, "muck" is qualitatively defined as that fraction of the sediments that is characterized by a high water

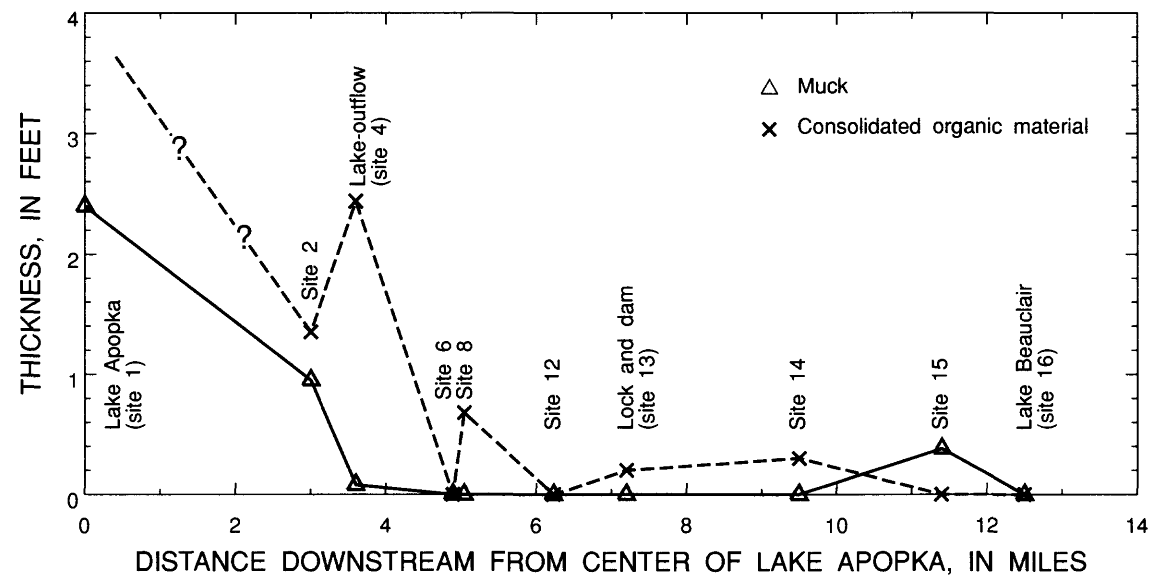


Figure 26. Thickness of muck and consolidated organic material at selected sampling sites from Lake Apopka to Lake Beauclair, June 15, 1989.

content and fine organic sediments. The muck layer is black and has the consistency of pudding. A layer of sediment that exists beneath the muck layer in Lake Apopka and in several places in the canal is referred to as "consolidated organic material" in this report. This layer has a lower water content than the muck layer, is medium to dark brown, and sometimes has the appearance of peat, with leaf fragments and plant roots. In the core sample collected in Lake Apopka, there was an additional layer of unconsolidated flocculent material about 0.75 ft thick above the muck layer. This flocculent layer and the muck layer (2.4 ft at sampled site) occupied most of the core sampling device used for collection. At the bottom of the core was the top of a layer of consolidated organic material (0.34 ft of the core); the thickness of this layer is unknown from this study (indicated by the '?', fig. 26), but an earlier study indicated that the mean thickness of this layer is 3.2 ft (Institute of Food and Agricultural Sciences, 1989).

The thicknesses of the muck and consolidated organic material were less at the first canal-sampling location (site 2) than in the lake, an indication of differences in hydraulic conditions between a quiescent lake environment and a more dynamic moving-water environment. A difference was noted in sediments at the lake-outflow site between May 1988, prior to the building of the constriction, and June 1989 after the constriction was built. Very little muck was present in a sample collected from the center of the channel at the lake-outflow site in June 1989 compared to the sample collected in May 1988, possibly as a result of scour caused by the acceleration of flowbecause of the constriction. For consistency in analysis of nutrients and organic carbon in bed sediments at the site before and after the constriction was built, the core sample submitted for analysis was collected from the side of the channel, where velocity effects on the sediments would be minimal.

The muck layer was largely absent downstream from the lake-outflow site, except at the Apopka-Beauclair Canal outlet (site 15). The muck layer at site 15 was similar in appearance to the muck at site 2, and is probably there as a result of the decrease in velocity as water leaves the canal system and enters Lake Beauclair. The layer of consolidated organic material was less than 0.75 ft thick at all sites downstream from site 7 and was absent at many sites. Silt and clay were present in bottom sediments at sites 6, 8, and 13. Sand with small black specks (possibly phosphatic material) was present in sediments at sites 12, 14, and 16 (Lake Beauclair). These sands and clays are native materials; the muck and consolidated organic layers result from natural decomposition of plant and animal tissues.

Constituent Concentrations in Sediments

Sediment samples collected from sites in Lakes Apopka and Beauclair and in the canal connecting these lakes were analyzed for nitrogen species, phosphorus, and organic and inorganic carbon concentrations. Results of these analyses for samples collected in May 1988, June 1989, and August 1990 are shown in figures 27-29.

Sampling locations nearest Lake Apopka (sites 2-5) tended to have higher concentrations of organic nitrogen and organic carbon than sites downstream. Organic-nitrogen and organic-carbon concentrations also tended to be elevated at site 15, 11.4 mi from the center of Lake Apopka and just upstream from Lake Beauclair (fig. 27). The elevated concentrations at this site probably are due to the greater thickness of muck at this site (fig. 26). Carbon concentrations in sediments were more similar from one sampling date to the next than were nitrogen and phosphorus concentrations. Only three samples could be analyzed for phosphorus concentration in sediment samples collected in August 1990 (fig. 29) because of interferences with the analytical procedures in the laboratory. The highest concentrations of total phosphorus in sediments were measured in the samples collected in May 1988 (fig. 27).

For all three sampling dates, organic species were the dominant forms of nitrogen and carbon in the sediments and concentrations of these constituents did not change significantly between sampling dates. Phosphorus concentrations in sediments had the most variability among sites and sampling dates and were highest at site 2.

Generally, organic constituents seem to be settling in the Apopka-Beauclair Canal near Lake Apopka and at the mouth of the canal at Lake Beauclair, an indication that much of the constituent load is not being transported downstream. These are locations where hydraulics may be affecting the deposition of bottom material. Muck was present at both locations, and organic nitrogen and phosphorus concentrations in bottom sediment generally were higher at sites in the upstream and downstream reaches of the canal than at sites in the middle reach of the canal.

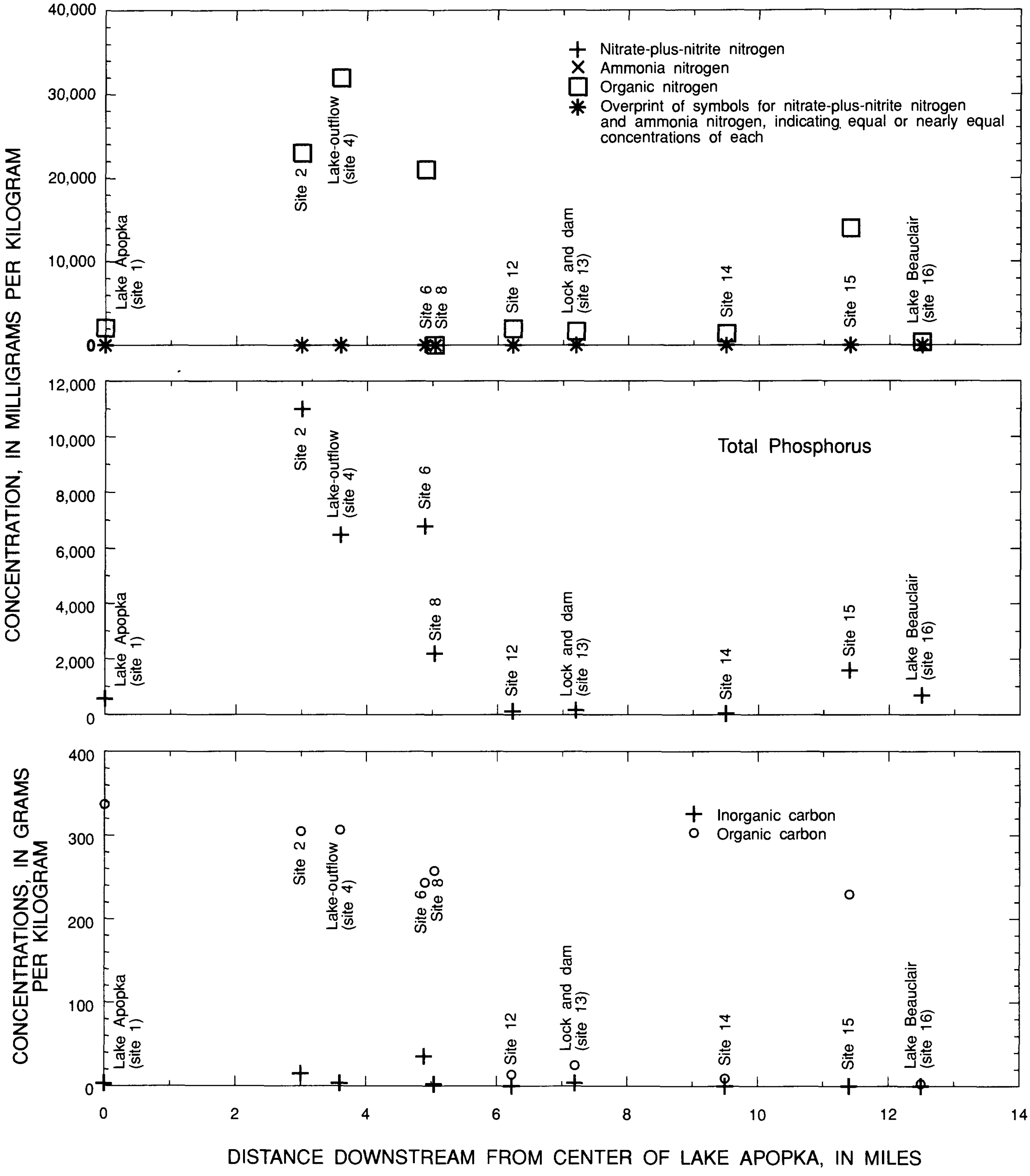


Figure 27. Concentration of nutrients and carbon in bottom sediments at selected sampling sites on the Apopka-Beauclair Canal, May 4, 1988.

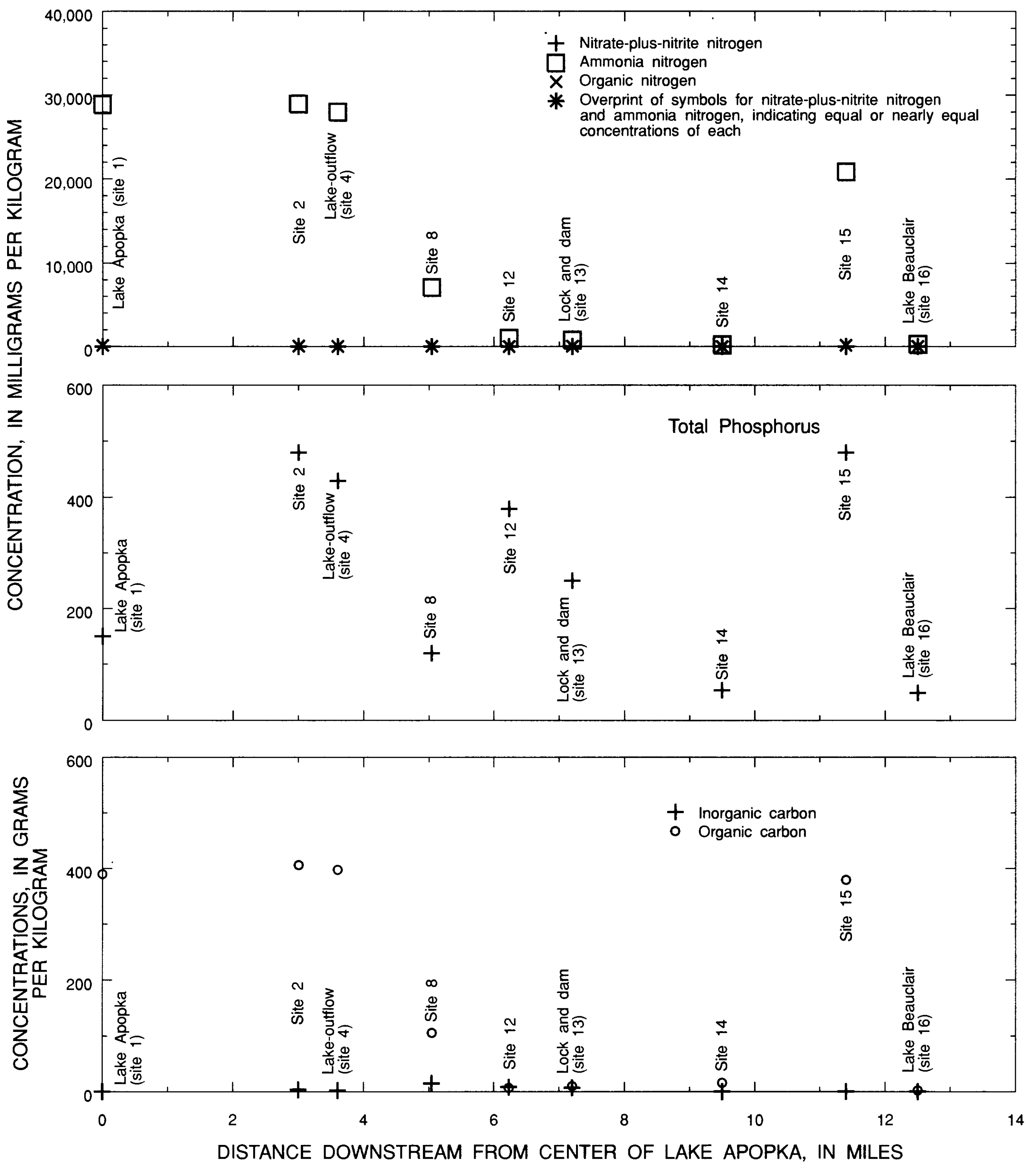


Figure 28. Concentration of nutrients and carbon in bottom sediments at selected sampling sites on the Apopka-Beauclair Canal, June 15, 1989.

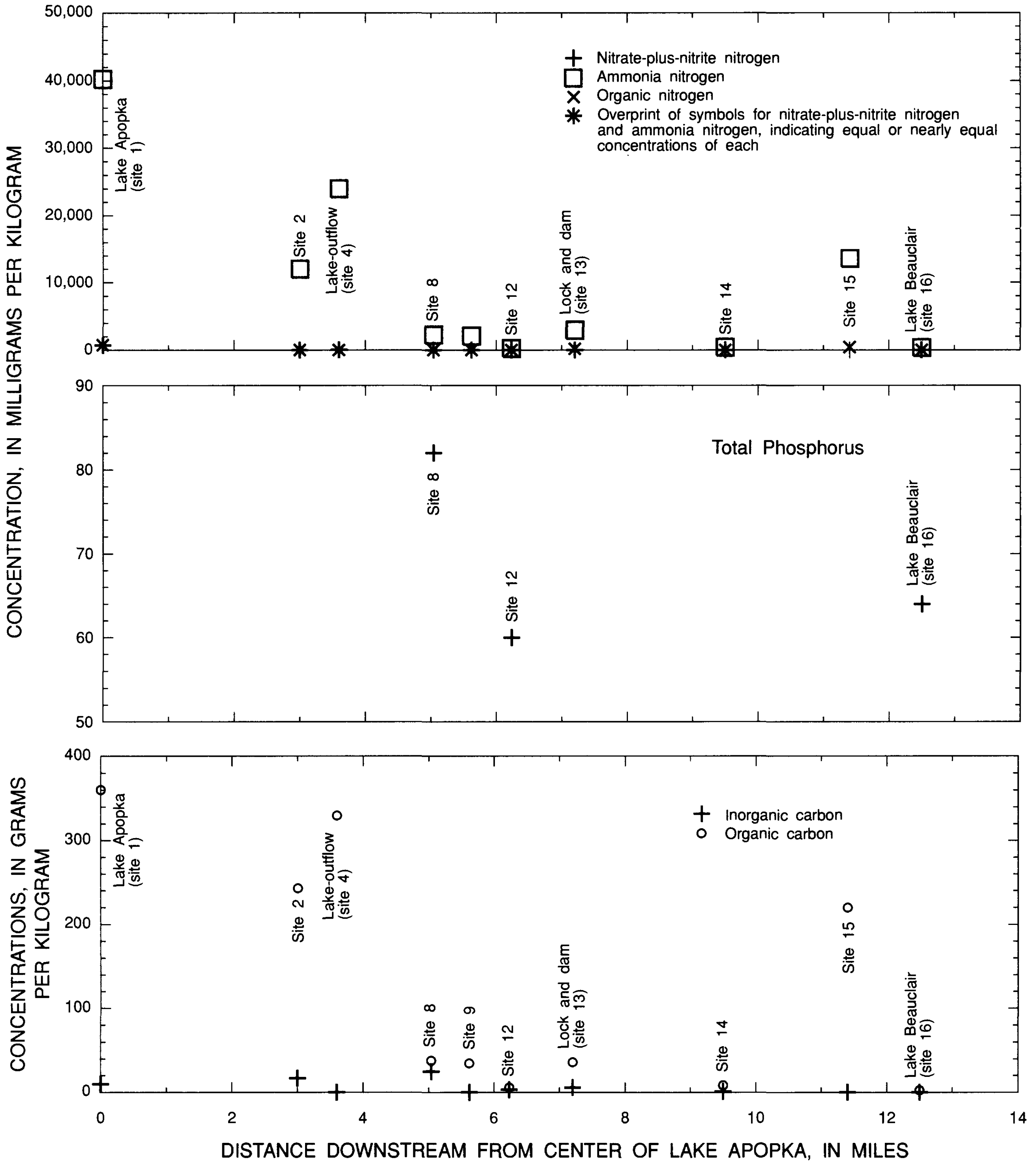


Figure 29. Concentration of nutrients and carbon in bottom sediments at selected sampling sites on the Apopka-Beauclair Canal, August 29, 1990.

Table 3. Nitrogen, phosphorus, and carbon concentrations in bottom sediments at the lake-outflow site (sites 4 and 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13)

[All concentrations are totals in milligrams per kilogram, except where noted. g/kg, grams per kilogram]

Constituent	Lake outflow (sites 4 and 5)				Apopka-Beauclair Canal lock-and-dam (site 13)			
	No. of samples	Minimum	Maximum	Mean	No. of samples	Minimum	Maximum	Mean
Ammonia nitrogen	3	0.40	24	11	3	0.40	170.0	75
Ammonia-plus-organic nitrogen	3	24,000	32,000	28,000	3	820	3,100	1,870
Nitrate-plus-nitrite nitrogen	3	2	31	13	3	2	6	4
Phosphorus	2	430	6,500	3,470	2	160	250	205
Inorganic carbon (g/kg)	3	.10	3.5	2.0	3	3.8	6.9	5.5
Organic-plus-inorganic carbon (g/kg)	3	310	400	350	3	17.0	42.0	29.3

A summary of nitrogen, phosphorus, and carbon concentrations in bed sediments at the two gaging sites (table 3) indicates that the mean concentration of ammonia nitrogen is much higher at the lock-and-dam site than at the lake-outflow site (table 3). However, the mean concentration of ammonia-plus-organic nitrogen is an order of magnitude greater at the lake-outflow site than at the lock-and-dam site (mean of 28,000 mg/kg and 1,870 mg/kg, respectively) indicating the presence of much more organic nitrogen at the lake-outflow site. Phosphorus concentrations also are much higher in sediments at the lake-outflow site than at the lock-and-dam site--the minimum value for the lake-outflow site (430 mg/kg) exceeds the maximum value measured at the lock-and-dam site (250 mg/kg). The mean phosphorus concentration in bed sediment at the lake-outflow site (3,470 mg/kg) is more than 16 times the mean concentration at the lock-and-dam site (205 mg/kg) which might indicate a tendency for phosphorus in bed sediments to remain in the upstream reach of the canal rather than be transported downstream.

NUTRIENT AND DISSOLVED-SOLIDS LOADS IN THE APOPKA-BEAUCLAIR CANAL

Constituent loads transported by the Apopka-Beauclair Canal were computed for total nitrogen, total ammonia-plus-organic nitrogen, total phosphorus, total organic carbon, and dissolved solids at the lake-outflow and lock-and-dam sites. The loads were computed by linearly interpolating constituent concentrations between sampling dates to estimate daily mean concentrations, then multiplying these estimated daily mean concentrations by the daily mean discharge to obtain estimated daily loads for each site. The accuracy of loads computed in this manner depends on the accuracy of the discharge data at each site and on the representativeness of the interpolated constituent concentrations. Qualified values (concentration less than or equal to detection limit) of nitrate-plus-nitrite nitrogen were set equal to the detection limit in the computation of total nitrogen concentrations. No other constituent concentrations used in load computations were below detection limits.

Although water-quality data collection at the lake-outflow and the lock-and-dam sites began in October 1986, loads could only be computed for the period when discharge data were available at these sites. Reliable discharge data for the lake-outflow site was not collected until after mid-September 1988, after the building of the constriction to increase flow velocities. Constituent loads were, therefore, computed only for the period October 1, 1988, through September 1990. Regression analysis to relate loads to discharge was attempted but resulted in no significant relations for either site.

Loads from Lake Apopka and at the Apopka-Beauclair Canal Lock and Dam

Monthly loads for total nitrogen, ammonia-plus-organic nitrogen, phosphorus, organic carbon, and dissolved solids for both gaging sites, and the difference in these loads are presented in figures 30-35.

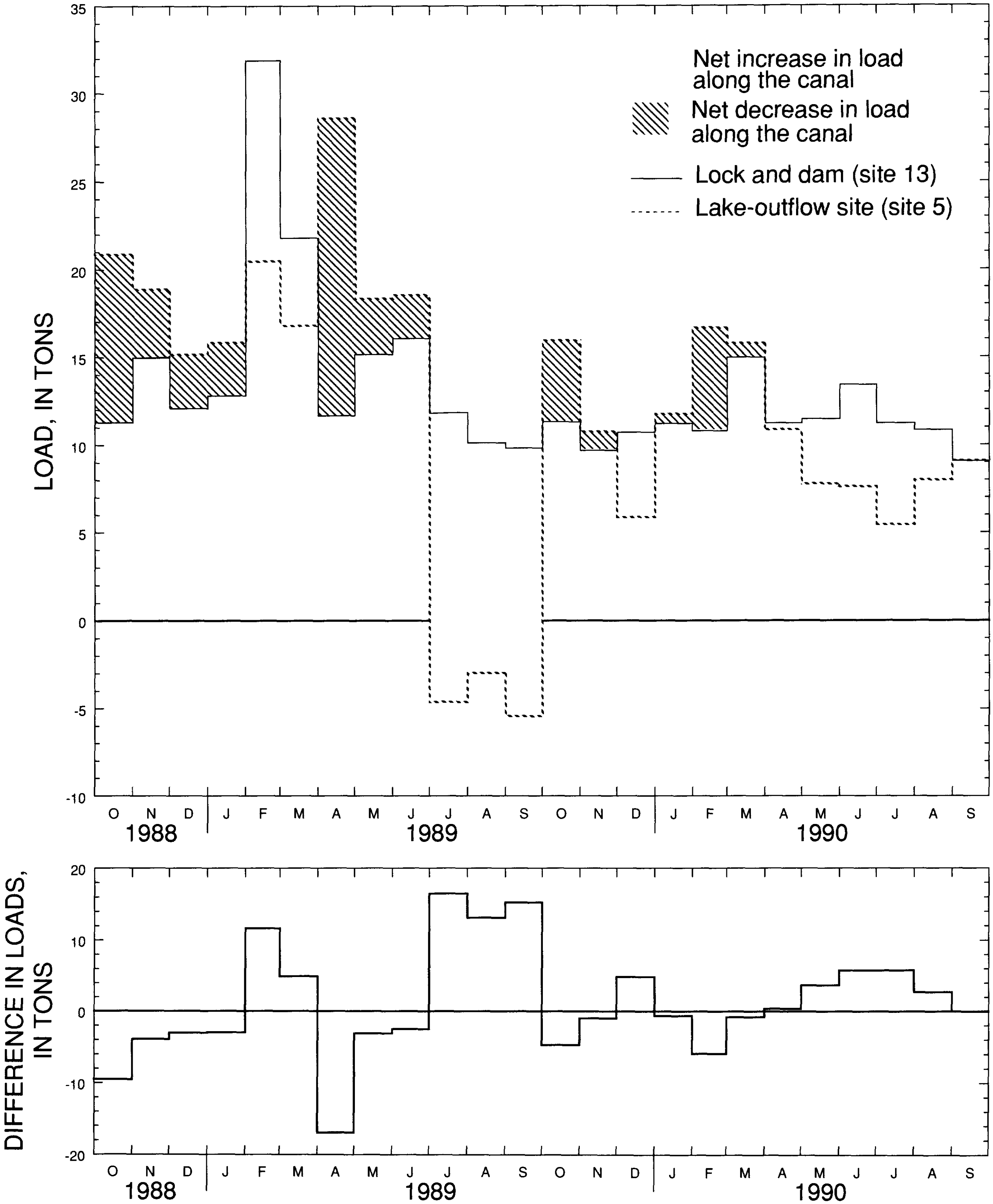


Figure 30. Monthly total nitrogen loads at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock and dam site (site 13), and difference in loads, October 1988 through September 1990.

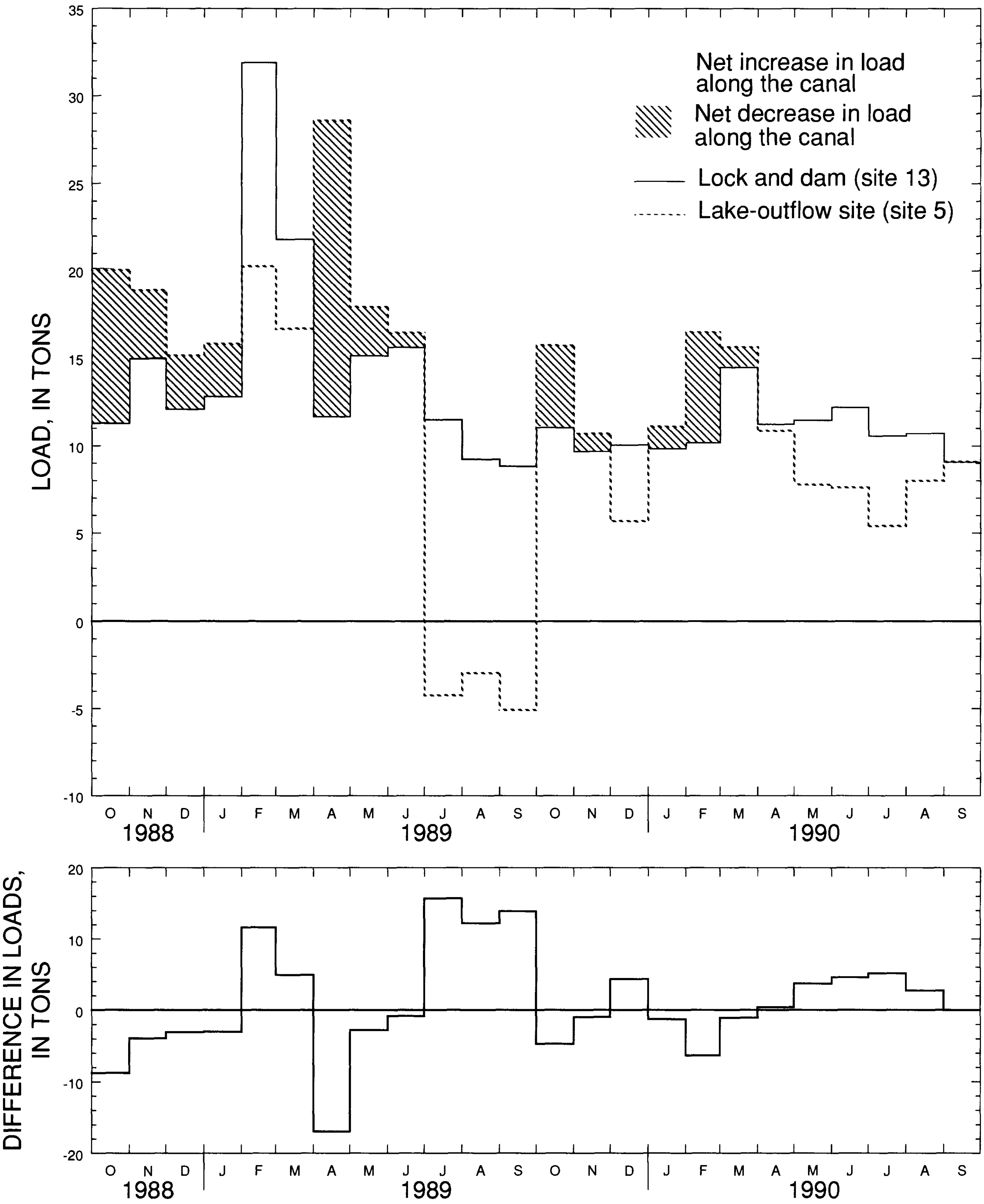


Figure 31. Monthly total ammonia-plus-organic nitrogen loads at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), and difference in loads, October 1988 through September 1990.

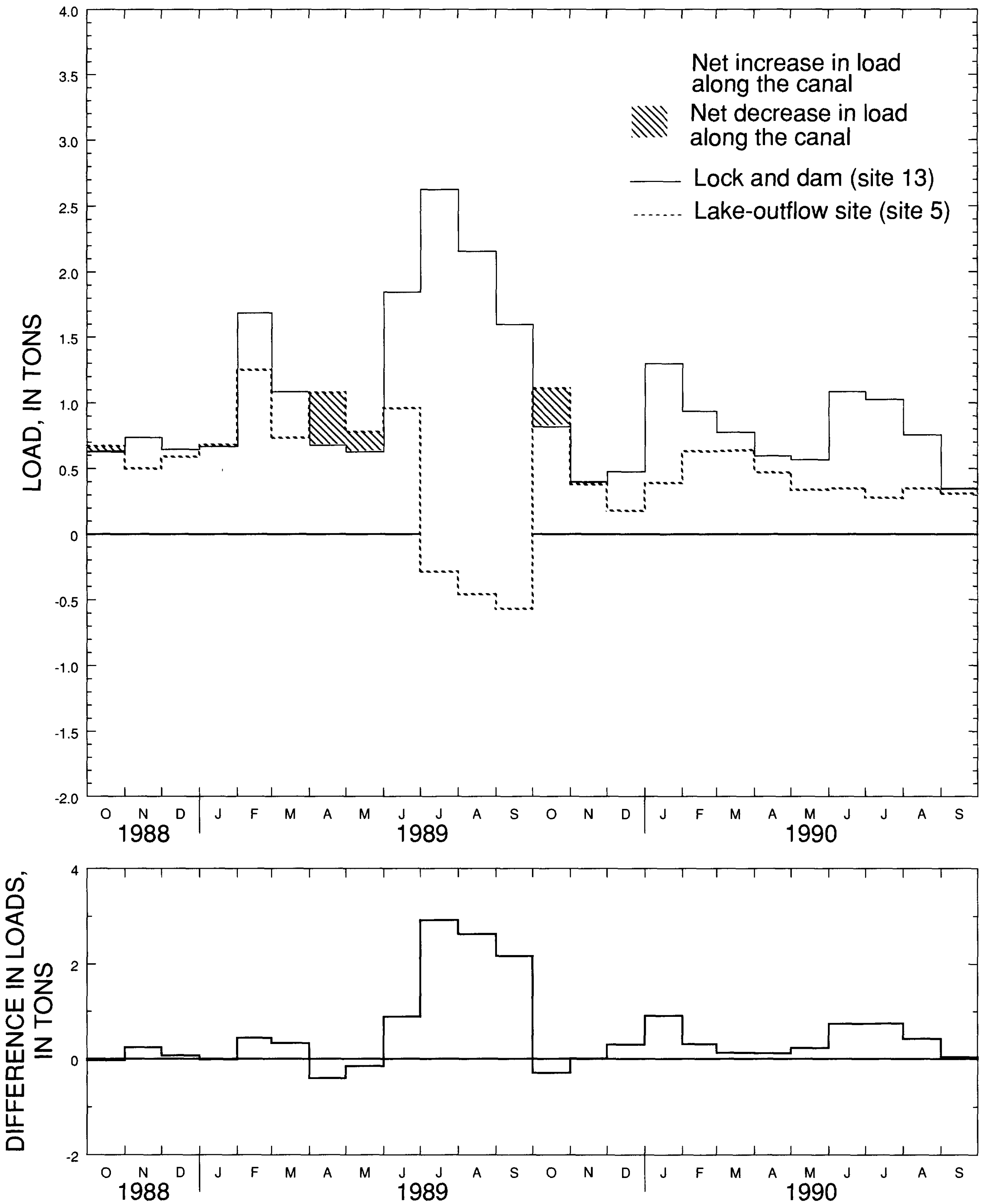


Figure 32. Monthly total phosphorus loads at the lake-outflow site (site 5) and at the Apopka-Beauclair Canal lock-and-dam site (site 13), and difference in loads, October 1988 through September 1990.

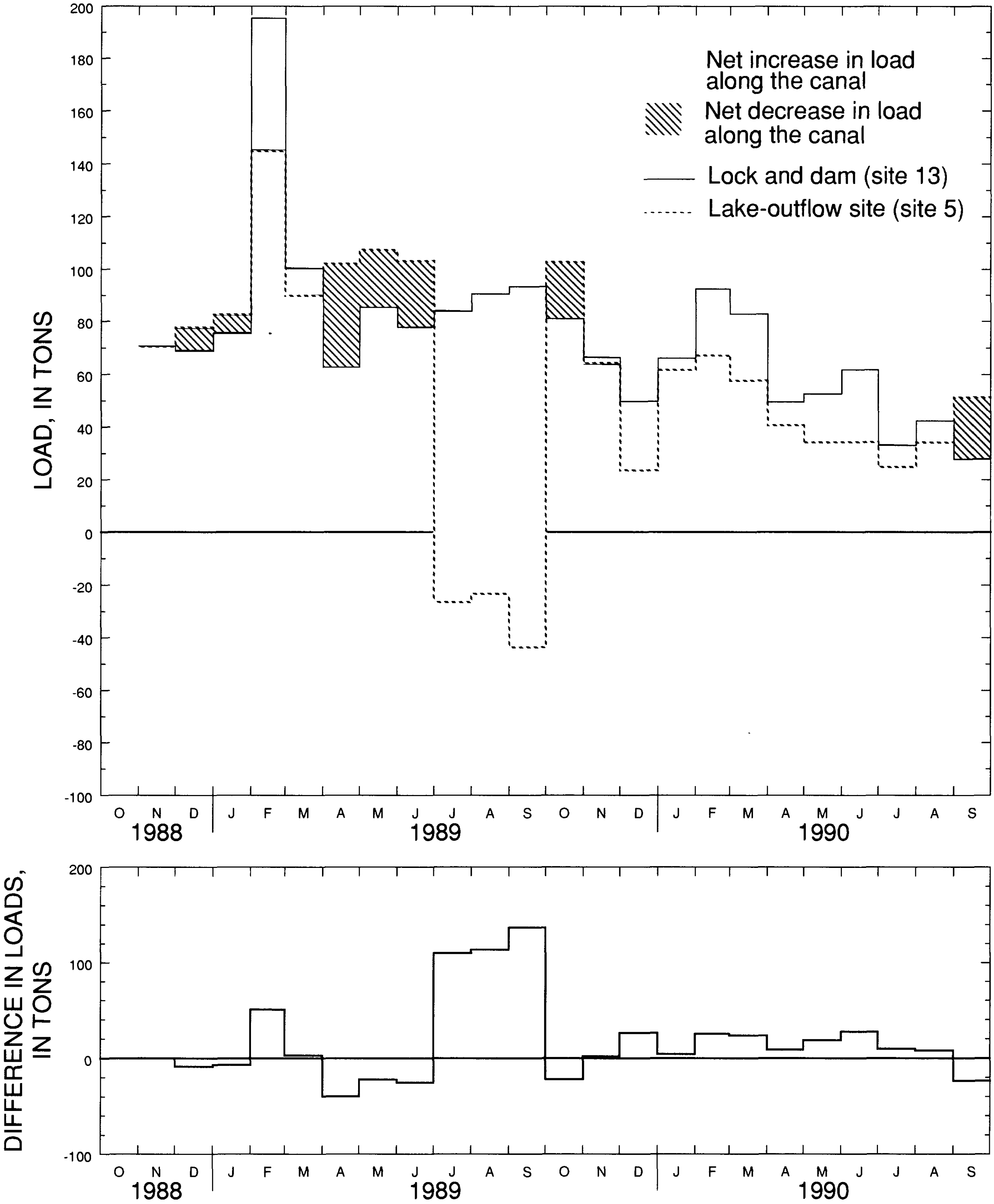


Figure 33. Monthly total organic carbon loads at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), and difference in loads, October 1988 through September 1990.

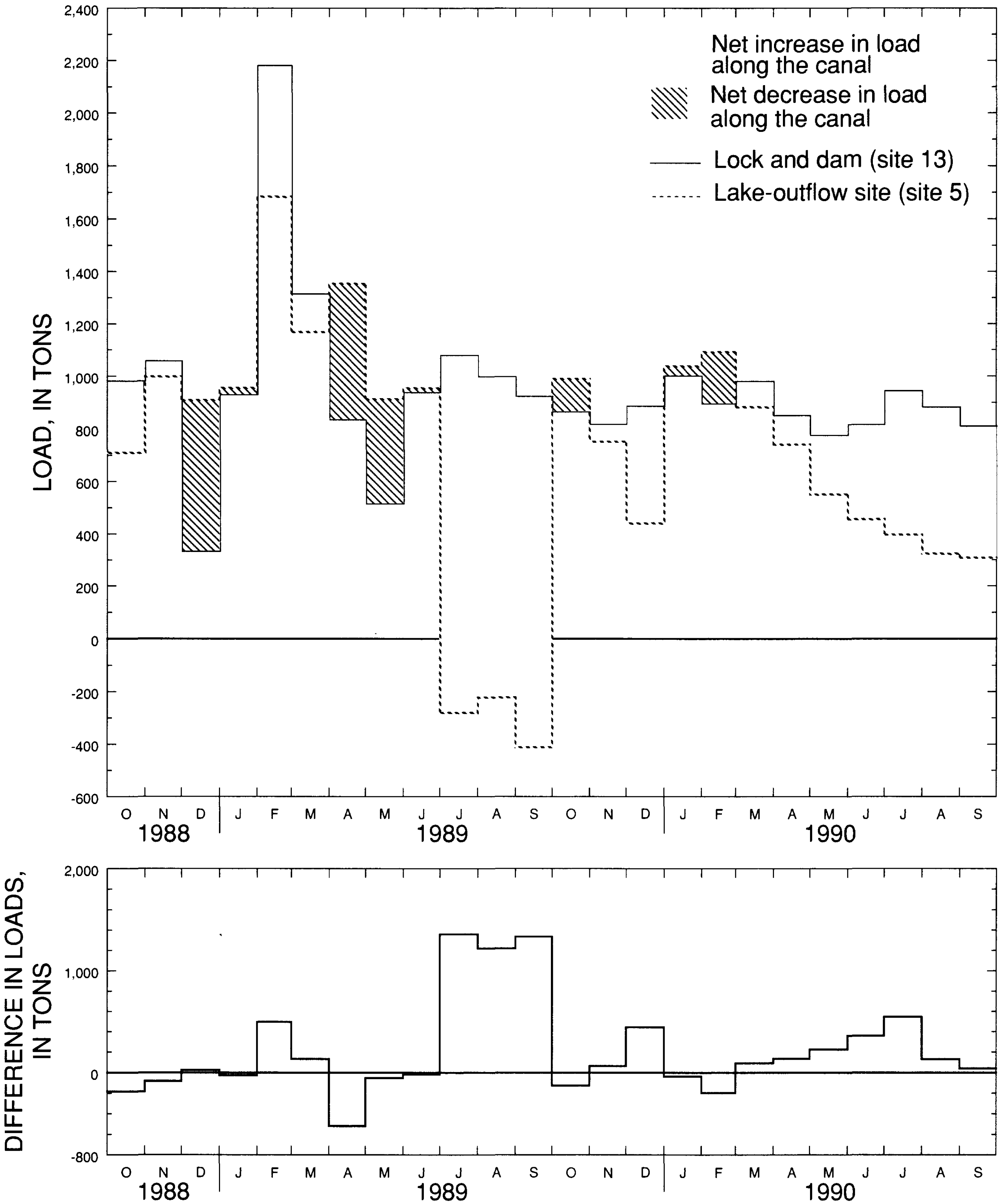


Figure 34. Monthly dissolved-solids loads, based on continuous record of specific conductance, at the lake-outflow site (site 5) and the Apopka-Beauclair Canal lock-and-dam site (site 13), and difference in loads, October 1988 through September 1990.

For the computation of dissolved-solids loads, concentrations were estimated based on the relation between dissolved-solids concentrations and recorded daily mean specific conductance data collected at both gaging sites. The difference in constituent loads at the two sites represents the load contributed between the lake and the lock and dam, and was computed by subtracting the load at the lake-outflow site (site 5) from the load at the lock and dam (site 13).

In figures 30-34, the upper graphs show the magnitude of the constituent load at each site, and the lower graphs show the input to (or withdrawal from) the canal between the two sites. The input to (or withdrawal from) the canal is also shown by the shaded area between the two curves of the upper graphs. If the load difference is less than zero in the lower graph, the constituent is being removed from the canal; if it is greater than zero, the constituent is being contributed to the canal.

One of the more unusual features common to figures 30-34 is the negative load at the lake-outflow site (upper graphs). The negative loads in July through September 1989 correspond to the reverse flow observed at the site. Loads at the lake-outflow site for this period are based on the discharge record discussed previously. This earlier discussion, indicating some uncertainty about discharge data during the period from July through September 1989, should be considered when looking at these figures. The record for this period would indicate a large increase in load to the canal between the two sites for all constituents presented in these figures.

Nitrogen loads at the lock and dam were relatively constant, except during February 1989, when the gates were opened and the load increased to about 32 tons because of the increase in discharge. The dominant form of nitrogen in the water was organic nitrogen, and the similarity of the plots in figures 30 and 31 indicate there was little ammonia nitrogen in the water. Nitrate-plus-nitrite nitrogen concentrations at both sites were at or near the detection limit (0.02 mg/L), an indication that nitrate-plus-nitrite nitrogen contributed little to the total nitrogen load.

Increased discharge was not the explanation for the increase in phosphorus loads June through October 1989 (fig. 32). Unlike nitrogen loads in this period, the phosphorus load at the lock and dam increased during the summer of 1989, when reverse flow was observed at the lake-outflow site. The highest phosphorus concentrations at the lock-and-dam and lake-outflow sites were observed during this period. The dominant form of phosphorus in the canal water during this period was orthophosphorus (as much as 92 percent of the total phosphorus at the lock and dam, and 84 percent at the lake-outflow site). These data tend to support the record of reversed flow at the lake-outflow site during these months. Maximum phosphorus concentrations at both sites observed concurrently with reverse flow at the lake-outflow site may be an indication that large volumes of water were being pumped into the canal from the farms.

Total organic carbon load (fig. 33) had the same pattern as total nitrogen. The maximum monthly load of total organic carbon at the lock-and-dam site was in February 1989 (195.4 tons). The maximum net increase in organic carbon load (difference between loads at the two sites) was in September 1989 (127.7 tons).

Dissolved-solids concentrations in water at the two monitored sites were not analyzed for this study, but were estimated using the ratio of specific conductance to dissolved-solids concentration from analyses of water samples collected by the USGS from Lake Apopka from 1959 through 1985. The median ratio of dissolved-solids concentration to specific conductance for 39 samples collected from the lake was 0.726. This ratio was multiplied by daily mean specific conductance to estimate the daily mean dissolved-solids concentrations for the two sites on the Apopka-Beauclair Canal. The estimated daily mean dissolved-solids concentrations were then used to compute loads.

Dissolved-solids loads computed using dissolved-solids concentrations estimated from the continuous record of specific conductance from the minimonitors at both sites are shown in figure 34. The maximum dissolved-solids load at the lock and dam was in February 1989 (2,180 tons), and the maximum net increase in load between the two monitoring sites was in July 1989 (1,359 tons).

Generally, the difference in nitrogen, phosphorus, carbon, and dissolved-solids loads at the two sites was positive, indicating that greater loads were transported downstream from the lock and dam than are entering the canal from Lake Apopka. The relative importance of the sources of the nutrient loads transported downstream through the lock and dam—the farms along the canal, or outflow from Lake Apopka—can be determined by comparing the loads contributed between the two sites to loads at the lake-outflow site.

However, the frequent occurrence of flow reversals at the lake-outflow site complicates this comparison. Another approach that could more accurately measure the effects of farms (and processes) along the Apopka-Beauclair Canal is presented in the following section.

Effective Loads in the Apopka-Beauclair Canal

The total load of constituents transported through the Apopka-Beauclair Canal lock and dam is not only a function of loads contributed by discharge from Lake Apopka and the load contributed to or withdrawn from the canal by farms in the area, but it is also a function of the gate settings at the lock and dam. Because the gates at the lock and dam control flow, they also control loads moving down the canal. When pumps are turned on to discharge excess water from the farms to the canal, discharge at the lock-and-dam commonly is not increased (gate settings are not changed). Because outflow is controlled at the lock and dam, water discharged from pumps along the canal displaces water entering the canal from the lake. When the total pump discharge into the canal exceeds the discharge at the lock and dam, the excess water flows back up the canal, south toward Lake Apopka. When this occurs, the canal effectively becomes a source of input to both Lakes Apopka and Beauclair and outflow from Lake Apopka stops.

A schematic diagram of the flow system of the Apopka-Beauclair Canal and equations relating discharge and loads are given on page 50. Loads are calculated as the product of concentration (C) and discharge (Q). As mentioned earlier, if the farm discharge exceeds the discharge at the lock and dam, then the lake no longer contributes to the load at the lock and dam. However, the general case expressed below holds true for the three possible flow regimes (1) no farm discharge, (2) farm discharge less than or equal to lock-and-dam discharge, and (3) farm discharge exceeding lock-and- dam discharge (lake contribution is negative because the lake becomes a receiving body for the farm discharge).

One of the main objectives of the study was to determine the relative contribution of loads to Lake Beauclair from Lake Apopka and from farms discharging along the canal. When the farms are not discharging, the load (and flow) at the lock and dam is equal to the load (and flow) from Lake Apopka, neglecting changes in storage in the lake and canal and processes in the canal (sedimentation, sorption, dissolution, and biological activity) that could affect water quality. The effect of discharge to the canal from the farms is to reduce the load being contributed from Lake Apopka. The displacement of a portion of the lake load may increase the total load at the lock and dam, or, for some constituents, total load may be reduced if the farm load is less than the lake load being displaced. The change in load at the lock and dam due to farm discharge along the canal is evaluated in this report by estimating the volume of lake water being displaced by the farm discharge and calculating the difference in load between what would have been contributed from the lake and what was contributed by the farms. This difference between the load from the farms and the "displaced" load from the lake (lake load for a volume of water equivalent to the farm discharge) represents the net effect on loads at the lock and dam from farm discharge, and is defined here as "farm-effective load."

The farm-effective load (FEL) can be expressed mathematically as follows:

$$FEL = (C_F Q_F) - (C_L Q_F), \qquad (4)$$

where

C_F is concentration in farm discharge water,

Q_F is farm discharge, and

C_L is concentration in water from the lake-outflow site.

Because C_F and Q_F were not measured, this equation cannot be used directly. However, an alternative equation for the farm-effective load can be derived by rearranging equation (3) as follows:

$$(C_F Q_F) = (C_D Q_D) - (C_L Q_D) + (C_L Q_F);$$

subtracting from both sides of the equation to obtain the expression for FEL on one side:

$$(C_F Q_F) - (C_L Q_F) = (C_D Q_D) - (C_L Q_D);$$

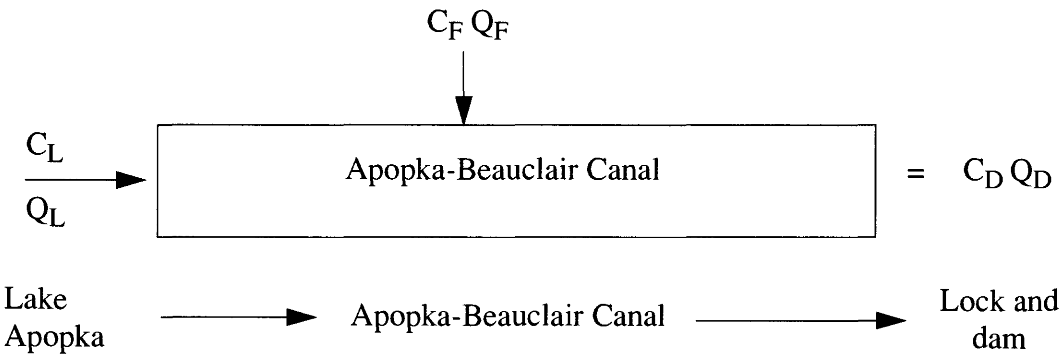
cancelling and combining terms leaves an equation for FEL:

$$FEL = Q_D(C_D - C_L). \qquad (5)$$

This expression, based on concentrations at the lake-outflow and the lock-and-dam sites, represents not only the changes in load resulting from farm discharge but also changes in load caused by physical, chemical, and biological processes occurring in the canal between the lake and the lock and dam, so rather than farm-effective load, a more descriptive term is "canal-effective load." This term will be used for the remainder of this report.

Because of the reversal of flow in the Apopka-Beauclair Canal, it is possible for farm discharge to flow into Lake Apopka. Then, after the pumps are shut off and flow reverses again (toward the lock and dam), the farm discharge can become a component of the "lake-outflow" water that is sampled at the lake-outflow site. Samples included for the computation of loads were for positive-flow conditions (toward the lock and dam); however, if some farm discharge mixed with the lake water and then flowed back down the canal, the effect would be (generally) to increase constituent concentrations in the "lake-outflow" water. This would decrease the computed "canal-effective load," which is based on the difference in concentrations between the lock-and-dam and the lake-outflow sites. If farm-discharge water

SCHEMATIC DIAGRAM OF THE FLOW SYSTEM



C is concentration
Q is discharge
CQ is load
Subscripts: L is lake outflow
F is farm input
D is lock and dam

Load equations are as follows:

$$C_L Q_L + C_F Q_F = C_D Q_D,$$

or

$$C_F Q_F = C_D Q_D - C_L Q_L \ . \qquad (1)$$

Discharge equations are as follows:

$$Q_L + Q_F = Q_D$$

or

$$Q_L = Q_D - Q_F \qquad (2)$$

Substituting equation 2 into equation 1 gives the following equation for the computation of load contributed by farm discharge ($C_F Q_F$):

$$C_F Q_F = C_D Q_D - C_L (Q_D - Q_F). \qquad (3)$$

and lake water were mixing (because of flow reversals) during sampling of the site, the canal-effective load would be underestimated. It is not possible to determine whether or not a component of the water sampled at the lake-outflow site was farm-discharge water "returning" to the canal from Lake Apopka. However, all canal-effective loads described here are based on samples collected while flow at the lake-outflow site was positive (toward the lock and dam).

Discharge data and constituent concentration data for samples collected biweekly are available for the lock-and-dam site from October 1986 through September 1990. Concentration data also are available for the lake-outflow site for that period so canal-effective loads can be computed for the entire study period using equation 5. Computing the difference in loads requires discharge data for the lake-outflow site which is unavailable before September 1988.

The maximum monthly loads for all constituents were observed in April 1987 during the period of unusually high discharge. Loads during April 1987 represent 59 percent of the ammonia-plus-organic nitrogen, 61 percent of the total nitrogen, 59 percent of the phosphorus, 51 percent of the total organic carbon, and 47 percent of the dissolved-solids loads for the entire water year. Discharge in April 1987 accounted for 52 percent of the total discharge for the 1987 water year. These high percentages indicate the critical role of the lock and dam in the transport of loads to downstream lakes.

Negative canal-effective loads indicate a reduction in constituent loads between Lake Apopka and the lock and dam, either because of water withdrawals by farms, lower concentrations in farm discharge water than in the lake water, or natural processes in the canal. The largest reduction in total nitrogen and ammonia-plus-organic nitrogen loads was in February 1987, but this reduction was not evident in phosphorus, dissolved-solids, or total organic carbon loads.

The canal-effective nitrogen load generally constituted less than 10 percent of the total nitrogen load at the lock and dam (fig. 35). The monthly canal-effective nitrogen and ammonia-plus-organic nitrogen loads generally were positive.

The difference between total nitrogen and ammonia-plus-organic nitrogen represents nitrate-plus-nitrite nitrogen. Under normal flow conditions in the canal, there is little nitrate-plus-nitrite nitrogen in the water. However, relatively large loads of nitrate-plus-nitrite nitrogen were transported downstream during periods of high flow at the lock and dam (March and April 1987, 16 and 41 tons, respectively; January through March 1988, 21 tons; and September 1988, 16 tons; fig. 36). The maximum canal-effective nitrate-plus-nitrite nitrogen load was 6.4 tons in September 1988; however, this only accounted for 40 percent of the total load at the lock and dam.

An inverse relation was observed between canal-effective nitrate-plus-nitrite nitrogen loads and discharge at the lock and dam for November 1987 through February 1988. During November and December 1987, discharge at the lock and dam was about 35 ft^3/s, and the canal-effective load of nitrate-plus-nitrite nitrogen was 72 and 90 percent of the load at the lock and dam, respectively. Monthly mean discharge at the lock and dam increased to 87 ft^3/s in January 1988, and to 146 ft^3/s in February; however, the canal-effective nitrate-plus-nitrite nitrogen load represented only about half of the total nitrate-plus-nitrite nitrogen load in January and only about 15 percent of the load in February. The percentage of the load attributable to lake outflow (lock-and-dam load minus canal-effective load) increased when the discharge at the lock and dam increased.

Compared to total nitrogen, much more of the phosphorus load at the lock and dam is attributable to the canal-effective load (fig. 37). The phosphorus primarily is in the orthophosphorus form (table 2), an inorganic form that could be indicative of fertilizer runoff. The canal-effective phosphorus load (as a percentage of the total load) was largest in January 1990 (73 percent), followed closely by December 1987 (69 percent). This increase in percent of the total load attributable to canal-effective load in January 1990 coincided with a relatively large net difference in phosphorus load between the lake outflow and lock-and-dam sites (fig. 32). Similar increases in phosphorus load contribution were observed during June through September 1989 (figs. 32 and 37), again indicating that farm discharge was high and flow was in reversal at the lake-outflow site. In June and July 1989, the canal-effective phosphorus load was 50 and 60 percent, respectively, of the phosphorus load at the lock and dam, supporting the previous computation of a large net input of phosphorus load to the canal based on discharge at the lake-outflow site. However, the canal-effective loads of other constituents for the same months were not of this magnitude. For example, the canal-effective dissolved-solids load was only 7 percent of the dissolved-solids load at the lock and dam in June, and 12 percent in July 1989.

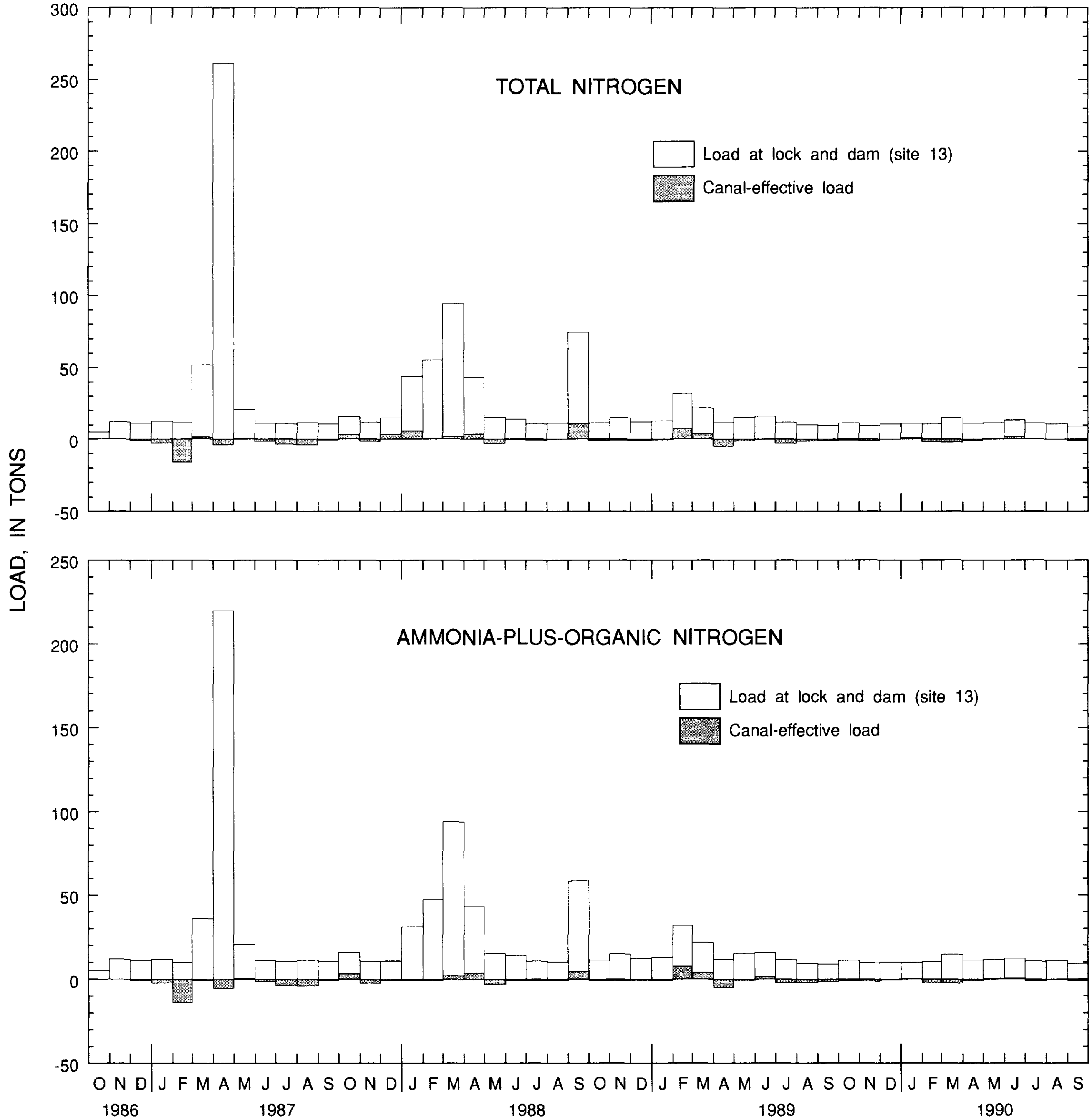


Figure 35. Monthly total nitrogen and ammonia-plus-organic nitrogen loads at the Apopka-Beauclair Canal lock and dam (site 13) and canal-effective load, October 1986 to September 1990.

Generally, the monthly canal-effective loads of total organic carbon in the Apopka-Beauclair Canal were less than 50 tons (fig. 39). In February 1990, the canal-effective load was about 50 percent of the total organic carbon load at the lock and dam; this was the largest percentage attributable to canal-effective load during the study. During the last month of data collection (September 1990) the canal-effective total organic carbon load was negative and larger than the load at the lock and dam, indicating that more carbon was being removed than was being contributed from Lake Apopka.

The significance of the canal-effective load is indicated by the data in table 4. For example, the net difference in phosphorus loads in 1989 between the two gaging sites was 9.0 tons, but the canal-effective load was 4.5 tons. This canal-effective load indicates that the discharge from farms along the canal

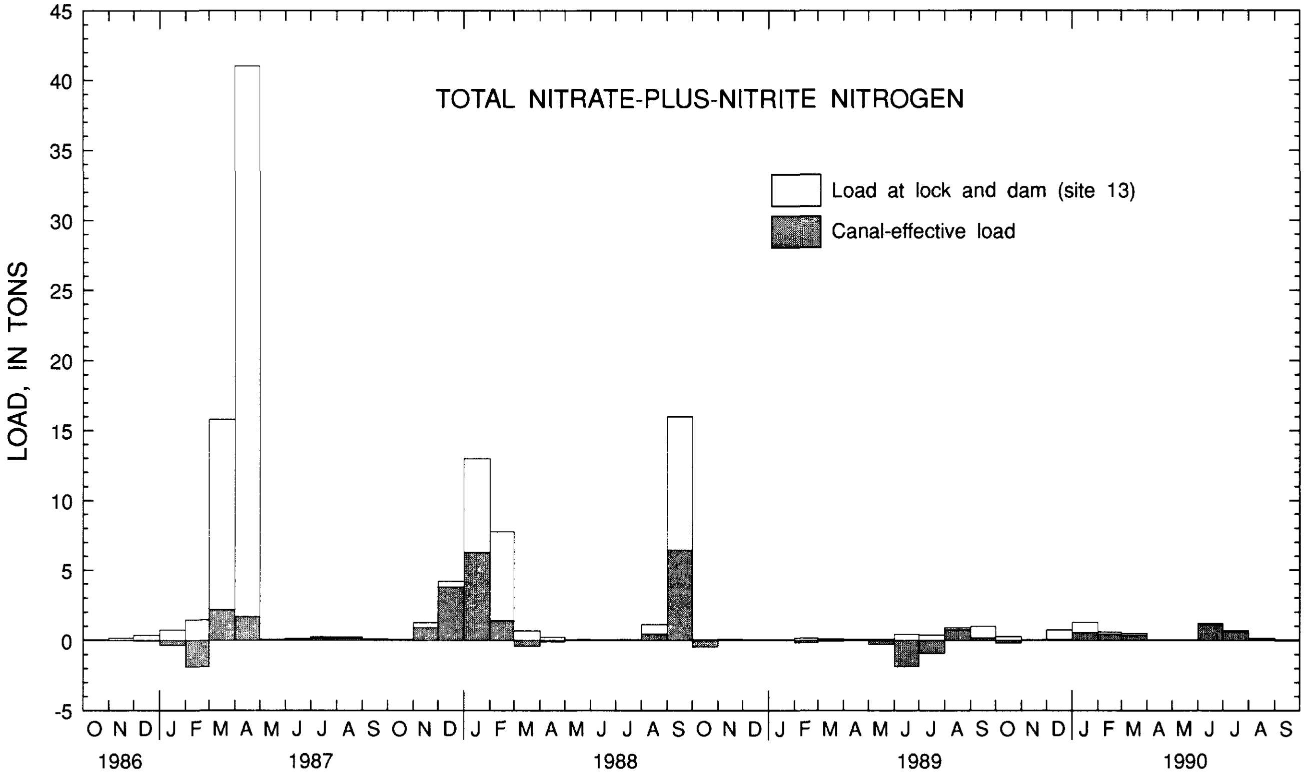


Figure 36. Monthly total nitrate-plus-nitrite nitrogen load at the Apopka-Beauclair Canal lock and dam (site 13) and canal-effective load, October 1986 through September 1990.

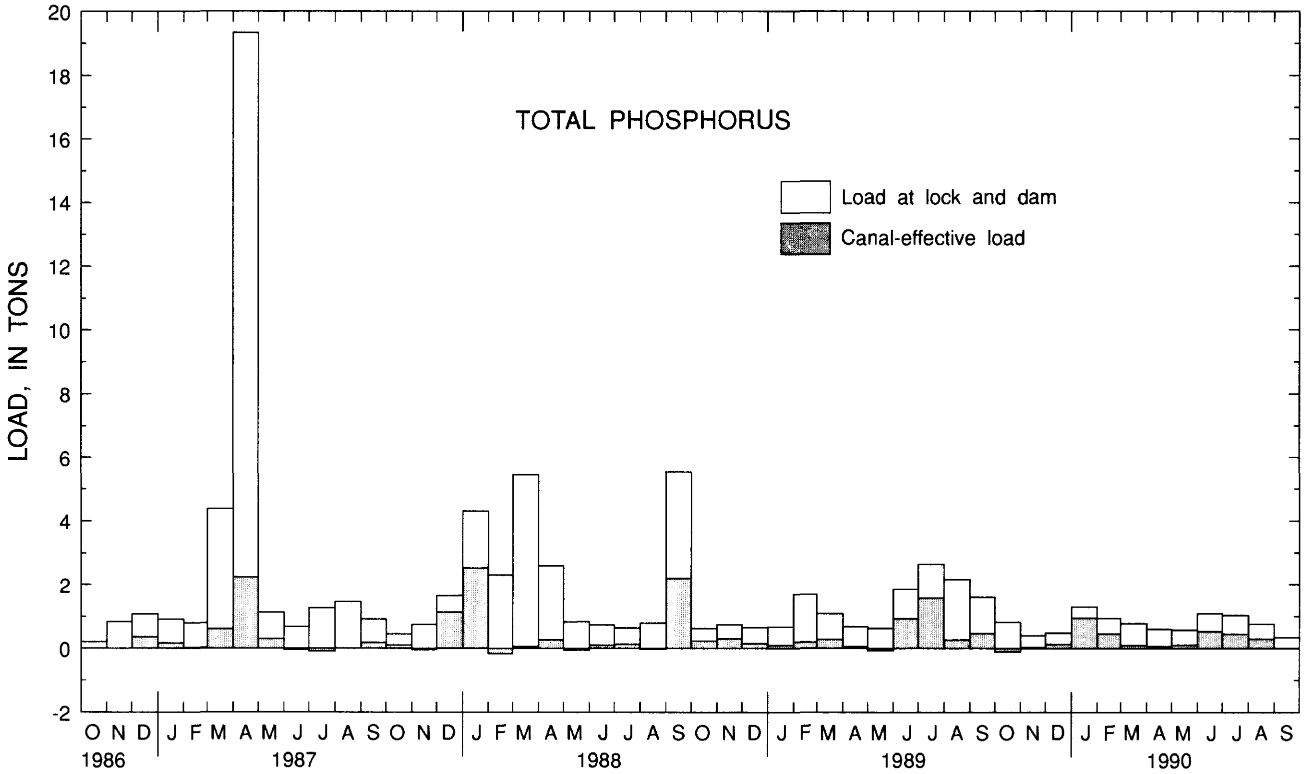


Figure 37. Monthly total phosphorus load at the Apopka-Beauclair Canal lock and dam (site 13) and canal-effective load, October 1986 through September 1990.

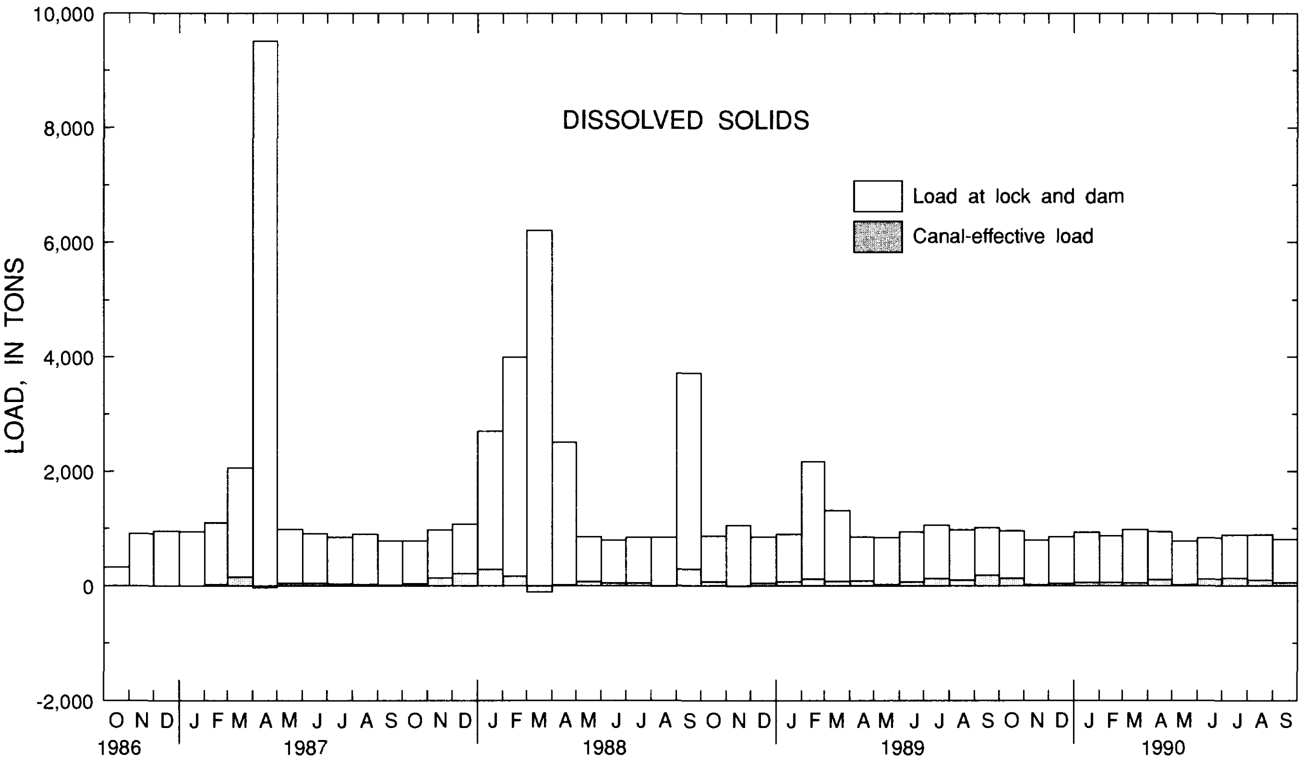


Figure 38. Monthly dissolved-solids load at the Apopka-Beauclair Canal lock and dam (site 13) and canal-effective load, October 1986 through September 1990.

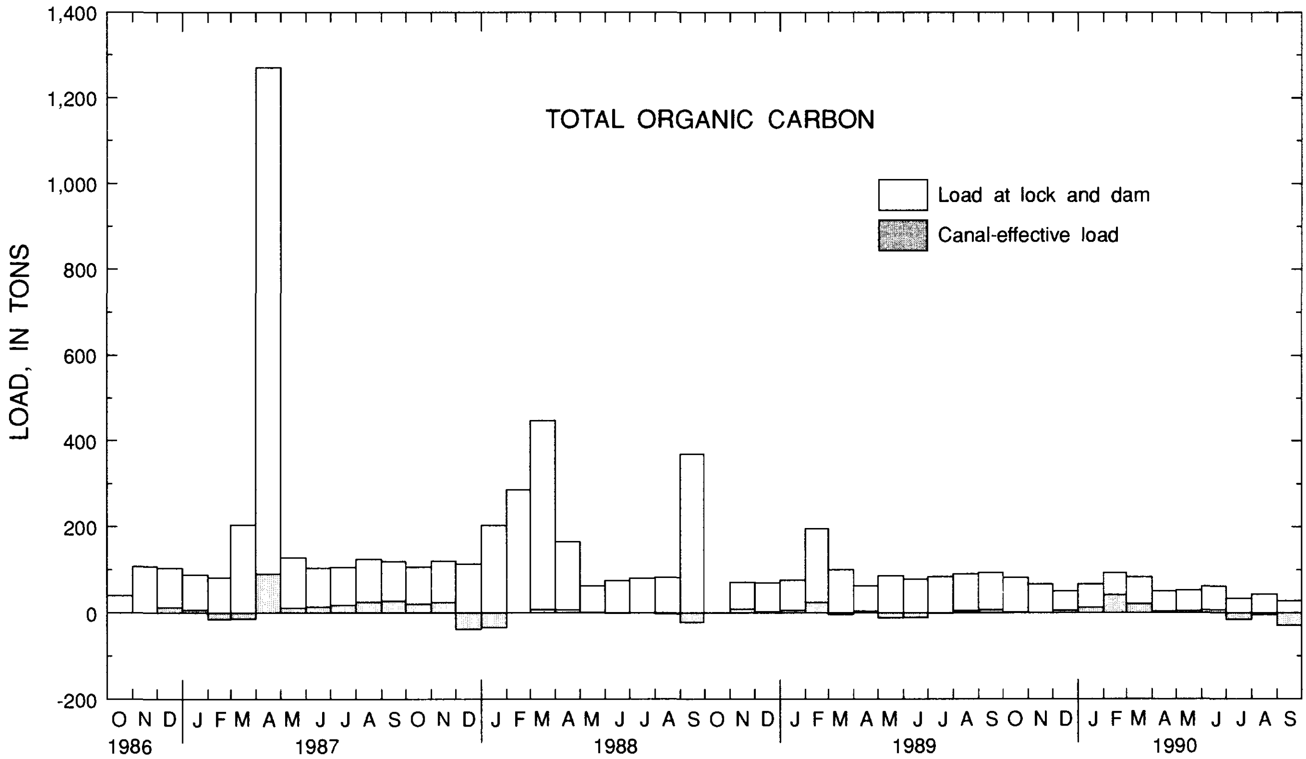


Figure 39. Monthly total organic carbon load at the Apopka-Beauclair Canal lock and dam (site 13) and canal-effective load, October 1986 through September 1990.

Table 4. Loads of selected constituents in the Apopka-Beauclair Canal, water year 1987-1990

[Water year begins October 1 of the year prior to that listed, and ends September 30 of the year listed. All loads are for total constituent, in tons. ft^3/s, cubic feet per second; -, no data]

Water year	Location or parameter	nitrogen	Ammonia plus organic nitrogen	Phosphorus	Organic carbon	Dissolved solids	Cumulative discharge[1] (ft^3/s)
1987	Lock and dam	430	370	33.0	2,470	20,200	26,500
	Lake-outflow site	-		-	-	-	-
	Difference	-		-	-	-	-
	Canal effec-tiveload	-30.5	-32.3	3.8	172	288	-
1988	Lock and dam	406	361	26.0	2,110	25,300	29,300
	Lake-outflow site	-		-	-	-	-
	Difference	-	-	-	-	-	-
	Canal-effec-tive load	23.1	4.4	6.2	-38	1,190	-
1989	Lock and dam	180	177	15	1,005	12,824	15,600
	Lake-outflow site	162	159	6.0	696	9,691	13,200
	Difference	18	18	9.0	309	3,132	2,400
	Canal-effec-tive load	-4.2	-1.4	4.5	27	950	-
1990	Lock and dam	136	131	9.1	706	10,500	12,200
	Lake-outflow site	126	125	5.5	600	8,600	10,900
	Difference	10	6.0	3.6	105	1,900	1,400
	Canal-effec-tive load	-5.5	-8.4	3.0	47	880	-

[1]Sum of daily mean discharges. Mean daily discharge for the water year was used in place of daily mean discharge for 4 days of missing record in 1989 and 9 days in 1990).

increased the load measured at the lock and dam by 4.5 tons above what would have been measured if the total load were contributed by Lake Apopka. The 6 tons of phosphorus at the lake-outflow site represents the load that was transported in the volume of water that could flow out of Lake Apopka, given the condition of farm discharge downstream from the site (more outflow would have been possible if no farms discharged to the canal). The difference in loads (9 tons) represents the difference between the controlled load (because of the control of discharge) at the lock and dam and the computed load at the lake-outflow site. However, because the computed load at the lake-outflow site is based on a reduced discharge (because of farm discharge), the net difference in the loads does not completely represent the effect of farm discharge. Thus, the canal-effective load more accurately evaluates the effect of farm discharge on the load at the lock and dam than does the net difference in loads.

Cumulative discharge at the lock and dam during the first 2 years of the study (water years 1987-88) was nearly double that of the last 2 years (water years 1989-90); the loads for the first 2 years reflect the higher discharge during those years (table 4).

The difference in discharge between the two gaged sites in those years for which data were available for the lake-outflow site (water years 1989-90) is small (less than 20 percent of the total outflow at the lock and dam).

Most of the nitrogen load at the lock and dam was in the ammonia-plus-organic nitrogen form during the last 2 years of the study (98 and 96 percent, water years 1989-90, respectively). However, when larger loads were transported through the lock and dam during periods of higher discharge in water years 1987 and 1988, nitrate-plus-nitrite nitrogen made up a larger percentage of the total nitrogen load (table 4).

The canal-effective nitrogen loads presented in table 4 indicate that farm discharge to the canal, and physical, chemical, and biological processes in the canal decreased total nitrogen loads between the lake-outflow and lock-and-dam sites during the 1987, 1989, and 1990 water years. Canal-effective total nitrogen loads were positive only in water year 1988 possibly as a result of the additional influx of nitrate-plus-nitrite nitrogen, probably from farm discharge water. The positive canal-effective total nitrogen load in water year 1988 is of interest because, unlike the other water years of the study, most of the nitrogen was in the nitrate-plus-nitrite form (18.7 tons, the difference between total nitrogen and ammonia-plus-organic nitrogen). The canal-effective load was 42 percent of the nitrate-plus-nitrite nitrogen load at the lock and dam in 1988.

Canal-effective phosphorus and dissolved-solids loads were positive for all water years of the study. Canal-effective phosphorus loads ranged from 11.4 percent of the phosphorus load at the lock and dam in water year 1987, to 33 percent of the phosphorus load in water year 1990. The total phosphorus load at the lock and dam decreased each water year from 1987 through 1990, ranging from 33 tons in 1987 to 9.1 tons in 1990. However, the percent of the total phosphorus load represented by the canal-effective load steadily increased during the same period.

The canal-effective load data indicates that, with the exception of phosphorus, the increase in load attributable to water discharged from farms and physical, chemical, and biological processes in the Apopka-Beauclair Canal generally is less than 10 percent of the total load based on the data in table 4. The probable reason for the small canal-effective load is that discharge from the farm areas (estimated as the difference in discharge between the lake-outflow and lock-and-dam sites) is small. Farm discharge represented about 15 percent of the lock-and-dam discharge in 1989, and about 11 percent in 1990 (table 4).

The computation of canal-effective loads provided information about constituent loads before the constriction was built, when discharge data were not available at the lake-outflow site. However, use of this method (canal-effective loads) still left some uncertainty about loads during the summer of 1989.

SUMMARY

The water entering Lake Beauclair, in the Ocklawaha River chain of lakes in central Florida, has high concentrations of the nutrients nitrogen and phosphorus. The major sources of these nutrients are Lake Apopka outflow and drainage from farming operations adjacent to the Apopka-Beauclair Canal. A study was conducted during 1986-90 to determine the relative contribution of nutrient loads from each of these sources to the Apopka-Beauclair Canal.

Two gaging and water-quality monitoring sites were established, one at a site 0.5 mile downstream from Lake Apopka (lake-outflow site), and one at the lock and dam on the Apopka-Beauclair Canal. Samples were collected biweekly for analysis of nutrients and monthly for analysis of major ions at both sites. In 1988, a constriction was built in the canal at the lake-outflow site to increase velocities and facilitate more accurate measurement of discharge. The study, which had been scheduled for completion in 1988, was extended 2 years to allow for collection of discharge data at the lake-outflow site. Supplemental water-quality data were collected following storms and three sets of reconnaissance samples of water and bottom sediment were collected during non-storm periods.

A regression between discharge gaged at the lake-outflow site and several hydrologic variables indicated that these variables explained a total of 72 percent of the variation in discharge. Of these variables, discharge at the lock and dam explained 64 percent of the variation in discharge at the lake-outflow site. A prediction equation for discharge was developed that worked well for those periods between storms, but large errors were associated with discharge predictions during periods following storms when flow at the lake-outflow site was reduced or reversed.

A summary of water-quality data for both monitoring sites indicated that mean and median specific conductance values at the lock-and-dam site were higher than those at the lake-outflow site. Other water-quality characteristics that tended to be higher at the lock-and-dam site include concentrations of nitrate-plus-nitrite nitrogen, total phosphorus, orthophosphorus, calcium, sulfate, color, hardness, and alkalinity. Organic nitrogen, dissolved oxygen, and pH generally were higher at the lake-outflow site than at the lock-and-dam site. However, the differences generally were small for the average conditions represented by the summary.

Water in the Apopka-Beauclair Canal generally is a calcium bicarbonate type. Mean hardness of water at the lake-outflow site was 159 milligrams per liter as $CaCO_3$, and at the lock-and-dam site, 174 milligrams per liter as $CaCO_3$, which is within the range indicated as hard (61-120 milligrams per liter as $CaCO_3$). Specific conductance of water in the canal ranged from 280 to 630 microsiemens per centimeter at 25 °C. The pH of the canal water generally was alkaline and ranged from 7.4 to 9.4 standard units. Nutrient concentrations generally were high, although median concentrations of nitrate-plus-nitrite nitrogen were below detection limits at the lake-outflow and lock-and-dam sites. Organic nitrogen, the dominant form of nitrogen in the canal water, ranged from a minimum of 2.1 milligrams per liter at the lock-and-dam site to a maximum of 4.5 milligrams per liter at the lake-outflow site. Phosphorus concentrations ranged from a mimimum of 0.04 milligrams per liter at the lake-outflow site to a maximum of 1.8 milligrams per liter at the lock-and-dam site.

Temperature, specific conductance, and dissolved oxygen concentrations varied daily and seasonally at the two gaging sites. Fluctuations in dissolved oxygen concentrations were larger during the summer, with highest concentrations in late afternoon and lowest concentrations in early or mid-morning. Dissolved oxygen concentrations generally were higher but less variable in winter. Dissolved oxygen concentrations were more erratic at the lake-outflow site than at the lock-and-dam site because of seiche effects and flow reversals at the lake-outflow site. Specific conductance of the canal water generally was higher at the lock-and-dam site than at the lake-outflow site probably because of the more mineralized water discharged from farms along the canal.

Reconnaissance water-quality samples collected during three non-storm periods in May 1988, June 1989, and August 1990 indicated that water quality changed little from Lake Apopka to Lake Beauclair during non-storm periods. Samples collected 1 to 2 days after storms indicated that water quality was much more variable following storms because of the inflow of water discharged (pumped) from farms to the canal.

Bottom-sediment samples in the Apopka-Beauclair Canal were collected at the time the three sets of reconnaissance samples were collected (May 1988, June 1989, and August 1990). Organic species of nitrogen and carbon were dominant in sediments; phosphorus was the most spatially variable of the constituents sampled and analyzed in sediments in the canal. Sand, silt, and clay are the native materials in the canal bed, but muck and organic material are deposited downstream from Lake Apopka to a distance of about 0.5 mile (the location of the lake-outflow site). Muck and organic material also were present in sediments at the outlet of the canal at Lake Beauclair, probably deposited there as as result of the canal hydraulics. Mean concentrations of nitrogen and phosphorus species except ammonia nitrogen and mean concentrations of organic carbon were higher in sediments at the lake-outflow site than in sediments at the lock-and-dam site, indicating that much of the nutrient and carbon load is not being transported downstream to the lock-and-dam site.

Constituent loads were computed using daily discharge data and periodic water-quality data at the gaging sites linearly interpolated between sampling dates to estimate daily mean concentrations. The load at the lake-outflow site was subtracted from the load at the lock and dam to determine the net load entering the canal, which was attributed to discharge from farms adjacent to the canal between the two gaging sites. The accuracy of the load computations is dependent on the accuracy of the discharge data at each site and the representativeness of the estimated concentrations. Common to all constituent loads computed was a large increase in net inflow to the canal during June through September 1989, the period during which reverse flow was frequently recorded at the lake-outflow site and the period for which there is some uncertainty in the discharge data. Therefore, this net inflow also has some uncertainty associated with it.

Median nitrate-plus-nitrite nitrogen concentrations at both gaging sites were at or below detection levels (0.02 milligrams per liter) and contributed very little to total nitrogen loads. Organic nitrogen was the dominant form of nitrogen in the water.

Maximum phosphorus loads were observed in the summer of 1989, when reverse flow was often observed at the lake-outflow site. High phosphorus concentrations during this period tend to support the validity of the discharge record because the high phosphorus concentrations indicated inflow from farms along the canal.

Dissolved-solids and total organic carbon loads followed a pattern similar to that of organic nitrogen during the 2 years that the lake-outflow site was gaged. Dissolved-solids concentrations for the computation of loads were estimated based on a relation between specific conductance and dissolved-solids concentrations in samples collected from Lake Apopka from 1959 to 1985. Daily mean specific conductance values (from hourly minimonitor data) at the lake-outflow and lock-and-dam sites were multiplied by the ratio obtained from data for Lake Apopka to estimate daily mean dissolved-solids concentrations. The maximum monthly dissolved-solids load at the lock and dam was 2,180 tons, and the maximum net increase in load between the two monitoring sites was 1,359 tons.

The effect of discharge from farms on constituent loads in the Apopka-Beauclair Canal was evaluated by computing a canal-effective load, a measure of the increase or decrease in a constituent load over the load that would have been transported had the discharge consisted only of water from Lake Apopka. Thus the canal-effective loads represent the net effect on loads attributable to discharge from farms along the canal and physical, chemical, and biological processes occurring between the two gaging sites. The computation of canal-effective load is based on water-quality data for the lock-and-dam and lake-outflow sites, and on discharge at the lock and dam.

Much of the constituent load transported through the lock and dam on the Apopka-Beauclair Canal was transported during periods of high discharge, when the gates at the lock and dam were opened. In April 1987 when discharges were as high as 589 ft^3/s, loads transported through the lock and dam accounted for 59 percent of the ammonia-plus-organic nitrogen load, 61 percent of the total nitrogen load, 59 percent of the phosphorus load, 51 percent of the total organic carbon load, and 47 percent of the dissolved-solids load transported during the 1987 water year. Discharge during April 1987 accounted for 52 percent of the total discharge for the year. These high percentages indicate the effect of the control of discharge at the lock and dam on the transport of loads to downstream lakes.

The canal-effective total nitrogen load generally was less than 10 percent of the total nitrogen load at the lock and dam. Most of the nitrogen load at the lock and dam was in the ammonia-plus-organic form. During the study, the canal-effective nitrate-plus-nitrite nitrogen load was as much as 90 percent of the total nitrate-plus-nitrite load at the lock and dam. However, the percentage of the nitrate-plus-nitrite load at the lock and dam attributable to lake-outflow increased (canal-effective loads decreased) when the gates were open and discharge was high. The maximum monthly nitrate-plus-nitrite nitrogen load at the lock and dam during the study was 41 tons in April 1987. The maximum canal-effective nitrate-plus-nitrite nitrogen load was 6.4 tons in September 1988; however, this only accounted for 40 percent of the total load at the lock and dam.

The monthly canal-effective phosphorus load was 73 percent of the phosphorus load at the lock and dam in January 1990 and 69 percent in December 1987. In June and July 1989, the canal-effective phosphorus load was 50 and 60 percent, respectively, of the phosphorus load at the lock and dam.

The canal-effective phosphorus load was 11.4 percent of the total phosphorus load in the 1987 water year and 33 percent of the phosphorus load in the 1990 water year. However, the yearly phosphorus load during this period decreased from 33 tons in 1987 to 9.1 tons in 1990. The canal-effective load computations indicated that discharges from farms along the canal (and physical, chemical, and biological processes in the canal) generally increased the total nutrient, dissolved-solids, and total organic carbon loads by less than 10 percent.

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APPENDIXES

Appendix Ia. Daily rainfall at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Rainfall is total accumulated for each day, in inches; ---, no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1988 (October 1987 to September 1988)												
1	---	---	0.00	0.04	0.01	0.00	0.00	---	---	0.06	0.00	1.48
2	---	---	.00	.03	.01	.00	.00	---	---	.00	.02	.00
3	---	---	.01	.03	.00	.00	.00	---	.00	.00	.45	.00
4	---	---	.02	.01	.01	.09	.00	---	.05	.00	.45	.00
5	---	---	.00	.00	.00	.23	.00	---	.05	.05	.09	1.26
6	---	---	.00	.01	.12	.09	.00	---	.04	.08	.02	.40
7	.03	---	.01	.05	.02	.01	.00	---	.20	.00	.40	.73
8	.00	---	.01	.02	.10	.00	.00	---	.01	.00	.04	.12
9	.00	---	.00	.12	.00	.17	.00	---	.00	.00	.35	---
10	.02	---	.00	.12	.00	.00	.06	---	.05	.07	.52	.00
11	.25	---	.02	.00	.05	.00	.02	---	.02	.00	.01	.00
12	.33	---	.01	.00	.02	.00	.14	---	.00	.00	.10	.00
13	.00	---	.00	.01	.00	.13	.00	---	.00	.29	.00	.00
14	.00	---	.01	.00	.00	.00	.00	---	.22	---	.18	.00
15	.00	---	.12	.00	.14	.00	.00	---	.00	.00	.06	.10
16	.03	---	.00	.04	.01	.00	.00	---	.00	.00	.01	.00
17	.01	.33	.00	.03	.00	.00	.00	---	.00	.00	.03	.00
18	.00	.01	.00	.00	.00	.22	---	---	.00	.11	.00	.00
19	.00	.12	.01	.00	.02	.04	---	---	.00	.07	.00	.00
20	.02	.00	.00	.00	.04	.00	---	---	.17	.06	.60	.04
21	.01	.00	---	.37	.09	.00	---	---	.01	.03	.00	.01
22	.01	.01	---	.00	.00	.00	---	---	.07	.07	.02	.00
23	.01	.02	.03	.00	.01	.00	---	---	.08	.12	.00	.00
24	.02	.02	.01	.40	.00	.00	---	---	.00	.03	.00	.00
25	.01	.01	.02	.35	.00	.01	---	---	.00	.00	.08	.00
26	.00	.23	.02	.00	.00	.00	---	---	.04	.00	.42	.07
27	.01	.06	.01	.00	.00	.00	---	---	.00	.39	1.11	.00
28	---	.01	.04	.00	.00	.00	---	---	.00	.00	.00	.00
29	---	.01	.00	.00	.00	.00	---	---	.00	.00	.00	.02
30	---	.00	.01	.00	---	.00	---	---	.00	.00	.00	.00
31	---	---	.03	.01	---	.00	---	---	---	.00	.07	---
TOTAL	---	---	---	1.64	0.65	0.99	---	---	---	---	5.03	---
Water year 1989 (October 1988 to September 1989)												
1	0.00	0.00	---	0.00	0.00	0.38	0.00	0.28	0.00	0.09	0.08	0.01
2	.10	.01	---	.00	.00	.04	.00	.00	.00	.34	.00	.00
3	.23	.11	---	.00	.00	.11	.00	.00	.00	.69	.32	.00
4	.01	.12	---	.00	.00	.05	.95	.00	.00	.12	.00	.00
5	.00	.05	---	.00	.00	.00	.01	.00	.25	.04	.00	.00
6	.00	.01	---	.00	.00	.00	.00	.00	.05	.01	.00	.18
7	.00	.00	---	.00	.00	.05	.00	.00	.14	.03	.00	.00
8	.00	.00	---	.00	.00	.00	.00	.00	.47	.00	.00	.02
9	.00	.00	---	.01	.00	.00	.00	.00	.00	.00	.23	.00
10	.00	---	---	.00	.00	.00	.00	.40	.00	.00	.00	.12
11	.00	.00	---	.00	.00	.00	.00	.00	.00	.00	.23	.00
12	.00	.00	---	.00	.00	.00	.00	.00	.01	.02	1.66	.00
13	.00	.00	---	.00	.00	.00	.00	.00	.00	.07	.03	.00
14	.00	.01	---	.00	.00	.00	.55	.15	.00	.25	.01	.00
15	.00	.01	---	.00	.00	.00	.59	.00	.00	.28	.00	.00
16	.00	.00	---	.00	.00	.00	.03	.00	.44	.10	.00	.69
17	.00	.00	---	.01	.00	.00	.00	.00	.00	.39	.00	.01
18	.00	.00	---	.00	.00	.00	.00	.00	.03	.32	.02	.00
19	.00	.00	---	.00	.00	.00	.03	.00	.00	.15	.35	.00
20	.00	.00	.00	.13	.00	.00	.00	.00	.06	.00	.46	.00
21	.00	.01	.00	.57	.10	.00	.00	.01	.27	.00	.04	.00
22	.00	.40	.00	.34	.43	.06	.00	.00	.07	.70	.74	.78
23	.00	.04	.00	.00	.00	.14	.00	.00	.19	.00	.00	.20
24	.00	.00	.01	.00	.00	.01	.00	.01	1.83	.29	.00	.04
25	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.05	.42
26	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.11	.01
27	.00	.00	.00	.00	.00	.00	.00	.00	.01	.00	.28	.00
28	.00	.05	.00	.00	.00	.00	.00	.13	.60	.00	.01	---
29	.00	.00	.00	.00	---	.09	.01	.04	.61	.00	.00	---
30	.01	---	.00	.00	---	.01	1.11	.01	.15	1.02	.00	.00
31	.01	---	.02	.00	---	.22	---	.00	---	.00	.17	---
TOTAL	0.36	---	---	1.06	0.53	1.16	3.28	1.03	5.18	4.91	4.79	---

Appendix Ia. Daily rainfall at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Rainfall is total accumulated for each day, in inches; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 to September 1990)												
1	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	.02	.00	.00	.00	.00	.00	.00	.00	.04	.38	.00	.09
3	.00	.00	.00	.00	.00	.00	.04	.00	.22	.07	.22	.02
4	.00	.00	.00	.39	.00	.00	.00	.00	.04	.00	.37	.01
5	.00	.00	.00	.37	.00	.00	.00	.00	.29	.00	.00	.01
6	.00	.00	.00	.00	.00	.00	.00	.01	.03	.00	.00	.00
7	.25	.00	.00	.00	.00	.00	.00	.00	.03	.00	.39	.00
8	.00	.00	.50	.33	.00	.00	.00	.00	1.11	.08	.01	.01
9	.00	.09	.02	.00	.00	.00	.00	.10	.01	.01	.02	.00
10	.00	.01	.00	.00	.64	.00	.00	.01	1.49	.00	.17	.00
11	.00	.01	.00	.00	.10	.00	.45	.00	1.17	.72	.09	.06
12	.00	.00	.03	.01	.00	.00	.00	.00	.01	1.72	.00	.00
13	.00	.01	.00	.00	.00	.00	.00	.00	.00	.05	1.10	.00
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.20	1.69	.00
15	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.01	.00
16	.02	.10	.02	.00	.00	.00	.00	.00	.00	.16	1.21	.01
17	.00	.00	.01	.00	.00	.05	.00	.00	1.40	.69	.05	.00
18	.22	.00	.24	.00	.00	.00	.00	.02	.01	.07	.02	.00
19	.00	.00	.22	.00	.00	.00	.63	.02	.00	.00	.02	.00
20	.00	.01	.23	.00	.00	.00	.00	.03	.00	.21	.53	.00
21	.00	.00	.00	.00	.15	.00	.00	.00	.00	.21	.01	.00
22	.00	.01	.26	.00	.13	.00	.06	.03	1.05	.01	.00	.00
23	.00	.28	.06	.00	.43	.00	.15	.06	.66	.00	.36	.00
24	.02	.00	.00	.00	.00	.00	.01	.00	.05	.00	.06	.00
25	.01	.03	.00	.00	.00	.00	.00	.00	.01	.06	.01	.00
26	.00	.11	.00	.02	.00	.00	.00	.00	.69	.00	.02	.00
27	.04	.02	.00	.00	.00	.00	.00	.25	.00	.00	.00	.02
28	.00	.00	.00	.00	.00	.00	.24	.00	.00	.00	.06	.45
29	.01	.00	.00	.00	---	.13	.00	.00	.04	.00	.01	.45
30	.03	.04	.00	.00	---	.17	.00	.00	.00	.00	.00	.00
31	.01	---	.00	.00	---	.16	---	.00	---	.00	.00	---
TOTAL	0.64	0.72	1.59	1.16	1.45	0.51	1.59	0.53	8.35	4.64	6.43	1.13

Appendix Ib. Daily mean gage height at the Apopka-Beauclair Canal lock and dam, October 1986 through September 1990
[Gage height is in feet above sea level; ---, no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1987 (October 1986 to September 1987)												
1	66.50	66.21	66.27	66.26	66.46	66.98	67.04	66.76	66.59	66.30	66.33	66.30
2	66.47	66.22	66.28	66.25	66.51	66.94	67.04	66.84	66.58	66.33	66.33	66.29
3	66.45	66.22	66.18	66.31	66.45	66.96	67.01	66.86	66.56	66.32	66.38	66.31
4	66.43	66.21	66.15	66.36	66.44	66.93	66.87	66.84	66.50	66.32	66.44	66.42
5	66.38	66.24	66.09	66.12	66.47	66.91	66.91	66.79	66.46	66.28	66.44	66.45
6	66.38	66.24	66.13	66.30	66.52	66.93	66.91	66.76	66.44	66.30	66.44	66.45
7	66.43	66.25	66.16	66.36	66.55	67.08	66.87	66.79	66.44	66.29	66.45	66.42
8	66.43	66.24	66.22	66.36	66.63	67.13	66.81	66.75	66.42	66.39	66.41	66.43
9	66.43	66.23	66.24	66.38	66.61	67.08	66.79	66.77	66.40	66.40	66.35	66.45
10	66.41	66.23	66.24	66.39	66.69	67.05	66.76	66.79	66.38	66.37	66.33	66.43
11	66.42	66.20	66.28	66.22	66.72	67.06	66.75	66.80	66.36	66.35	66.44	66.43
12	66.41	66.19	66.24	66.27	66.70	67.05	66.76	66.79	66.38	66.32	66.46	66.48
13	66.43	66.10	66.12	66.31	66.70	67.02	66.76	66.79	66.36	66.27	66.43	66.58
14	66.40	66.09	66.18	66.35	66.72	67.07	66.73	66.79	66.36	66.21	66.44	66.59
15	66.33	66.09	66.19	66.37	66.76	67.06	66.69	66.86	66.33	66.24	66.47	66.62
16	66.25	66.14	66.18	66.37	66.81	67.06	66.63	66.84	66.30	66.26	66.51	66.60
17	66.20	66.12	66.19	66.36	66.82	67.07	66.56	66.87	66.30	66.25	66.49	66.58
18	66.18	66.12	66.18	66.38	66.82	67.11	66.52	66.84	66.33	66.22	66.48	66.54
19	66.20	66.12	66.19	66.37	66.78	67.06	66.51	66.84	66.41	66.22	66.46	66.53
20	66.15	66.14	66.18	66.33	66.79	67.04	66.50	66.89	66.39	66.27	66.46	66.51
21	66.17	66.08	66.12	66.38	66.82	67.03	66.47	66.87	66.40	66.27	66.47	66.50
22	66.16	66.10	66.13	66.39	66.88	67.02	66.45	66.83	66.37	66.25	66.45	66.50
23	66.19	66.10	66.24	66.34	66.83	67.02	66.42	66.82	66.31	66.23	66.45	66.48
24	66.20	66.13	66.22	66.45	66.87	67.10	66.67	66.80	66.27	66.24	66.44	66.46
25	66.20	66.18	66.21	66.51	66.89	67.05	66.84	66.77	66.25	66.21	66.39	66.48
26	66.18	66.18	66.20	66.37	66.90	67.13	66.81	66.68	66.27	66.20	66.39	66.47
27	66.16	66.13	66.18	66.37	66.91	67.24	66.79	66.69	66.26	66.24	66.38	66.45
28	66.14	66.12	66.15	66.45	66.97	67.30	66.74	66.65	66.25	66.23	66.36	66.43
29	66.17	66.15	66.16	66.47	---	67.21	66.73	66.63	66.24	66.23	66.36	66.43
30	66.15	66.27	66.15	66.47	---	67.23	66.70	66.60	66.25	66.25	66.36	66.45
31	66.19	---	66.23	66.38	---	66.98	---	66.60	---	66.30	66.35	---
MEAN	66.30	66.17	66.19	66.35	66.71	67.06	66.73	66.78	66.37	66.28	66.42	66.47
MAX	66.50	66.27	66.28	66.51	66.97	67.30	67.04	66.89	66.59	66.40	66.51	66.62
MIN	66.14	66.08	66.09	66.12	66.44	66.91	66.42	66.60	66.24	66.20	66.33	66.29
Water year 1988 (October 1987 to September 1988)												
1	66.38	66.21	66.87	66.81	67.05	66.94	67.12	66.70	66.35	66.30	66.36	66.54
2	66.41	66.24	66.88	66.80	67.09	66.98	67.09	66.72	66.33	66.39	66.33	66.68
3	66.37	66.43	66.88	66.79	67.11	66.99	67.07	66.78	66.29	66.37	66.34	66.69
4	66.32	66.77	66.78	66.76	67.10	66.98	67.03	66.69	66.26	66.33	66.34	66.70
5	66.33	66.78	66.80	66.71	67.02	66.95	66.96	66.47	66.32	66.25	66.32	66.78
6	66.32	66.69	66.84	66.73	66.92	67.08	66.92	66.31	66.37	66.29	66.34	67.07
7	66.29	66.77	66.87	66.81	67.03	67.12	66.71	66.23	66.46	66.30	66.34	66.99
8	66.25	66.80	66.87	66.80	67.03	67.14	66.84	66.26	66.46	66.28	66.35	66.69
9	66.26	66.82	66.85	66.77	67.06	67.11	66.89	66.27	66.47	66.29	66.33	66.50
10	66.24	66.81	66.86	66.77	67.06	66.94	66.91	66.26	66.43	66.27	66.34	66.47
11	66.25	66.70	66.83	66.77	67.08	67.07	66.86	66.36	66.40	66.26	66.41	66.42
12	66.29	66.72	66.85	66.81	66.98	67.11	66.78	66.60	66.41	66.26	66.40	66.65
13	66.23	66.76	66.85	66.81	66.98	67.16	66.76	66.60	66.37	66.25	66.34	66.80
14	66.32	66.76	66.87	66.74	67.05	67.12	66.82	66.59	66.39	66.26	66.37	66.80
15	66.33	66.77	66.91	66.74	67.07	67.05	66.81	66.58	66.36	66.27	66.42	66.78
16	66.33	66.82	66.80	66.80	67.01	67.11	66.79	66.60	66.37	66.28	66.43	66.77
17	66.33	66.83	66.79	66.83	67.04	67.15	66.79	66.57	66.36	66.28	66.39	66.74
18	66.34	66.83	66.84	66.81	67.06	67.20	66.81	66.50	66.35	66.27	66.40	66.77
19	66.36	66.83	66.86	66.85	67.08	67.09	66.81	66.50	66.32	66.26	66.41	66.92
20	66.39	66.75	66.86	66.89	67.04	67.05	66.83	66.47	66.31	66.32	66.39	67.00
21	66.34	66.73	66.86	66.88	66.97	67.06	66.81	66.48	66.36	66.37	66.37	66.96
22	66.29	66.80	66.86	66.85	67.04	67.05	66.81	66.43	66.38	66.36	66.35	66.97
23	66.28	66.81	66.85	66.88	67.03	67.08	66.81	66.44	66.36	66.38	66.34	66.96
24	66.30	66.80	66.88	66.88	67.01	67.06	66.78	66.41	66.34	66.37	66.31	66.93
25	66.24	66.82	66.88	67.09	66.94	67.03	66.78	66.48	66.33	66.38	66.28	66.90
26	66.26	66.84	66.88	66.73	66.95	66.98	66.74	66.43	66.40	66.39	66.33	66.90
27	66.29	66.91	66.87	66.69	66.96	66.97	66.73	66.44	66.38	66.37	66.37	66.90
28	66.19	66.92	66.87	67.02	66.95	67.10	66.67	66.45	66.35	66.41	66.48	66.87
29	66.18	66.89	66.67	67.03	66.96	67.16	66.66	66.44	66.38	66.41	66.48	66.88
30	66.21	66.85	66.75	67.04	---	67.13	66.71	66.42	66.33	66.40	66.50	66.88
31	66.18	---	66.80	67.05	---	67.15	---	66.37	---	66.40	66.47	---
MEAN	66.29	66.75	66.84	66.84	67.02	67.07	66.84	66.48	66.37	66.32	66.38	66.80
MAX	66.41	66.92	66.91	67.09	67.11	67.20	67.12	66.78	66.47	66.41	66.50	67.07
MIN	66.18	66.21	66.67	66.69	66.92	66.94	66.66	66.23	66.26	66.25	66.28	66.42

Appendix Ib. Daily mean gage height at the Apopka-Beauclair Canal lock and dam, October 1986 through September 1990

[Gage height is in feet above sea level; ---, no data]--Continued

Water year 1989 (October 1988 to September 1989)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	66.87	66.61	66.96	67.07	67.30	67.00	66.77	67.01	66.48	66.46	66.49	66.50
2	66.86	66.61	66.96	67.06	67.27	67.03	66.88	66.86	66.46	66.52	66.45	66.53
3	66.94	66.66	66.97	67.00	67.26	67.08	66.87	66.89	66.42	66.66	66.42	66.54
4	66.96	66.75	66.96	66.97	67.23	67.08	66.88	66.93	66.37	66.69	66.45	66.49
5	66.92	66.69	66.95	67.04	67.26	67.12	66.89	66.92	66.35	66.69	66.44	66.46
6	66.88	66.66	66.98	67.06	67.24	67.11	66.79	66.83	66.34	66.71	66.40	66.48
7	66.83	66.65	67.00	67.04	67.22	67.00	66.80	66.72	66.33	66.72	66.36	66.52
8	66.82	66.66	66.99	67.03	67.17	66.95	66.85	66.77	66.36	66.70	66.40	66.52
9	66.85	66.66	66.99	67.03	67.08	66.84	66.84	66.78	66.45	66.68	66.37	66.54
10	66.85	66.64	66.99	67.00	67.06	66.92	66.80	66.73	66.43	66.65	66.35	66.53
11	66.87	66.62	67.00	67.01	67.07	66.97	66.73	66.70	66.43	66.62	66.35	66.54
12	66.84	66.62	66.96	67.03	67.05	66.99	66.71	66.71	66.43	66.59	66.40	66.52
13	66.78	66.62	66.99	67.03	67.11	67.00	66.72	66.72	66.39	66.57	66.54	66.51
14	66.78	66.61	67.06	67.04	67.16	67.02	66.76	66.72	66.40	66.58	66.53	66.51
15	66.78	66.60	67.07	67.02	67.15	67.01	66.87	66.69	66.39	66.58	66.51	66.55
16	66.79	66.61	67.05	66.99	67.14	67.01	66.97	66.68	66.37	66.55	66.49	66.51
17	66.77	66.59	66.97	66.98	67.10	67.01	67.00	66.67	66.36	66.54	66.50	66.53
18	66.78	66.60	66.99	66.98	67.05	67.01	66.98	66.68	66.32	66.55	66.51	66.49
19	66.78	66.62	67.04	66.99	67.07	66.97	66.97	66.65	66.30	66.55	66.50	66.47
20	66.78	66.61	67.04	66.97	67.11	67.00	66.95	66.62	66.31	66.58	66.57	66.46
21	66.75	66.56	67.04	67.02	67.15	66.97	66.89	66.57	66.29	66.59	66.58	66.39
22	66.71	66.54	67.05	67.14	67.04	66.97	66.91	66.55	66.40	66.58	66.57	66.50
23	66.73	66.76	67.05	67.24	66.80	67.04	66.92	66.52	66.44	66.60	66.58	66.60
24	66.72	66.93	67.07	67.32	66.87	66.91	66.90	66.49	66.50	66.61	66.56	66.69
25	66.66	67.00	67.06	67.34	66.97	66.92	66.87	66.48	66.50	66.58	66.53	66.75
26	66.69	67.04	67.06	67.35	66.99	66.93	66.85	66.48	66.49	66.54	66.51	66.80
27	66.69	67.04	67.08	67.33	67.02	66.97	66.83	66.49	66.49	66.53	66.50	66.79
28	66.68	66.96	67.08	67.35	67.00	66.96	66.80	66.48	66.46	66.50	66.51	66.81
29	66.67	66.99	67.08	67.35	---	66.95	66.83	66.47	66.42	66.49	66.50	66.82
30	66.63	67.00	67.07	67.36	---	66.97	66.89	66.49	66.40	66.49	66.48	66.86
31	66.64	---	67.09	67.34	---	66.85	---	66.49	---	66.51	66.47	---
MEAN	66.78	66.72	67.02	67.11	67.10	66.99	66.86	66.67	66.40	66.59	66.48	66.57
MAX	66.96	67.04	67.09	67.36	67.30	67.12	67.00	67.01	66.50	66.72	66.58	66.86
MIN	66.63	66.54	66.95	66.97	66.80	66.84	66.71	66.47	66.29	66.46	66.35	66.39

Water year 1990 (October 1989 to September 1990)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	66.83	66.54	66.35	66.68	66.71	66.94	66.66	66.25	65.75	66.05	66.36	66.54
2	66.76	66.52	66.36	66.69	66.73	66.95	66.68	66.28	65.71	65.99	66.34	66.49
3	66.74	66.49	66.23	66.72	66.73	66.89	66.56	66.33	65.83	66.03	66.36	66.49
4	66.75	66.50	66.27	66.72	66.73	66.89	66.51	66.31	65.90	66.04	66.42	66.48
5	66.76	66.50	66.31	66.76	66.54	66.88	66.59	66.18	65.89	65.98	66.44	66.46
6	66.77	66.50	66.33	66.80	66.65	66.87	66.59	66.11	65.89	65.94	66.42	66.43
7	66.76	66.51	66.33	66.83	66.64	66.88	66.55	66.09	65.92	65.99	66.41	66.43
8	66.76	66.50	66.41	66.79	66.64	66.92	66.54	66.17	65.92	66.01	66.46	66.44
9	66.71	66.49	66.35	66.78	66.67	66.88	66.58	66.17	65.95	66.01	66.47	66.43
10	66.72	66.45	66.40	66.78	66.68	66.87	66.56	66.09	65.96	65.98	66.48	66.41
11	66.69	66.46	66.46	66.80	66.72	66.85	66.51	66.04	66.01	65.94	66.49	66.35
12	66.70	66.45	66.51	66.75	66.70	66.85	66.43	66.09	66.06	66.02	66.51	66.35
13	66.70	66.46	66.33	66.66	66.76	66.84	66.46	66.05	66.06	66.25	66.53	66.34
14	66.70	66.45	66.41	66.74	66.77	66.85	66.45	66.00	66.03	66.36	66.53	66.32
15	66.69	66.46	66.44	66.76	66.78	66.87	66.46	66.03	65.99	66.36	66.56	66.29
16	66.70	66.40	66.42	66.78	66.78	66.89	66.42	66.04	65.97	66.34	66.57	66.28
17	66.70	66.37	66.41	66.77	66.70	66.87	66.43	65.98	65.95	66.37	66.57	66.27
18	66.67	66.39	66.47	66.78	66.74	66.72	66.39	65.95	65.99	66.40	66.55	66.25
19	66.56	66.38	66.52	66.78	66.73	66.72	66.42	65.96	66.04	66.39	66.55	66.23
20	66.41	66.38	66.53	66.80	66.67	66.63	66.43	65.92	66.00	66.37	66.56	66.22
21	66.54	66.37	66.56	66.78	66.74	66.64	66.38	65.89	65.99	66.39	66.56	66.22
22	66.53	66.41	66.53	66.73	66.82	66.66	66.34	65.82	65.97	66.43	66.53	66.19
23	66.53	66.38	66.46	66.76	66.91	66.66	66.34	65.84	66.01	66.42	66.57	66.16
24	66.47	66.39	66.51	66.77	66.84	66.66	66.40	65.88	66.01	66.42	66.60	66.12
25	66.48	66.44	66.65	66.79	66.90	66.63	66.41	65.87	66.04	66.42	66.61	66.12
26	66.48	66.42	66.67	66.59	66.91	66.62	66.38	65.88	66.09	66.40	66.58	66.14
27	66.49	66.43	66.70	66.69	66.92	66.58	66.41	65.85	66.13	66.33	66.56	66.14
28	66.43	66.43	66.70	66.71	66.92	66.59	66.41	65.80	66.14	66.37	66.54	66.17
29	66.35	66.36	66.71	66.71	---	66.61	66.30	65.70	66.12	66.40	66.53	66.23
30	66.49	66.30	66.71	66.72	---	66.67	66.27	65.76	66.09	66.41	66.49	66.27
31	66.53	---	66.75	66.69	---	66.72	---	65.77	---	66.39	66.51	---
MEAN	66.63	66.44	66.48	66.75	66.75	66.78	66.46	66.00	65.98	66.23	66.51	66.31
MAX	66.83	66.54	66.75	66.83	66.92	66.95	66.68	66.33	66.14	66.43	66.61	66.54
MIN	66.35	66.30	66.23	66.59	66.54	66.58	66.27	65.70	65.71	65.94	66.34	66.12

Appendix Ic. Daily mean discharge at the Apopka-Beauclair Canal lock and dam, October 1986 through September 1990

[Discharge is in cubic feet per second; ---, no data]

Water year 1987 (October 1986 to September 1987)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	34	34	36	33	34	38	589	136	34	40	34	33
2	34	32	36	33	34	34	589	48	36	40	37	33
3	34	32	32	33	34	34	583	49	34	33	35	35
4	33	32	32	33	34	34	554	49	34	34	37	33
5	34	34	32	32	34	34	562	41	34	40	37	34
6	33	33	32	33	34	36	562	47	34	33	37	34
7	33	33	32	33	34	35	554	51	34	40	37	33
8	35	33	32	33	34	35	542	51	35	33	35	33
9	33	32	33	33	34	39	538	51	33	36	34	34
10	33	32	34	33	35	34	530	51	33	33	37	33
11	33	32	33	32	35	35	528	52	33	33	37	33
12	33	32	33	33	35	40	531	51	33	33	37	35
13	34	32	32	33	35	36	531	44	33	33	37	34
14	33	32	32	33	35	36	524	51	33	38	37	34
15	33	32	32	33	35	36	516	52	42	33	38	34
16	33	32	32	33	35	36	504	37	33	33	38	34
17	32	32	32	33	35	36	491	37	36	33	41	34
18	32	32	32	33	35	37	483	36	50	32	38	34
19	32	34	32	33	35	36	481	37	33	32	37	34
20	32	32	32	33	35	36	479	36	33	34	37	34
21	32	32	32	33	35	36	473	36	38	33	38	34
22	32	32	32	33	36	36	469	35	37	33	38	34
23	32	32	33	33	35	44	463	35	38	32	37	35
24	32	32	33	34	36	37	338	38	33	32	44	34
25	32	33	32	34	36	43	210	35	39	32	33	34
26	32	32	32	35	36	37	210	66	33	32	33	34
27	32	32	32	33	36	37	211	37	33	36	33	34
28	32	32	32	34	36	41	207	35	33	32	33	33
29	32	32	32	34	---	101	207	34	55	17	33	33
30	32	34	32	34	---	457	205	34	33	15	33	34
31	32	---	32	33	---	577	---	34	---	34	33	---
TOTAL	1015	972	1007	1028	977	2163	13664	1426	1072	1024	1125	1014
MEAN	32.7	32.4	32.5	33.2	34.9	69.8	455	46.0	35.7	33.0	36.3	33.8
MAX	35	34	36	35	36	577	589	136	55	40	44	35
MIN	32	32	32	32	34	34	205	34	33	15	33	33

Water year 1988 (October 1987 to September 1988)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	33	32	36	35	225	104	202	35	33	33	33	34
2	33	33	36	35	184	105	201	35	33	33	33	35
3	33	33	36	35	154	105	201	35	34	33	33	35
4	33	35	35	35	153	105	200	35	33	33	33	35
5	33	35	35	35	152	104	198	34	33	34	35	35
6	33	35	35	35	150	106	197	33	33	33	33	103
7	33	35	36	35	152	134	192	32	37	33	33	209
8	33	36	36	35	152	154	134	33	44	33	33	428
9	33	35	35	35	153	209	101	33	34	33	34	471
10	33	35	35	35	153	241	101	33	33	33	33	465
11	33	35	35	35	153	245	100	33	33	33	33	455
12	33	35	35	35	151	246	99	34	33	33	34	360
13	32	35	35	35	151	247	99	34	35	33	39	256
14	33	35	36	35	152	246	100	34	33	33	33	256
15	33	36	36	35	153	244	100	34	33	33	39	255
16	33	35	35	35	152	246	100	34	33	33	33	255
17	33	35	35	35	152	247	100	34	33	34	33	254
18	33	35	35	35	153	249	100	34	33	33	33	255
19	33	35	35	35	153	292	100	34	33	33	33	125
20	33	35	35	35	152	350	76	34	33	34	33	36
21	33	35	35	36	151	349	35	34	34	33	33	36
22	33	35	35	35	152	349	35	33	33	33	33	36
23	33	35	35	36	152	350	35	34	33	33	33	36
24	33	35	36	36	122	349	35	33	35	33	33	36
25	33	35	36	90	104	348	35	34	33	33	33	36
26	33	35	36	386	104	347	35	33	33	33	33	36
27	33	36	36	415	104	346	35	34	33	37	33	36
28	32	36	36	243	104	258	35	34	36	33	34	36
29	32	36	35	244	104	203	35	34	33	33	34	36
30	33	35	35	244	---	202	35	34	33	33	34	36
31	32	---	35	244	---	203	---	37	---	33	34	---
TOTAL	1019	1048	1097	2709	4247	7283	3051	1051	1015	1030	1043	4717
MEAN	32.9	34.9	35.4	87.4	146	235	102	33.9	33.8	33.2	33.6	157
MAX	33	36	36	415	225	350	202	37	44	37	39	471
MIN	32	32	35	35	104	104	35	32	33	33	33	34

Appendix Ic. Daily mean discharge at the Apopka-Beauclair Canal lock and dam, October 1986 through September 1990

[Discharge is in cubic feet per second; ---, no data]--Continued

Water year 1989 (October 1988 to September 1989)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	36	34	36	36	117	57	35	36	34	34	34	34
2	35	34	36	36	159	57	36	35	34	34	34	34
3	36	35	36	36	160	59	36	36	33	35	33	34
4	36	35	36	36	159	59	36	36	33	35	34	34
5	36	35	36	36	160	59	36	37	33	35	34	34
6	36	35	36	36	158	58	35	35	33	35	33	34
7	35	35	36	36	158	57	35	35	33	36	33	34
8	35	35	36	36	157	57	35	35	33	35	33	34
9	35	35	36	36	155	56	35	35	35	35	33	34
10	35	34	36	36	155	57	35	35	33	35	33	34
11	36	34	36	36	155	57	35	35	35	34	33	34
12	35	34	36	36	155	58	35	35	34	34	33	34
13	35	34	36	36	120	57	35	35	33	34	34	34
14	35	34	36	36	58	57	35	35	34	34	34	34
15	35	34	36	36	58	57	36	35	33	34	34	34
16	35	34	36	36	58	57	36	35	33	34	34	34
17	35	34	36	36	58	57	36	35	33	34	34	34
18	35	34	36	36	58	58	36	35	33	34	34	34
19	35	34	36	36	58	58	36	35	33	34	34	34
20	35	34	36	36	58	57	36	34	36	34	34	34
21	35	34	36	36	58	57	36	34	33	34	34	33
22	35	55	36	37	57	57	36	34	33	34	34	34
23	35	99	36	37	56	58	36	34	35	34	34	34
24	35	101	36	38	56	57	36	34	34	34	34	35
25	35	102	36	38	57	57	36	34	35	34	34	35
26	35	103	36	38	57	57	35	34	34	34	34	35
27	35	103	36	38	57	57	35	34	34	34	34	35
28	35	62	36	38	57	45	35	34	35	34	34	35
29	35	36	36	38	---	36	35	34	33	34	34	35
30	34	36	36	38	---	36	36	34	34	34	34	35
31	34	---	37	39	---	35	---	34	---	34	34	---
TOTAL	1089	1418	1117	1135	2829	1701	1066	1078	1011	1063	1046	1026
MEAN	35.1	47.3	36.0	36.6	101	54.9	35.5	34.8	33.7	34.3	33.7	34.2
MAX	36	103	37	39	160	59	36	37	36	36	34	35
MIN	34	34	36	36	56	35	35	34	33	34	33	33

Water year 1990 (October 1989 to September 1990)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	35	34	33	35	35	36	35	33	30	32	33	34
2	35	34	33	35	35	36	35	33	30	31	33	34
3	35	34	32	35	35	36	34	33	30	31	34	34
4	35	34	33	35	35	36	34	33	31	31	33	34
5	35	34	33	36	34	36	34	32	31	31	34	34
6	35	34	33	35	35	36	34	32	31	31	33	33
7	35	34	33	35	34	36	34	32	31	31	33	33
8	35	34	33	35	34	36	34	32	31	31	34	34
9	35	34	33	35	35	36	34	32	31	31	34	33
10	35	34	33	35	35	37	34	32	31	31	34	33
11	35	34	34	35	35	36	34	31	31	31	34	33
12	35	34	34	35	35	35	33	32	32	31	34	33
13	35	34	33	35	35	35	34	32	32	33	34	33
14	35	34	33	35	35	35	34	31	31	33	34	33
15	35	34	34	35	35	36	34	31	31	33	34	33
16	35	33	33	35	35	36	33	31	31	33	34	33
17	35	33	33	35	35	36	33	31	31	33	34	33
18	35	33	34	35	36	35	33	31	31	33	34	33
19	34	33	34	35	35	35	33	31	31	33	34	32
20	33	33	34	35	35	34	33	31	31	33	34	32
21	34	33	34	35	35	34	33	31	31	33	34	32
22	34	33	34	35	35	35	33	30	31	33	34	32
23	34	33	34	35	36	35	33	30	31	33	34	32
24	34	33	34	35	35	35	33	31	31	33	34	32
25	34	34	35	35	36	34	33	31	31	33	34	32
26	34	33	35	34	36	34	33	31	32	33	34	32
27	34	33	35	35	36	34	33	30	32	33	34	32
28	33	33	35	35	36	34	33	30	32	33	34	32
29	33	33	35	35	---	34	33	30	32	33	34	32
30	34	33	35	35	---	35	33	30	32	33	34	34
31	34	---	35	35	---	35	---	30	---	33	34	---
TOTAL	1069	1006	1046	1085	983	1093	1006	970	934	1000	1049	986
MEAN	34.5	33.5	33.7	35.0	35.1	35.3	33.5	31.3	31.1	32.3	33.8	32.9
MAX	35	34	35	36	36	37	35	33	32	33	34	34
MIN	33	33	32	34	34	34	33	30	30	31	33	32

Appendix Id. Daily mean water temperature at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Temperature is in degrees Celsius; ---, no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1988 (October 1987 to 1988)												
1	---	---	---	---	---	---	---	---	---	---	33.8	32.2
2	---	---	---	---	---	---	---	---	---	---	33.5	31.3
3	---	---	---	---	---	---	---	---	---	---	32.5	31.0
4	---	---	---	---	---	---	---	---	---	---	33.2	31.7
5	---	---	---	---	---	---	---	---	---	---	33.4	31.0
6	---	---	---	---	---	---	---	---	---	---	33.5	28.4
7	---	---	---	---	---	---	---	---	---	---	33.4	27.4
8	---	---	---	---	---	---	---	---	---	---	33.0	27.6
9	---	---	---	---	---	---	---	---	---	---	33.0	---
10	---	---	---	---	---	---	---	---	---	---	33.3	30.1
11	---	---	---	---	---	---	---	---	---	---	32.8	30.4
12	---	---	---	---	---	---	---	---	---	---	32.4	29.3
13	---	---	---	---	---	---	---	---	---	---	31.8	29.1
14	---	---	---	---	---	---	---	---	---	---	31.4	28.9
15	---	---	---	---	---	---	---	---	---	31.0	31.4	29.1
16	---	---	---	---	---	---	---	---	---	31.7	31.8	31.3
17	---	---	---	---	---	---	---	---	---	32.9	31.4	30.1
18	---	---	---	---	---	---	---	---	---	32.4	31.9	31.1
19	---	---	---	---	---	---	---	---	---	32.6	33.1	30.4
20	---	---	---	---	---	---	---	---	---	31.9	33.1	30.2
21	---	---	---	---	---	---	---	---	---	31.8	32.7	30.2
22	---	---	---	---	---	---	---	---	---	31.8	32.7	30.2
23	---	---	---	---	---	---	---	---	---	31.2	32.7	30.3
24	---	---	---	---	---	---	---	---	---	30.3	32.8	29.8
25	---	---	---	---	---	---	---	---	---	29.9	32.8	29.9
26	---	---	---	---	---	---	---	---	---	30.2	32.5	29.6
27	---	---	---	---	---	---	---	---	---	31.2	31.6	29.3
28	---	---	---	---	---	---	---	---	---	31.5	30.9	28.8
29	---	---	---	---	---	---	---	---	---	32.0	31.9	28.4
30	---	---	---	---	---	---	---	---	---	32.5	32.4	27.9
31	---	---	---	---	---	---	---	---	---	33.2	32.5	---
MEAN	---	---	---	---	---	---	---	---	---	---	32.6	---
MAX	---	---	---	---	---	---	---	---	---	---	33.8	---
MIN	---	---	---	---	---	---	---	---	---	---	30.9	---
Water year 1989 (October 1988 to September 1989)												
1	27.1	25.0	---	20.3	20.3	14.3	23.8	25.1	31.0	30.9	30.8	32.2
2	27.1	23.6	---	20.5	21.7	15.5	22.8	24.7	31.4	30.9	31.1	32.0
3	29.4	22.3	---	20.4	22.8	15.9	23.7	24.3	31.3	30.9	30.9	32.1
4	28.6	22.6	---	19.4	23.2	17.4	24.0	24.7	31.0	30.4	31.1	31.5
5	28.3	22.9	---	17.5	23.7	19.2	23.9	26.0	29.7	30.0	31.0	30.3
6	27.3	22.6	---	16.9	23.7	20.3	23.4	25.9	28.5	30.3	31.9	30.1
7	26.4	22.5	---	18.0	24.0	19.1	22.2	24.9	26.9	29.9	32.1	30.1
8	24.9	22.8	---	18.6	24.1	16.4	22.0	24.2	26.2	30.5	31.6	30.0
9	23.6	22.4	---	19.6	22.0	12.8	22.9	23.9	26.7	31.1	31.0	29.9
10	23.4	---	---	19.9	19.1	11.0	24.2	23.5	27.6	31.5	30.5	29.7
11	22.5	22.4	---	20.2	17.0	11.1	23.0	23.5	28.7	31.2	30.6	29.9
12	21.8	22.9	---	20.8	16.5	12.2	21.0	22.7	29.9	30.9	29.9	30.0
13	21.9	23.5	---	21.4	17.1	14.1	20.8	23.0	30.2	30.6	28.5	29.6
14	21.4	23.8	---	21.8	18.6	16.3	21.9	24.8	30.6	30.1	28.2	28.9
15	20.9	23.9	---	22.1	20.4	17.7	21.7	25.8	30.8	30.2	28.9	28.5
16	21.1	24.4	---	22.4	21.6	20.6	22.7	27.8	30.4	30.8	29.8	28.7
17	21.7	24.5	---	21.6	22.6	23.1	23.6	28.5	30.0	31.2	30.1	28.0
18	22.3	24.8	---	20.7	21.8	23.6	24.2	28.7	29.8	31.0	30.9	27.9
19	22.8	25.0	---	19.7	20.9	24.5	24.7	27.9	30.0	30.4	30.7	28.1
20	23.0	25.3	10.7	19.5	20.8	25.1	25.4	28.3	29.6	30.4	30.2	27.1
21	23.9	25.0	11.6	18.4	21.6	25.0	24.4	28.2	30.3	31.4	30.1	26.0
22	23.5	25.7	12.9	16.9	21.7	24.5	23.9	28.5	30.4	31.0	31.0	25.7
23	22.7	23.5	13.8	14.9	16.8	23.9	23.5	28.4	31.3	30.6	31.3	25.5
24	22.7	21.1	15.0	14.5	10.6	22.7	24.8	28.7	31.2	30.1	31.8	25.1
25	22.8	20.3	15.6	15.1	9.6	22.3	25.1	29.1	30.1	30.1	32.0	28.7
26	22.1	20.8	15.2	16.1	9.3	23.1	25.1	29.2	31.0	29.7	31.8	30.2
27	22.6	21.8	14.7	17.3	10.3	24.4	25.8	30.3	31.6	29.5	32.0	32.1
28	23.4	21.8	16.2	17.9	12.4	25.5	26.1	31.3	30.3	30.3	32.1	---
29	24.5	19.6	18.6	18.9	---	25.8	25.9	30.8	30.2	30.8	32.7	---
30	25.1	---	19.1	19.5	---	25.5	26.0	31.3	30.1	31.0	32.3	26.0
31	25.1	---	19.4	19.8	---	25.4	---	30.8	---	31.0	32.4	---
MEAN	24.0	---	---	19.1	19.1	20.0	23.7	26.9	29.9	30.6	30.9	---
MAX	29.4	---	---	22.4	24.1	25.8	26.1	31.3	31.6	31.5	32.7	---
MIN	20.9	---	---	14.5	9.3	11.0	20.8	22.7	26.2	29.5	28.2	---

Appendix Id. Daily mean water temperature at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Temperature is in degrees Celsiusl; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 to September 1990)												
1	25.6	22.0	17.2	14.7	20.7	18.7	25.7	27.8	28.9	30.8	31.8	29.3
2	25.2	22.7	16.8	14.5	22.0	18.8	26.0	28.4	29.8	30.1	32.1	28.5
3	24.4	22.7	15.9	15.3	22.7	19.8	25.9	29.4	30.3	29.4	31.8	28.6
4	24.3	22.4	13.8	16.3	23.5	20.0	23.8	28.9	29.7	29.1	31.6	28.3
5	24.5	22.7	13.5	17.3	21.9	20.3	22.6	28.2	30.0	29.4	31.6	27.6
6	25.1	22.9	13.9	19.0	20.0	20.7	23.1	26.9	30.2	29.6	32.1	28.3
7	25.5	23.8	14.4	20.1	20.5	20.8	23.7	26.4	29.8	29.8	31.8	30.1
8	25.2	24.2	16.0	20.7	21.0	21.4	23.4	25.6	29.4	30.1	32.2	30.7
9	24.6	24.0	17.1	19.3	21.3	21.7	22.8	25.3	30.2	29.2	31.3	31.2
10	24.1	23.0	15.2	18.7	21.6	22.3	23.4	25.7	30.2	28.2	30.8	31.6
11	29.5	22.1	13.8	18.4	21.7	22.8	23.6	26.1	28.9	27.7	30.2	30.8
12	26.5	21.5	13.7	17.7	20.4	23.5	---	26.3	29.0	26.6	30.7	29.1
13	23.6	21.6	13.6	15.6	19.7	24.4	23.0	27.7	28.7	29.2	31.0	28.1
14	24.3	22.0	12.3	14.3	20.2	25.3	23.5	27.8	27.3	31.8	30.9	28.1
15	25.2	23.0	12.3	14.6	20.3	26.1	24.4	28.8	27.4	29.2	30.1	29.7
16	25.4	22.9	12.8	15.0	21.3	26.7	24.4	29.9	28.1	31.0	29.8	29.0
17	24.9	20.3	12.4	16.6	22.1	26.2	25.6	30.1	28.8	29.7	31.0	29.5
18	25.7	18.8	12.7	18.2	22.9	24.5	26.8	30.0	28.7	28.5	30.9	30.6
19	24.6	17.9	13.2	19.4	23.9	23.3	26.1	29.6	28.7	29.5	31.2	29.0
20	19.5	18.0	14.1	20.7	23.5	23.0	25.9	30.1	30.0	30.2	31.1	27.7
21	16.9	17.9	12.3	21.7	22.8	21.9	25.2	29.7	30.6	31.2	30.5	28.4
22	16.4	18.5	11.2	22.1	22.9	21.5	25.1	28.5	30.3	31.9	31.7	29.4
23	16.4	19.1	9.0	21.0	22.1	21.5	25.3	27.9	28.6	31.8	30.8	28.9
24	17.0	18.2	5.7	21.2	19.4	21.9	25.6	27.3	27.8	31.8	29.8	28.2
25	18.0	18.0	4.8	21.0	17.7	22.6	25.6	27.1	29.0	31.9	28.5	27.3
26	18.6	19.3	5.6	19.4	16.9	23.4	25.9	26.8	29.1	31.8	29.3	26.9
27	18.6	20.2	7.2	17.8	17.5	23.9	26.1	27.9	28.6	31.7	29.8	26.9
28	19.6	21.2	8.4	18.5	18.2	24.5	25.2	28.5	28.2	31.6	29.9	27.8
29	20.7	21.4	9.6	17.8	---	25.7	25.9	28.5	29.6	31.7	30.3	27.1
30	20.7	18.8	11.6	19.0	---	26.1	27.1	28.4	31.0	30.6	29.6	26.1
31	21.5	---	13.5	19.6	---	26.1	---	28.7	---	31.1	28.6	---
MEAN	22.6	21.0	12.4	18.2	21.0	22.9	---	28.0	29.2	30.2	30.7	28.8
MAX	29.5	24.2	17.2	22.1	23.9	26.7	---	30.1	31.0	31.9	32.2	31.6
MIN	16.4	17.9	4.8	14.3	16.9	18.7	---	25.3	27.3	26.6	28.5	26.1

Appendix Ie. Daily mean specific conductance of water at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Specific conductance is in microsiemens per centimeter at 25 °C: ---, no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1988 (October 1987 to September 1988)												
1	---	---	---	---	---	---	---	---	---	---	487	442
2	---	---	---	---	---	---	---	---	---	---	485	401
3	---	---	---	---	---	---	---	---	---	---	512	412
4	---	---	---	---	---	---	---	---	---	---	467	445
5	---	---	---	---	---	---	---	---	---	---	463	454
6	---	---	---	---	---	---	---	---	---	---	463	452
7	---	---	---	---	---	---	---	---	---	---	434	471
8	---	---	---	---	---	---	---	---	---	---	445	191
9	---	---	---	---	---	---	---	---	---	---	471	---
10	---	---	---	---	---	---	---	---	---	---	467	408
11	---	---	---	---	---	---	---	---	---	---	450	374
12	---	---	---	---	---	---	---	---	---	---	449	383
13	---	---	---	---	---	---	---	---	---	---	434	386
14	---	---	---	---	---	---	---	---	---	---	443	380
15	---	---	---	---	---	---	---	---	---	475	423	399
16	---	---	---	---	---	---	---	---	---	514	405	391
17	---	---	---	---	---	---	---	---	---	460	417	382
18	---	---	---	---	---	---	---	---	---	459	434	394
19	---	---	---	---	---	---	---	---	---	507	416	385
20	---	---	---	---	---	---	---	---	---	452	419	401
21	---	---	---	---	---	---	---	---	---	522	453	429
22	---	---	---	---	---	---	---	---	---	475	469	440
23	---	---	---	---	---	---	---	---	---	499	465	447
24	---	---	---	---	---	---	---	---	---	535	449	442
25	---	---	---	---	---	---	---	---	---	541	419	421
26	---	---	---	---	---	---	---	---	---	554	440	412
27	---	---	---	---	---	---	---	---	---	534	433	428
28	---	---	---	---	---	---	---	---	---	520	441	465
29	---	---	---	---	---	---	---	---	---	527	459	440
30	---	---	---	---	---	---	---	---	---	538	444	420
31	---	---	---	---	---	---	---	---	---	511	461	---
MEAN	---	---	---	---	---	---	---	---	---	---	449	---
MAX	---	---	---	---	---	---	---	---	---	---	512	---
MIN	---	---	---	---	---	---	---	---	---	---	405	---
Water year 1989 (October 1988 to September 1989)												
1	447	436	---	394	420	386	414	424	435	530	524	450
2	407	458	---	393	406	427	397	451	449	549	494	437
3	406	485	---	419	396	406	384	427	444	591	535	414
4	445	485	---	425	391	381	394	---	444	578	508	432
5	467	497	---	408	386	401	403	---	433	563	491	486
6	434	497	---	410	388	412	435	---	434	601	436	426
7	421	457	---	402	381	405	400	---	443	569	494	460
8	431	387	---	394	390	390	390	---	421	525	465	514
9	432	397	---	374	396	421	387	---	469	498	502	495
10	440	---	---	389	372	392	399	---	439	465	555	494
11	445	390	---	396	372	383	400	---	436	501	513	461
12	465	380	---	391	373	384	415	---	471	517	502	446
13	457	357	---	406	367	395	429	---	477	551	432	514
14	438	381	---	422	387	401	395	---	442	490	422	465
15	473	388	---	410	406	402	382	---	458	441	475	436
16	500	386	---	411	411	383	397	---	489	464	567	415
17	495	370	---	405	411	391	418	403	448	450	498	444
18	493	357	---	402	429	385	390	407	506	508	473	477
19	498	364	---	401	424	377	398	416	458	495	521	488
20	508	381	379	395	408	390	397	418	488	533	465	415
21	528	366	394	406	400	389	394	421	433	490	483	434
22	540	383	385	417	433	383	428	419	400	486	491	435
23	523	382	370	440	445	385	389	416	515	443	515	463
24	430	380	386	497	383	424	386	409	537	533	481	542
25	431	411	397	498	390	393	380	425	507	556	467	550
26	439	380	380	454	387	390	384	431	474	546	504	546
27	442	388	411	446	389	387	390	423	524	569	506	595
28	456	381	407	436	397	386	399	425	578	512	438	---
29	478	407	395	419	---	386	402	433	541	540	462	505
30	452	---	387	437	---	391	405	434	575	482	444	523
31	427	---	406	430	---	387	---	437	---	458	424	---
MEAN	460	---	---	417	398	394	399	---	472	517	487	---
MAX	540	---	---	498	445	427	435	---	578	601	567	---
MIN	406	---	---	374	367	377	380	---	400	441	422	---

Appendix Ie. Daily mean specific conductance of water at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Specific conductance is in microsiemens per centimeter at 25 °C; ---, no data--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 to September 1990)												
1	475	411	418	461	464	490	495	419	409	509	451	404
2	507	407	412	476	444	458	491	408	414	457	464	387
3	437	412	431	442	471	462	475	412	411	440	434	408
4	446	414	419	413	466	486	482	411	424	431	417	372
5	422	406	414	407	472	452	470	411	408	432	406	390
6	393	427	412	464	487	450	458	411	406	425	414	404
7	392	411	426	445	445	450	456	408	408	417	410	417
8	424	410	425	511	442	457	459	397	411	395	403	415
9	400	414	452	488	438	462	455	398	412	383	436	422
10	425	427	440	438	435	449	452	399	414	374	403	429
11	397	404	426	452	458	459	438	411	412	364	418	428
12	393	415	417	455	497	455	---	396	408	353	431	443
13	399	397	413	467	492	444	467	397	435	398	421	430
14	381	401	432	484	456	449	442	404	429	489	415	413
15	376	402	406	469	461	452	438	399	435	532	463	447
16	382	415	392	477	443	449	442	402	417	696	479	441
17	394	424	411	501	450	450	441	406	399	651	470	425
18	430	401	411	499	464	464	428	408	416	560	472	433
19	419	411	445	497	461	493	428	405	464	591	491	439
20	426	399	424	485	452	457	420	409	475	566	443	414
21	398	400	439	470	492	458	431	413	440	538	417	414
22	383	427	411	473	470	449	440	412	410	546	432	416
23	383	404	423	485	453	447	425	410	423	548	434	443
24	432	453	484	484	471	446	446	409	501	563	447	435
25	391	417	451	492	496	447	447	413	507	512	413	421
26	425	424	416	505	520	450	421	411	478	514	401	410
27	415	435	482	498	462	451	415	411	528	448	411	410
28	429	412	449	455	446	454	404	412	587	415	406	413
29	411	416	432	462	---	456	430	414	571	427	408	414
30	395	431	487	457	---	460	434	414	500	437	387	442
31	399	---	480	470	---	471	---	408	---	460	405	---
MEAN	412	414	432	470	465	457	---	408	445	480	429	419
MAX	507	453	487	511	520	493	---	419	587	696	491	447
MIN	376	397	392	407	435	444	---	396	399	353	387	372

Appendix If. Daily mean dissolved oxygen concentration in water at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Dissolved oxygen concentration is in milligrams per liter; ---, no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1988 (October 1987 to September 1988)												
1	---	---	---	---	---	---	---	---	---	---	2.1	---
2	---	---	---	---	---	---	---	---	---	---	2.1	---
3	---	---	---	---	---	---	---	---	---	---	1.9	---
4	---	---	---	---	---	---	---	---	---	---	1.7	---
5	---	---	---	---	---	---	---	---	---	---	1.6	---
6	---	---	---	---	---	---	---	---	---	---	1.5	---
7	---	---	---	---	---	---	---	---	---	---	1.3	---
8	---	---	---	---	---	---	---	---	---	---	1.0	---
9	---	---	---	---	---	---	---	---	---	---	.9	---
10	---	---	---	---	---	---	---	---	---	---	.8	---
11	---	---	---	---	---	---	---	---	---	---	.8	---
12	---	---	---	---	---	---	---	---	---	---	1.0	4.0
13	---	---	---	---	---	---	---	---	---	---	1.3	8.6
14	---	---	---	---	---	---	---	---	---	---	1.3	8.1
15	---	---	---	---	---	---	---	---	---	2.8	.8	7.3
16	---	---	---	---	---	---	---	---	---	4.6	1.1	7.4
17	---	---	---	---	---	---	---	---	---	5.1	1.2	7.4
18	---	---	---	---	---	---	---	---	---	3.7	1.2	7.2
19	---	---	---	---	---	---	---	---	---	2.8	---	5.5
20	---	---	---	---	---	---	---	---	---	3.1	---	3.7
21	---	---	---	---	---	---	---	---	---	2.6	---	2.8
22	---	---	---	---	---	---	---	---	---	3.0	---	1.9
23	---	---	---	---	---	---	---	---	---	2.1	---	1.8
24	---	---	---	---	---	---	---	---	---	1.1	---	1.7
25	---	---	---	---	---	---	---	---	---	1.1	---	1.9
26	---	---	---	---	---	---	---	---	---	2.2	---	2.1
27	---	---	---	---	---	---	---	---	---	2.9	---	1.6
28	---	---	---	---	---	---	---	---	---	2.5	---	1.1
29	---	---	---	---	---	---	---	---	---	1.9	---	1.5
30	---	---	---	---	---	---	---	---	---	2.2	---	2.6
31	---	---	---	---	---	---	---	---	---	2.3	---	---
MEAN	---	---	---	---	---	---	---	---	---	---	---	---
MAX	---	---	---	---	---	---	---	---	---	---	---	---
MIN	---	---	---	---	---	---	---	---	---	---	---	---
Water year 1989 (October 1988 to September 1989)												
1	4.0	5.3	---	7.1	6.1	9.0	6.0	4.0	5.9	1.3	3.0	2.2
2	5.2	4.9	---	6.5	7.0	7.0	7.1	4.9	5.6	1.4	2.9	2.4
3	5.3	5.6	---	5.1	7.2	6.7	8.5	6.4	5.5	2.9	3.1	2.4
4	2.6	5.9	---	4.8	6.9	7.0	8.1	6.3	5.2	2.5	3.0	2.0
5	2.8	6.5	---	5.6	7.1	8.8	5.9	7.1	4.7	3.2	3.1	1.5
6	3.6	6.1	---	6.6	6.7	8.7	5.3	7.3	3.6	3.3	3.8	1.8
7	5.1	6.5	---	8.2	7.1	6.4	6.1	6.4	2.8	2.2	2.9	1.6
8	6.5	7.0	---	8.8	5.8	5.6	6.3	7.5	4.4	4.5	3.4	2.2
9	6.7	8.8	---	8.8	6.0	6.3	7.5	7.5	3.2	4.8	1.9	3.9
10	6.7	---	---	8.4	7.8	9.0	8.5	6.5	6.1	5.4	---	3.4
11	7.0	---	---	7.3	7.7	9.9	6.3	7.0	7.6	1.5	2.5	4.8
12	6.2	3.0	---	7.0	9.2	11.8	5.0	6.6	4.2	1.8	2.5	3.9
13	7.3	9.2	---	6.6	10.0	12.7	7.0	7.8	3.1	1.5	1.6	3.4
14	7.4	9.4	---	5.7	9.4	11.8	9.5	8.8	5.8	2.4	1.4	4.0
15	7.3	8.3	---	6.0	8.5	11.6	6.9	8.0	4.7	3.8	1.6	4.2
16	8.2	7.8	---	5.7	7.8	12.3	6.6	7.3	4.0	4.3	2.5	3.2
17	6.7	6.7	---	5.4	6.8	11.5	7.0	7.4	4.9	3.4	3.9	2.0
18	6.6	6.1	---	5.5	5.2	9.1	7.4	6.8	3.7	3.0	4.1	2.0
19	7.1	5.6	---	6.4	5.5	8.4	7.6	4.8	4.2	3.9	3.7	2.6
20	7.6	4.8	9.4	6.9	6.2	7.8	7.4	6.3	2.5	5.2	2.0	3.0
21	7.1	4.2	5.0	6.2	7.1	7.1	5.1	5.4	4.2	5.2	2.6	3.4
22	6.3	3.3	8.7	5.8	5.3	6.6	5.3	5.8	5.1	---	3.3	3.7
23	5.4	4.0	8.0	4.9	5.5	6.1	7.2	5.7	1.8	---	4.0	2.3
24	6.1	3.9	2.8	5.5	8.5	5.4	8.9	5.8	1.8	---	5.1	1.1
25	5.7	4.3	9.4	6.5	8.9	6.3	8.7	5.6	2.6	---	4.8	.9
26	5.7	6.6	7.7	7.7	10.4	8.3	7.8	4.8	4.4	---	2.9	1.3
27	6.5	7.2	7.1	7.8	11.0	9.4	7.7	5.8	5.6	---	2.9	1.1
28	7.0	7.3	8.4	7.7	10.8	9.2	7.3	5.3	2.7	4.2	2.4	---
29	6.9	6.5	7.6	7.2	---	8.5	6.4	3.7	1.1	4.2	3.0	---
30	7.0	---	7.3	6.6	---	6.6	5.5	5.0	2.0	4.4	2.9	3.8
31	5.7	---	7.2	6.2	---	5.9	---	5.4	---	3.4	2.8	---
MEAN	6.1	---	---	6.6	7.6	8.4	7.0	6.2	4.1	---	---	---
MAX	8.2	---	---	8.8	11.0	12.7	9.5	8.8	7.6	---	---	---
MIN	2.6	---	---	4.8	5.2	5.4	5.0	3.7	1.1	---	---	---

Appendix If. Daily mean dissolved oxygen concentration in water at the Apopka-Beauclair Canal lock and dam, October 1987 through September 1990

[Dissolved oxygen concentration is in milligrams per liter; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 to September 1990)												
1	3.5	6.0	7.5	7.1	5.8	7.1	3.9	8.5	8.3	4.6	4.3	3.0
2	2.6	6.7	8.2	6.8	6.7	7.3	5.2	9.2	7.9	4.5	4.2	3.8
3	3.3	6.9	7.7	7.5	5.3	7.1	5.6	9.2	6.0	3.1	3.7	3.7
4	3.6	7.0	8.5	7.5	5.3	6.8	6.5	9.0	4.5	4.3	3.5	4.8
5	3.6	7.9	8.9	5.9	5.4	7.9	6.8	8.4	5.2	5.1	4.8	5.0
6	4.2	6.7	9.1	6.4	5.0	8.2	9.2	7.9	5.9	5.7	5.2	5.4
7	3.8	7.7	9.1	7.6	6.6	7.5	8.9	7.6	5.5	6.1	5.1	5.2
8	3.3	7.2	9.1	4.3	7.2	7.2	9.3	8.3	5.6	6.3	5.1	5.7
9	2.8	5.8	7.3	4.7	7.7	7.5	8.7	8.3	6.0	4.8	4.2	5.9
10	2.7	5.0	7.3	4.6	7.1	9.0	8.9	7.8	7.5	5.4	5.2	5.7
11	2.7	6.2	7.8	4.5	4.5	9.9	8.3	7.1	6.2	5.8	4.7	4.8
12	3.3	6.5	8.2	7.6	3.3	11.2	---	8.8	6.3	4.3	5.3	4.3
13	3.9	7.5	8.9	8.7	4.1	10.8	7.2	8.2	5.5	3.2	6.4	4.6
14	4.4	7.8	8.4	10.0	5.6	9.3	8.4	7.0	6.9	1.9	4.2	5.3
15	4.2	8.1	7.9	9.2	6.1	6.8	9.4	7.3	7.6	2.5	1.7	4.9
16	4.1	6.7	7.7	8.3	6.5	4.9	8.8	6.7	7.6	2.6	2.2	5.0
17	4.5	5.9	8.4	7.9	6.2	4.7	9.3	5.9	7.2	4.4	3.4	5.0
18	4.4	7.2	8.6	6.6	5.7	4.0	9.4	6.1	5.2	7.0	3.0	5.2
19	2.5	7.6	8.0	6.2	5.9	5.0	7.5	6.7	4.5	7.2	2.8	5.4
20	3.9	8.0	8.0	5.7	4.8	6.2	7.2	7.0	6.8	7.3	3.2	6.0
21	6.1	8.7	7.3	5.0	4.3	7.2	6.9	7.4	7.0	6.4	4.1	6.5
22	6.8	8.4	7.7	4.0	4.4	7.4	8.0	7.3	5.8	5.2	3.6	6.8
23	7.0	8.4	7.9	2.9	3.6	7.8	8.4	6.9	3.7	4.7	2.5	5.3
24	7.0	6.9	9.2	4.4	3.7	9.1	7.1	7.4	3.0	4.7	2.3	5.1
25	8.2	7.3	10.6	4.9	4.2	9.4	7.1	8.0	5.0	4.6	3.3	5.7
26	7.5	6.8	10.9	4.6	5.4	9.2	8.1	8.0	5.4	3.7	3.6	6.6
27	7.1	6.6	9.3	4.9	6.5	8.6	8.5	7.3	4.0	3.2	3.7	6.8
28	7.2	8.0	9.8	6.4	6.8	7.5	6.7	6.7	4.1	3.7	3.1	6.3
29	7.1	7.5	9.7	6.4	---	7.1	6.4	6.5	6.2	4.0	3.0	5.5
30	6.8	6.2	7.6	6.7	---	6.0	7.7	6.8	6.0	4.0	3.4	4.5
31	6.3	---	7.3	5.9	---	4.4	---	8.2	---	5.2	2.8	---
MEAN	4.8	7.1	8.4	6.2	5.5	7.5	---	7.6	5.9	4.7	3.8	5.3
MAX	8.2	8.7	10.9	10.0	7.7	11.2	---	9.2	8.3	7.3	6.4	6.8
MIN	2.5	5.0	7.3	2.9	3.3	4.0	---	5.9	3.0	1.9	1.7	3.0

Appendix IIa. Daily mean gage height at the Lake Apopka outflow site, August 1988 through September 1990
[Gage height is in feet above datum; Datum is 20.68 feet above sea level; ---, no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1988 (October 1987 to September 1988)												
1	---	---	---	---	---	---	---	---	---	---	---	45.92
2	---	---	---	---	---	---	---	---	---	---	---	46.04
3	---	---	---	---	---	---	---	---	---	---	---	46.06
4	---	---	---	---	---	---	---	---	---	---	---	46.08
5	---	---	---	---	---	---	---	---	---	---	45.70	46.15
6	---	---	---	---	---	---	---	---	---	---	45.71	46.44
7	---	---	---	---	---	---	---	---	---	---	45.70	46.47
8	---	---	---	---	---	---	---	---	---	---	45.72	46.51
9	---	---	---	---	---	---	---	---	---	---	45.71	46.51
10	---	---	---	---	---	---	---	---	---	---	45.72	46.50
11	---	---	---	---	---	---	---	---	---	---	45.79	46.46
12	---	---	---	---	---	---	---	---	---	---	45.76	46.47
13	---	---	---	---	---	---	---	---	---	---	45.72	---
14	---	---	---	---	---	---	---	---	---	---	45.74	---
15	---	---	---	---	---	---	---	---	---	---	45.80	46.44
16	---	---	---	---	---	---	---	---	---	---	45.79	46.43
17	---	---	---	---	---	---	---	---	---	---	45.76	46.37
18	---	---	---	---	---	---	---	---	---	---	45.78	46.37
19	---	---	---	---	---	---	---	---	---	---	45.79	46.38
20	---	---	---	---	---	---	---	---	---	---	45.77	46.39
21	---	---	---	---	---	---	---	---	---	---	45.75	46.35
22	---	---	---	---	---	---	---	---	---	---	45.73	46.35
23	---	---	---	---	---	---	---	---	---	---	45.72	46.35
24	---	---	---	---	---	---	---	---	---	---	45.69	46.32
25	---	---	---	---	---	---	---	---	---	---	45.67	46.28
26	---	---	---	---	---	---	---	---	---	---	45.69	46.27
27	---	---	---	---	---	---	---	---	---	---	45.74	46.29
28	---	---	---	---	---	---	---	---	---	---	45.86	46.26
29	---	---	---	---	---	---	---	---	---	---	45.86	46.26
30	---	---	---	---	---	---	---	---	---	---	45.87	46.26
31	---	---	---	---	---	---	---	---	---	---	45.86	---
MEAN	---	---	---	---	---	---	---	---	---	---	---	---
MAX	---	---	---	---	---	---	---	---	---	---	---	---
MIN	---	---	---	---	---	---	---	---	---	---	---	---
Water year 1989 (October 1988 to September 1989)												
1	46.25	45.99	46.36	46.46	46.73	---	46.18	46.37	45.86	45.85	45.87	45.89
2	46.23	45.99	46.36	46.45	46.72	---	46.27	46.25	45.84	45.91	45.84	45.91
3	46.31	46.04	46.36	46.40	46.71	46.47	46.26	46.28	45.80	46.04	45.81	45.92
4	46.35	46.12	46.36	46.38	46.69	46.48	46.25	46.31	45.76	46.07	45.84	45.88
5	46.32	46.06	46.35	46.43	46.71	46.51	46.28	46.30	45.74	46.08	45.82	45.86
6	46.28	46.05	46.37	46.45	46.70	46.50	46.19	46.21	45.72	46.10	45.79	45.86
7	46.22	46.04	46.38	46.43	46.68	46.42	46.19	46.12	45.72	46.10	45.75	45.91
8	46.21	46.04	46.38	46.42	46.63	46.37	46.23	46.16	45.75	46.09	45.77	45.91
9	46.23	46.04	46.38	46.42	46.56	46.29	46.22	46.16	45.83	46.07	45.76	45.92
10	46.23	46.02	46.38	46.40	46.54	46.35	46.19	46.11	45.80	46.04	45.74	45.92
11	46.24	46.01	46.40	46.40	46.53	46.38	46.13	46.09	45.81	46.00	45.74	45.93
12	46.21	46.00	46.37	46.42	46.52	46.39	46.12	46.10	45.82	45.98	45.77	45.92
13	46.17	46.01	46.40	46.42	46.54	46.40	46.12	46.11	45.77	45.96	45.91	45.90
14	46.15	45.99	46.46	46.42	46.55	46.41	46.16	46.11	45.79	45.97	45.91	---
15	46.15	45.98	46.46	46.41	46.54	46.40	46.26	46.08	45.77	45.96	45.90	---
16	46.16	45.99	46.44	46.38	46.54	46.41	46.36	46.07	45.75	45.94	45.88	45.88
17	46.14	45.97	46.38	46.38	46.50	46.41	46.39	46.06	45.74	45.93	45.89	45.91
18	46.15	45.98	46.39	46.37	46.47	46.41	46.37	46.07	45.70	45.93	45.89	45.88
19	46.14	46.00	46.44	46.38	46.48	46.37	46.36	46.04	45.69	45.93	45.89	45.87
20	46.15	45.98	46.44	46.36	46.51	46.39	46.34	46.00	45.69	45.96	45.96	45.86
21	46.12	45.95	46.44	46.42	46.53	46.37	46.29	45.96	45.67	45.97	45.96	45.78
22	46.08	45.95	46.45	46.55	46.43	46.36	46.30	45.93	45.78	45.96	45.96	45.84
23	46.09	46.21	46.45	46.65	46.23	46.42	46.31	45.90	45.82	45.99	45.97	45.98
24	46.08	46.36	46.46	46.72	46.29	46.31	46.29	45.88	45.87	45.99	45.95	46.08
25	46.05	46.42	46.46	46.73	46.37	46.32	46.26	45.86	45.88	45.96	45.91	46.13
26	46.06	46.46	46.46	46.74	46.39	46.33	46.23	45.87	45.87	45.93	45.90	46.18
27	46.07	46.46	46.47	46.73	46.41	46.36	46.22	45.87	45.87	45.92	45.88	46.18
28	46.05	46.37	46.47	46.74	46.40	46.35	46.18	45.86	45.84	45.89	45.90	46.20
29	46.04	46.39	46.47	46.74	---	46.33	46.21	45.86	45.81	45.88	45.89	46.21
30	46.01	46.40	46.46	46.75	---	46.34	46.26	45.88	45.79	45.88	45.87	46.24
31	46.02	---	46.47	46.74	---	46.23	---	45.87	---	45.90	45.85	---
MEAN	46.16	46.11	46.42	46.51	46.53	---	46.25	46.06	45.78	45.97	45.86	---
MAX	46.35	46.46	46.47	46.75	46.73	---	46.39	46.37	45.88	46.10	45.97	---
MIN	46.01	45.95	46.35	46.36	46.23	---	46.12	45.86	45.67	45.85	45.74	---

Appendix IIa. Daily mean gage height at the Lake Apopka outflow site, August 1988 through September 1990

[Gage height is in feet above datum; Datum is 20.68 feet above sea level; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Auag.	Sep.
Water year 1990 (October 1989 to September 1990)												
1	46.21	45.93	45.75	46.08	46.10	46.34	46.07	45.65	45.13	45.45	45.75	45.94
2	46.15	45.91	45.75	46.09	46.11	46.34	46.06	45.67	45.10	45.39	45.74	45.89
3	46.13	45.89	45.64	46.11	46.11	46.28	45.97	45.72	45.22	45.42	45.76	45.90
4	46.14	45.89	45.67	46.11	46.11	46.29	45.92	45.70	45.29	45.43	45.82	45.88
5	46.15	45.89	45.71	46.17	45.96	46.29	45.99	45.58	45.28	45.38	45.83	45.86
6	46.15	45.89	45.72	46.19	46.05	46.28	45.98	45.51	45.29	45.34	45.81	45.83
7	46.15	45.90	45.72	46.22	46.03	46.30	45.95	45.50	45.30	45.38	45.81	45.83
8	46.15	45.89	45.78	46.19	46.04	46.33	45.94	45.57	45.31	45.39	45.86	45.83
9	46.11	---	45.75	46.19	46.05	46.28	45.98	45.56	45.34	45.41	45.87	45.82
10	46.12	45.84	45.81	46.18	46.06	46.26	45.95	45.48	45.35	45.37	45.87	45.80
11	46.09	45.85	45.86	46.19	46.11	46.25	45.89	45.44	45.41	45.33	45.89	45.75
12	46.09	45.84	45.89	46.15	46.11	46.24	45.84	45.48	45.46	45.40	45.91	45.75
13	46.09	45.85	45.74	46.09	46.16	46.20	45.86	45.43	45.45	45.61	45.93	45.74
14	46.09	45.84	45.81	46.15	46.17	---	45.84	45.40	45.42	45.73	45.92	45.71
15	46.08	45.84	45.83	46.16	46.17	---	45.85	45.42	45.38	45.75	45.95	45.68
16	46.09	45.80	45.82	46.18	46.17	46.28	45.82	45.43	45.37	45.73	45.96	45.68
17	46.09	45.78	45.81	46.17	46.10	46.23	45.81	45.36	45.34	45.77	45.96	45.67
18	46.06	45.78	45.87	46.17	46.13	46.12	45.79	45.34	45.39	45.80	45.95	45.65
19	45.97	45.78	45.91	46.17	46.12	46.12	45.83	45.35	45.42	45.78	45.95	45.63
20	45.82	45.77	45.94	46.19	46.07	46.04	45.83	45.31	45.39	45.77	45.96	45.62
21	45.94	45.76	45.97	46.17	46.14	46.05	45.77	45.28	45.38	45.78	45.95	45.61
22	45.93	45.80	45.95	46.14	46.20	46.06	45.74	45.23	45.36	45.82	45.93	45.58
23	45.93	45.77	45.90	46.16	46.30	46.06	45.74	45.25	45.39	45.81	45.96	45.56
24	45.88	45.78	45.94	46.16	46.25	46.05	45.80	45.27	45.40	45.81	46.00	45.53
25	45.89	45.82	46.05	46.17	46.31	46.03	45.80	45.26	45.43	45.82	46.01	45.53
26	45.89	45.81	46.07	46.02	46.32	46.01	45.77	45.26	45.47	45.81	45.98	45.54
27	45.89	45.82	46.09	46.10	46.33	45.99	45.80	45.22	45.52	---	45.96	45.53
28	45.85	45.82	46.10	46.11	46.32	45.99	45.79	45.17	45.53	45.77	45.95	45.56
29	45.78	45.76	46.10	46.10	---	46.00	45.69	45.09	45.52	45.80	45.93	45.61
30	45.89	45.71	46.11	46.11	---	46.06	45.67	45.14	45.48	45.81	45.89	45.66
31	45.93	---	46.14	46.09	---	46.12	---	45.15	---	45.78	45.91	---
MEAN	46.02	---	45.88	46.14	46.15	---	45.86	45.39	45.37	---	45.90	45.71
MAX	46.21	---	46.14	46.22	46.33	---	46.07	45.72	45.53	---	46.01	45.94
MIN	45.78	---	45.64	46.02	45.96	---	45.67	45.09	45.10	---	45.74	45.53

Appendix IIb. Daily mean discharge at the Lake Apopka outflow site, September 1988 through September 1990

[Discharge is in cubic feet per second; ---, no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1988 (October 1987 to September 1988)												
1	---	---	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	---	---	---	---
5	---	---	---	---	---	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---	---	---	---	---	---
7	---	---	---	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---	---	---	---
9	---	---	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---	---	---
11	---	---	---	---	---	---	---	---	---	---	---	---
12	---	---	---	---	---	---	---	---	---	---	---	---
13	---	---	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---	---	---
15	---	---	---	---	---	---	---	---	---	---	---	280
16	---	---	---	---	---	---	---	---	---	---	---	269
17	---	---	---	---	---	---	---	---	---	---	---	276
18	---	---	---	---	---	---	---	---	---	---	---	235
19	---	---	---	---	---	---	---	---	---	---	---	306
20	---	---	---	---	---	---	---	---	---	---	---	15
21	---	---	---	---	---	---	---	---	---	---	---	44
22	---	---	---	---	---	---	---	---	---	---	---	42
23	---	---	---	---	---	---	---	---	---	---	---	43
24	---	---	---	---	---	---	---	---	---	---	---	57
25	---	---	---	---	---	---	---	---	---	---	---	57
26	---	---	---	---	---	---	---	---	---	---	---	58
27	---	---	---	---	---	---	---	---	---	---	---	36
28	---	---	---	---	---	---	---	---	---	---	---	52
29	---	---	---	---	---	---	---	---	---	---	---	43
30	---	---	---	---	---	---	---	---	---	---	---	56
31	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL	---	---	---	---	---	---	---	---	---	---	---	---
MEAN	---	---	---	---	---	---	---	---	---	---	---	---
MAX	---	---	---	---	---	---	---	---	---	---	---	---
MIN	---	---	---	---	---	---	---	---	---	---	---	---
Water year 1989 (October 1988 to September 1989)												
1	60	39	38	40	115	---	81	48	40	-20	-18	-17
2	60	54	42	24	144	---	78	26	57	7.8	-5.4	-13
3	24	42	51	36	133	30	44	49	71	-29	6.2	-15
4	33	40	38	26	149	32	54	45	80	-45	1.8	-21
5	54	30	44	46	142	29	48	21	84	-3.2	-12	-7.0
6	69	44	56	47	146	39	87	19	74	-3.9	-24	-19
7	69	24	47	48	135	45	63	40	77	-7.8	-4.5	-29
8	58	51	52	51	143	22	61	39	69	-2.7	-1.3	-20
9	69	61	57	45	148	48	54	10	50	4.0	-4.8	-25
10	56	73	47	53	151	55	64	33	40	-21	11	-15
11	58	76	45	57	148	55	32	21	39	-18	3.3	-18
12	60	53	33	54	152	49	59	52	48	-2.4	-19	-24
13	46	57	57	46	113	53	78	64	52	4.0	-63	-25
14	77	56	43	64	52	40	105	35	68	11	-31	---
15	74	63	46	26	51	65	60	27	53	-18	-3.0	---
16	57	55	28	59	62	73	58	56	57	-35	7.7	-21
17	44	52	40	60	61	62	56	38	42	-38	14	-23
18	61	40	46	61	65	65	58	36	56	-21	17	-16
19	56	46	40	37	69	55	71	30	47	-29	17	-11
20	67	39	30	44	80	69	63	27	71	-10	20	-23
21	48	32	33	42	48	62	36	32	54	2.7	22	-13
22	66	36	36	-11	18	64	42	45	28	10	-6.3	-21
23	62	61	40	26	31	51	45	54	14	-17	-37	-22
24	59	99	37	32	34	54	63	55	-11	-8.8	-24	-21
25	64	97	38	43	3.8	57	75	42	-16	-22	-28	-16
26	65	92	32	49	-3.7	47	68	48	-31	-11	-23	-25
27	59	94	44	37	-6.6	56	64	45	-12	-2.9	-19	-22
28	61	47	44	55	14	45	57	48	-21	-2.2	-23	-5.4
29	72	52	41	40	---	36	76	44	-22	18	-18	1.3
30	73	40	34	45	---	60	46	32	-8.5	-11	-14	4.5
31	49	---	40	53	---	47	---	28	---	-8.3	-22	---
TOTAL	1830	1645	1299	1335	2397.5	---	1846	1189	1149.5	-329.7	-280.3	---
MEAN	59.0	54.8	41.9	43.1	85.6	---	61.5	38.4	38.3	-10.6	-9.04	---
MAX	77	99	57	64	152	---	105	64	84	18	22	---
MIN	24	24	28	-11	-6.6	---	32	10	-31	-45	-63	---

Appendix IIb. Daily mean discharge at the Lake Apopka outflow site, September 1988 through September 1990
[Discharge is in cubic feet per second; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 to September 1990)												
1	-8.1	79	29	23	32	24	29	25	17	22	27	26
2	-7.5	65	19	31	16	25	21	31	22	24	30	25
3	-8.3	64	17	27	22	31	27	30	20	15	43	31
4	19	61	23	29	26	34	42	28	23	25	35	29
5	17	50	27	17	37	32	40	17	22	22	29	29
6	18	44	31	26	36	32	35	24	38	21	30	30
7	21	32	36	29	46	31	33	25	36	27	39	35
8	24	-1.3	29	30	51	33	30	35	42	30	26	30
9	19	---	20	43	56	35	41	29	48	23	35	30
10	24	24	29	37	59	36	34	19	33	25	31	35
11	57	28	17	41	63	34	3.2	27	30	34	32	29
12	57	31	28	42	66	33	27	32	7.2	26	23	29
13	54	39	18	43	70	46	26	21	14	-37	32	33
14	57	39	19	42	77	---	29	35	14	-16	9.0	26
15	49	31	9.8	43	81	---	23	36	12	-13	-4.6	26
16	47	19	26	42	82	46	40	33	34	4.7	9.5	29
17	28	26	36	41	75	11	47	19	32	3.8	2.5	32
18	33	21	29	34	88	30	37	25	8.9	3.3	9.9	26
19	41	24	22	39	86	30	40	23	6.9	9.3	23	34
20	83	27	13	45	72	34	25	22	14	22	25	33
21	77	17	15	45	52	46	34	18	30	7.4	19	36
22	71	27	5.9	42	29	48	30	20	17	---	28	25
23	62	8.2	-11	52	13	39	25	18	11	---	25	30
24	67	28	3.6	63	2.4	34	25	16	18	---	23	35
25	62	27	-1.0	54	6.3	33	34	13	7.8	---	27	32
26	67	18	-10	66	10	33	36	15	16	---	27	30
27	65	26	5.0	47	21	32	36	13	-17	---	27	34
28	77	29	13	48	23	36	10	14	2.0	36	27	30
29	74	23	7.8	46	---	34	10	8.8	17	28	24	31
30	75	29	16	28	---	31	20	15	10	33	29	14
31	80	---	21	41	---	2.8	---	15	---	25	29	---
TOTAL	1401.1	---	543.1	1236	1297.7	---	889.2	701.8	585.8	---	771.3	894
MEAN	45.2	---	17.5	39.9	46.3	---	29.6	22.6	19.5	---	24.9	29.8
MAX	83	---	36	66	88	---	47	36	48	---	43	36
MIN	-8.3	---	-11	17	2.4	---	3.2	8.8	-17	---	-4.6	14

Appendix IIc. Daily mean water temperature at the Lake Apopka outflow site, August 1988 through September 1990

[Temperature is in degrees Celsius; ---, no data]

Water year 1988 (October 1987 through September 1988)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	---	---	---	---	---	---	---	---	---	---	---	29.5
2	---	---	---	---	---	---	---	---	---	---	---	29.2
3	---	---	---	---	---	---	---	---	---	---	---	29.9
4	---	---	---	---	---	---	---	---	---	---	---	29.8
5	---	---	---	---	---	---	---	---	---	---	32.1	28.0
6	---	---	---	---	---	---	---	---	---	---	32.1	25.8
7	---	---	---	---	---	---	---	---	---	---	31.5	24.9
8	---	---	---	---	---	---	---	---	---	---	31.2	24.9
9	---	---	---	---	---	---	---	---	---	---	30.9	26.2
10	---	---	---	---	---	---	---	---	---	---	30.7	28.3
11	---	---	---	---	---	---	---	---	---	---	30.2	29.1
12	---	---	---	---	---	---	---	---	---	---	29.4	28.7
13	---	---	---	---	---	---	---	---	---	---	28.8	28.4
14	---	---	---	---	---	---	---	---	---	---	29.0	28.4
15	---	---	---	---	---	---	---	---	---	---	29.0	28.8
16	---	---	---	---	---	---	---	---	---	---	28.9	29.0
17	---	---	---	---	---	---	---	---	---	---	29.2	29.7
18	---	---	---	---	---	---	---	---	---	---	30.8	30.3
19	---	---	---	---	---	---	---	---	---	---	31.5	30.5
20	---	---	---	---	---	---	---	---	---	---	30.9	31.0
21	---	---	---	---	---	---	---	---	---	---	30.5	30.4
22	---	---	---	---	---	---	---	---	---	---	30.0	29.3
23	---	---	---	---	---	---	---	---	---	---	29.9	29.8
24	---	---	---	---	---	---	---	---	---	---	30.5	30.2
25	---	---	---	---	---	---	---	---	---	---	29.6	29.9
26	---	---	---	---	---	---	---	---	---	---	29.6	29.1
27	---	---	---	---	---	---	---	---	---	---	28.9	28.2
28	---	---	---	---	---	---	---	---	---	---	29.1	27.7
29	---	---	---	---	---	---	---	---	---	---	30.0	28.0
30	---	---	---	---	---	---	---	---	---	---	30.8	27.8
31	---	---	---	---	---	---	---	---	---	---	30.3	---
MEAN	---	---	---	---	---	---	---	---	---	---	---	28.7
MAX	---	---	---	---	---	---	---	---	---	---	---	31.0
MIN	---	---	---	---	---	---	---	---	---	---	---	24.9

Water year 1989 (October 1988 to September 1989)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	28.0	---	18.6	22.1	21.1	---	23.7	26.1	31.8	29.8	32.0	31.4
2	28.3	---	17.2	21.4	22.7	---	22.4	25.8	31.6	29.2	32.3	30.6
3	28.1	---	16.1	20.8	23.4	19.0	23.5	25.9	31.3	29.7	31.1	31.6
4	26.7	---	15.3	19.9	23.7	21.0	24.4	26.6	31.1	30.6	30.7	30.8
5	26.2	---	14.9	18.8	23.8	22.8	24.3	27.3	30.6	31.4	31.8	29.3
6	25.9	---	16.0	18.4	23.8	23.1	23.9	27.6	29.2	30.8	31.5	29.5
7	24.4	---	17.1	18.6	24.4	21.5	22.6	26.9	27.2	31.5	31.3	29.4
8	22.3	21.2	17.9	20.3	24.1	18.6	22.3	25.5	26.6	32.6	31.5	29.3
9	21.7	21.7	19.1	22.0	22.0	14.7	24.0	25.6	27.8	33.2	30.7	30.1
10	22.2	22.4	19.1	21.2	18.2	13.0	24.8	25.3	29.2	32.9	30.0	29.4
11	22.3	21.8	18.7	21.8	16.9	13.8	23.5	24.7	31.4	32.3	29.6	30.0
12	22.0	22.6	17.3	22.4	16.7	15.7	20.6	25.0	32.0	31.7	29.8	30.4
13	21.7	23.8	15.1	22.7	17.7	18.0	20.6	26.5	31.6	30.4	28.9	30.1
14	20.8	23.7	14.3	23.1	20.0	19.8	22.6	28.4	32.1	29.6	29.5	---
15	20.7	23.4	14.6	23.7	22.2	22.0	23.2	27.5	31.7	30.9	29.9	---
16	21.4	24.5	15.1	23.3	23.3	23.8	23.4	28.4	30.8	31.7	30.2	31.4
17	21.9	25.7	14.1	21.8	22.8	24.2	25.3	29.5	30.9	31.4	31.3	30.1
18	---	25.9	12.3	20.8	21.9	25.7	25.5	30.1	31.5	30.2	31.3	29.1
19	---	25.5	11.8	20.4	20.5	26.2	26.3	27.9	32.1	29.7	30.6	28.4
20	---	25.5	12.3	20.9	21.1	25.9	26.2	27.7	30.6	30.3	30.0	28.3
21	---	25.1	14.9	19.2	22.1	25.3	25.1	28.6	31.2	30.4	30.0	28.3
22	---	24.0	15.0	17.6	21.6	25.4	24.5	28.6	30.8	30.1	31.3	28.0
23	---	22.2	16.4	16.1	17.9	24.4	25.3	29.1	30.7	30.0	32.3	27.7
24	---	20.7	17.6	16.3	12.7	23.4	26.5	28.9	29.8	29.6	33.1	26.8
25	---	20.5	17.1	17.6	11.3	23.3	27.2	28.9	30.2	29.9	33.2	26.6
26	---	20.9	17.6	18.5	12.0	24.9	27.3	30.5	30.6	30.6	31.7	26.7
27	---	21.7	18.5	19.2	13.9	26.3	27.0	31.4	31.9	31.2	32.2	28.1
28	---	21.8	18.9	19.6	16.1	27.1	27.1	31.2	32.2	30.8	32.9	29.6
29	---	19.4	20.5	20.8	---	26.8	27.7	30.8	31.0	30.2	32.0	29.9
30	---	18.8	21.5	21.2	---	26.0	27.3	30.9	29.9	30.7	32.2	29.9
31	---	---	21.5	21.1	---	25.5	---	31.0	---	31.1	32.7	---
MEAN	---	---	16.7	20.4	19.9	---	24.6	28.0	30.6	30.8	31.2	---
MAX	---	---	21.5	23.7	24.4	---	27.7	31.4	32.2	33.2	33.2	---
MIN	---	---	11.8	16.1	11.3	---	20.6	24.7	26.6	29.2	28.9	---

Appendix IIc. Daily mean water temperature at the Lake Apopka outflow site, August 1988 through September 1990
[Temperature is in degrees Celsius; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 through September 1990)												
1	29.4	23.4	17.8	16.3	22.3	19.3	25.5	29.5	30.0	32.1	31.3	---
2	29.0	24.3	18.2	15.5	23.6	20.1	25.7	30.2	31.0	30.4	30.9	---
3	27.9	23.7	16.9	16.1	24.0	20.7	25.3	30.0	31.4	29.3	31.0	---
4	28.1	23.3	14.4	17.1	24.3	20.3	23.0	29.1	31.2	30.0	30.4	---
5	29.3	23.9	13.4	18.3	22.1	19.7	22.6	28.3	30.8	30.5	31.5	---
6	29.5	25.1	14.5	19.8	20.0	21.4	23.4	27.5	31.4	30.3	32.4	---
7	28.5	26.1	16.5	21.1	20.1	21.6	24.0	26.5	32.1	31.5	32.4	---
8	27.7	25.4	18.7	21.2	21.5	21.1	23.2	25.5	31.6	32.8	32.1	---
9	26.9	24.9	18.8	19.5	22.9	21.2	22.3	24.7	32.5	32.6	31.2	---
10	26.4	23.6	15.9	18.3	22.7	22.9	23.1	26.0	32.0	33.5	30.5	---
11	25.9	22.3	14.4	18.1	22.4	24.4	24.8	27.3	30.6	33.5	29.8	---
12	26.0	22.1	15.1	17.4	20.9	25.1	23.3	27.9	30.3	32.1	30.1	---
13	26.3	22.4	16.1	15.1	20.2	25.6	22.5	28.4	29.9	29.4	31.4	---
14	27.4	23.7	14.1	14.1	20.3	---	23.5	29.2	30.5	27.2	31.1	---
15	27.9	25.3	14.4	15.2	21.2	---	24.5	30.2	30.1	26.6	30.1	---
16	29.0	24.4	14.8	16.6	22.2	25.3	24.6	30.9	29.9	27.1	30.8	---
17	29.6	20.7	14.0	17.7	23.1	24.8	26.1	30.5	30.5	28.0	---	---
18	29.3	18.4	13.8	19.4	24.0	23.7	27.4	30.3	30.5	29.1	---	29.1
19	27.3	17.6	14.8	20.3	25.0	23.4	27.0	30.4	32.7	29.7	---	28.4
20	22.0	18.2	15.4	21.6	24.1	22.9	24.8	30.9	33.1	31.0	---	28.1
21	19.3	17.8	14.9	22.1	22.8	21.1	24.1	30.5	33.4	31.8	---	29.4
22	18.3	18.8	13.2	21.9	22.9	20.9	25.1	29.0	32.6	31.0	---	30.4
23	19.0	19.5	10.4	20.8	22.0	21.5	26.1	28.5	30.3	30.4	---	29.4
24	20.1	18.3	6.8	20.9	19.4	23.5	26.4	28.7	29.6	30.6	---	27.8
25	20.8	18.5	6.1	21.7	18.3	24.5	25.3	28.3	30.5	31.4	---	26.6
26	21.2	19.9	6.8	20.1	16.9	25.1	25.6	28.1	30.7	31.5	---	28.0
27	20.8	22.0	8.7	17.6	17.0	24.9	25.8	29.1	29.8	31.2	---	29.5
28	20.4	23.4	10.7	17.9	17.9	25.0	24.6	29.9	31.0	30.1	---	28.8
29	19.5	22.6	11.8	19.7	---	26.3	26.6	30.1	32.4	29.9	---	27.3
30	20.6	19.5	13.3	21.0	---	26.3	28.7	30.1	32.5	31.4	---	26.0
31	21.9	---	14.7	21.2	---	25.7	---	30.0	---	32.2	---	---
MEAN	25.0	22.0	13.9	18.8	21.6	---	24.8	28.9	31.2	30.6	---	---
MAX	29.6	26.1	18.8	22.1	25.0	---	28.7	30.9	33.4	33.5	---	---
MIN	18.3	17.6	6.1	14.1	16.9	---	22.3	24.7	29.6	26.6	---	---

Appendix IId. Daily mean specific conductance of water at the Lake Apopka outflow site, August 1988 through September 1990

[Specific conductance is in microsiemens per centimeter at 25 $^{\circ}C$; ---, no data]

Water year 1988 (October 1987 through September 1988)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Maar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	---	---	---	---	---	---	---	---	---	---	---	399
2	---	---	---	---	---	---	---	---	---	---	---	396
3	---	---	---	---	---	---	---	---	---	---	---	422
4	---	---	---	---	---	---	---	---	---	---	---	412
5	---	---	---	---	---	---	---	---	---	---	402	389
6	---	---	---	---	---	---	---	---	---	---	406	382
7	---	---	---	---	---	---	---	---	---	---	405	389
8	---	---	---	---	---	---	---	---	---	---	405	397
9	---	---	---	---	---	---	---	---	---	---	394	390
10	---	---	---	---	---	---	---	---	---	---	395	372
11	---	---	---	---	---	---	---	---	---	---	402	369
12	---	---	---	---	---	---	---	---	---	---	394	365
13	---	---	---	---	---	---	---	---	---	---	392	369
14	---	---	---	---	---	---	---	---	---	---	389	368
15	---	---	---	---	---	---	---	---	---	---	384	371
16	---	---	---	---	---	---	---	---	---	---	384	376
17	---	---	---	---	---	---	---	---	---	---	388	375
18	---	---	---	---	---	---	---	---	---	---	404	378
19	---	---	---	---	---	---	---	---	---	---	419	381
20	---	---	---	---	---	---	---	---	---	---	417	387
21	---	---	---	---	---	---	---	---	---	---	410	384
22	---	---	---	---	---	---	---	---	---	---	403	387
23	---	---	---	---	---	---	---	---	---	---	403	387
24	---	---	---	---	---	---	---	---	---	---	417	386
25	---	---	---	---	---	---	---	---	---	---	416	394
26	---	---	---	---	---	---	---	---	---	---	412	401
27	---	---	---	---	---	---	---	---	---	---	395	398
28	---	---	---	---	---	---	---	---	---	---	393	386
29	---	---	---	---	---	---	---	---	---	---	398	383
30	---	---	---	---	---	---	---	---	---	---	402	368
31	---	---	---	---	---	---	---	---	---	---	402	---
MEAN	---	---	---	---	---	---	---	---	---	---	---	385
MAX	---	---	---	---	---	---	---	---	---	---	---	422
MIN	---	---	---	---	---	---	---	---	---	---	---	365

Water year 1989 (October 1988 through September 1989)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Maar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	378	---	382	368	376	---	367	368	425	438	407	382
2	383	---	371	335	369	---	372	374	428	427	405	403
3	380	---	374	327	368	384	371	386	418	395	410	399
4	379	---	372	339	364	407	370	381	414	427	415	398
5	381	---	376	356	357	403	359	370	414	436	410	415
6	379	---	381	360	355	397	368	370	423	416	427	400
7	380	---	361	344	359	392	364	389	412	460	411	380
8	380	381	335	353	359	399	374	388	426	449	424	401
9	380	379	362	362	353	403	380	381	419	428	420	414
10	381	376	372	365	349	388	379	378	432	427	407	419
11	362	351	369	368	348	400	394	385	428	424	405	434
12	341	368	366	366	346	403	387	383	439	430	389	436
13	359	380	349	370	346	405	375	381	444	441	381	422
14	374	381	354	373	349	407	372	384	448	424	416	---
15	381	377	345	370	352	405	374	384	443	446	464	---
16	384	354	363	374	359	388	361	387	444	440	441	395
17	349	367	355	375	362	353	374	389	445	441	443	382
18	---	374	335	367	363	360	368	394	431	434	426	384
19	---	369	347	362	359	368	368	393	435	426	403	419
20	---	375	337	358	359	369	367	390	386	426	401	416
21	---	382	340	359	360	351	375	395	432	426	409	384
22	---	377	357	324	346	373	372	383	423	420	433	383
23	---	355	365	333	365	377	367	395	413	413	439	378
24	---	360	324	344	404	378	362	400	406	434	422	396
25	---	371	328	354	406	375	375	404	413	477	408	416
26	---	379	346	369	407	370	381	408	454	474	411	446
27	---	370	354	376	402	370	380	408	505	453	415	463
28	---	374	360	384	402	368	389	415	463	433	411	434
29	---	382	348	384	---	367	399	420	455	417	404	404
30	---	378	362	388	---	367	381	412	439	417	394	395
31	---	---	366	388	---	364	---	415	---	415	390	---
MEAN	---	---	357	361	366	---	374	391	432	433	414	---
MAX	---	---	382	388	407	---	399	420	505	477	464	---
MIN	---	---	324	324	346	---	359	368	386	395	381	---

Appendix IId. Daily mean specific conductance of water at the Lake Apopka outflow site, August 1988 through September 1990

[Specific conductance is in microsiemens per centimeter at 25 °C; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Maar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 through September 1990)												
1	373	389	410	418	424	446	458	414	404	388	376	---
2	365	391	412	395	425	447	458	409	402	407	407	---
3	364	399	411	398	425	448	466	407	395	414	395	---
4	365	387	411	382	428	450	452	402	393	400	402	---
5	369	392	412	402	433	444	447	399	397	411	381	---
6	365	393	430	409	426	438	447	401	403	401	382	---
7	361	395	415	437	426	439	450	400	403	401	385	---
8	361	395	414	413	426	442	443	397	412	409	384	---
9	359	392	410	435	427	469	430	393	423	406	398	---
10	356	394	410	437	428	453	428	389	408	409	386	---
11	348	389	408	442	426	439	426	392	389	405	385	---
12	346	389	408	474	440	449	431	396	383	389	374	---
13	346	393	407	441	424	444	426	394	374	387	376	---
14	356	395	382	425	421	---	430	399	384	435	379	---
15	356	396	401	438	425	---	425	399	382	440	377	---
16	366	395	410	429	426	438	420	400	379	448	387	---
17	354	395	414	439	427	443	409	397	389	433	---	---
18	360	393	410	390	429	452	408	400	383	425	---	399
19	356	397	402	403	433	446	410	405	377	441	---	404
20	359	398	403	428	442	445	412	405	375	436	---	403
21	360	398	403	436	436	443	412	404	392	387	---	405
22	361	403	408	450	438	440	410	401	390	372	---	403
23	360	410	403	439	433	441	409	402	391	368	---	399
24	368	414	403	434	427	442	411	399	398	368	---	408
25	369	401	417	429	414	442	408	393	417	340	---	410
26	381	401	428	433	420	443	394	394	407	361	---	408
27	351	407	456	429	433	447	397	398	397	356	---	408
28	353	411	477	427	440	445	398	397	394	440	---	403
29	351	413	439	424	---	444	400	396	384	420	---	392
30	360	409	457	424	---	442	407	402	381	383	---	384
31	383	---	410	426	---	444	---	404	---	385	---	---
MEAN	361	398	416	425	429	---	424	400	394	402	---	---
MAX	383	414	477	474	442	---	466	414	423	448	---	---
MIN	346	387	382	382	414	---	394	389	374	340	---	---

Appendix IIe. Daily mean dissolved oxygen concentration in water at the Lake Apopka outflow site, August 1988 through September 1990

[Dissolved oxygen concentration is in milligrams per liter; ---, no data]--

Water year 1988 (October 1987 through September 1988)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	---	---	---	---	---	---	---	---	---	---	---	3.5
2	---	---	---	---	---	---	---	---	---	---	---	2.1
3	---	---	---	---	---	---	---	---	---	---	---	3.3
4	---	---	---	---	---	---	---	---	---	---	---	5.5
5	---	---	---	---	---	---	---	---	---	---	6.5	4.0
6	---	---	---	---	---	---	---	---	---	---	5.7	---
7	---	---	---	---	---	---	---	---	---	---	4.6	---
8	---	---	---	---	---	---	---	---	---	---	5.2	2.9
9	---	---	---	---	---	---	---	---	---	---	5.8	6.3
10	---	---	---	---	---	---	---	---	---	---	4.7	9.4
11	---	---	---	---	---	---	---	---	---	---	4.4	9.6
12	---	---	---	---	---	---	---	---	---	---	4.8	8.4
13	---	---	---	---	---	---	---	---	---	---	5.3	7.1
14	---	---	---	---	---	---	---	---	---	---	5.9	6.9
15	---	---	---	---	---	---	---	---	---	---	6.0	7.0
16	---	---	---	---	---	---	---	---	---	---	6.5	6.8
17	---	---	---	---	---	---	---	---	---	---	5.7	7.0
18	---	---	---	---	---	---	---	---	---	---	7.3	6.8
19	---	---	---	---	---	---	---	---	---	---	7.3	5.1
20	---	---	---	---	---	---	---	---	---	---	6.2	4.4
21	---	---	---	---	---	---	---	---	---	---	4.7	3.1
22	---	---	---	---	---	---	---	---	---	---	3.5	1.7
23	---	---	---	---	---	---	---	---	---	---	4.3	4.0
24	---	---	---	---	---	---	---	---	---	---	5.7	6.8
25	---	---	---	---	---	---	---	---	---	---	3.8	5.9
26	---	---	---	---	---	---	---	---	---	---	5.5	4.7
27	---	---	---	---	---	---	---	---	---	---	4.8	3.2
28	---	---	---	---	---	---	---	---	---	---	3.1	4.4
29	---	---	---	---	---	---	---	---	---	---	6.4	7.0
30	---	---	---	---	---	---	---	---	---	---	6.9	5.2
31	---	---	---	---	---	---	---	---	---	---	5.5	---
MEAN	---	---	---	---	---	---	---	---	---	---	---	5.1
MAX	---	---	---	---	---	---	---	---	---	---	---	9.6
MIN	---	---	---	---	---	---	---	---	---	---	---	.1

Water year 1989 (October 1988 to September 1989)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	6.5	---	6.7	10.2	7.3	9.3	6.2	3.1	1.8	---	---	---
2	7.1	---	7.6	5.1	10.7	5.5	10.1	3.4	1.6	---	---	---
3	5.9	---	9.7	3.3	10.3	7.6	10.1	4.2	2.4	---	---	---
4	2.0	---	10.7	2.9	9.7	11.3	8.7	6.6	2.5	---	---	---
5	3.0	---	10.2	6.3	9.1	11.7	4.6	6.6	2.3	---	---	---
6	5.8	---	---	8.5	7.7	8.5	4.2	3.7	2.3	---	---	---
7	4.9	---	---	7.9	9.0	5.7	7.0	4.7	2.2	---	---	---
8	4.8	10.1	7.4	9.8	8.4	5.1	8.3	5.6	3.1	---	---	---
9	6.6	10.7	10.0	10.4	8.1	5.0	9.9	7.4	3.9	---	---	---
10	9.1	10.4	7.6	7.8	9.3	8.9	8.3	5.6	4.9	---	---	---
11	6.8	7.6	7.3	7.8	11.1	11.8	4.7	4.2	4.5	---	---	---
12	5.6	7.5	6.1	8.1	12.1	13.8	5.5	7.2	4.2	---	---	---
13	5.0	9.7	7.5	6.9	12.9	11.6	6.8	9.1	3.3	---	---	---
14	5.1	8.9	8.8	6.4	11.9	12.8	8.8	8.0	2.6	---	---	---
15	8.7	8.6	7.6	7.0	11.4	13.8	6.0	3.7	1.9	---	---	---
16	8.7	7.2	9.5	5.8	10.1	13.2	3.8	4.9	---	---	---	---
17	5.6	8.0	8.2	6.2	7.7	9.1	6.9	5.3	---	---	---	---
18	---	7.2	6.9	7.0	7.1	9.3	6.8	5.0	---	---	---	---
19	---	5.7	8.6	8.5	8.0	8.3	7.5	3.7	---	---	---	---
20	---	5.8	8.3	9.0	9.9	7.5	4.9	4.3	---	---	---	---
21	---	4.9	9.2	6.3	7.6	8.2	2.8	3.7	---	---	---	---
22	---	2.8	---	5.5	5.2	7.0	6.3	3.2	---	---	---	---
23	---	3.0	---	6.1	4.9	5.2	8.0	3.9	---	---	---	---
24	---	1.6	6.8	5.5	8.0	4.7	8.0	4.0	---	---	---	---
25	---	5.3	6.6	4.7	10.7	7.9	7.3	3.1	---	---	---	---
26	---	9.1	8.5	6.6	11.7	10.4	6.9	2.8	---	---	---	---
27	---	9.9	7.0	9.1	10.2	8.3	6.0	2.2	---	---	---	---
28	---	8.2	8.7	8.2	10.0	7.8	5.1	2.2	---	---	---	---
29	---	7.3	8.9	8.4	---	7.5	6.1	1.0	---	---	---	---
30	---	9.3	10.2	8.6	---	6.8	3.8	1.8	---	---	---	---
31	---	---	9.7	5.1	---	5.6	---	1.9	---	---	---	---
MEAN	---	---	---	7.1	9.3	8.6	6.6	4.4	---	---	---	---
MAX	---	---	---	10.4	12.9	13.8	10.1	9.1	---	---	---	---
MIN	---	---	---	2.9	4.9	4.7	2.8	1.0	---	---	---	---

Appendix IIe. Daily mean dissolved oxygen concentration in water at the Lake Apopka outflow site, August 1988 through September 1990

[Dissolved oxygen concentration is in milligrams per liter; ---, no data]--Continued

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Water year 1990 (October 1989 through September 1990)												
1	---	10.0	9.7	7.6	9.0	7.4	4.2	6.3	6.0	4.2	5.4	---
2	---	9.8	10.1	7.0	8.5	7.4	5.6	7.6	5.1	2.9	3.1	---
3	---	9.1	9.9	6.3	8.1	7.2	4.8	7.1	3.6	3.7	3.6	---
4	---	8.0	10.4	6.8	7.9	6.0	7.5	6.6	5.5	5.3	3.3	---
5	---	8.8	11.4	5.9	6.4	7.0	8.3	6.5	6.0	4.6	4.4	---
6	---	7.5	10.4	5.3	7.8	8.0	10.1	5.8	7.2	5.0	7.1	---
7	---	9.6	11.7	2.3	8.0	7.6	9.0	7.2	5.9	7.1	6.2	---
8	---	7.9	10.6	3.0	8.7	8.0	8.8	8.0	2.6	6.0	5.4	---
9	---	7.5	8.5	3.5	9.3	7.8	9.0	7.7	5.3	6.6	4.4	---
10	---	7.5	8.2	6.9	7.8	8.3	8.9	7.8	7.7	8.2	4.8	---
11	---	9.3	10.6	8.0	6.0	9.8	8.9	7.9	4.8	6.9	4.6	---
12	5.7	9.0	10.1	6.3	6.1	8.5	7.3	8.6	4.6	4.6	5.9	---
13	5.9	9.5	6.9	6.9	8.3	8.2	8.6	7.6	6.0	4.7	7.2	---
14	6.6	9.2	6.6	9.8	9.4	---	8.6	7.8	6.1	4.4	5.5	---
15	5.9	8.9	8.8	9.3	9.5	---	8.8	7.8	6.6	5.8	3.8	---
16	7.5	7.5	9.4	10.4	8.9	6.4	7.9	7.2	6.6	6.3	3.2	---
17	5.3	7.8	9.7	7.9	7.8	6.0	9.5	7.3	5.9	6.3	---	---
18	5.7	9.0	9.7	6.5	7.9	5.1	8.5	6.8	3.9	7.5	---	6.1
19	3.7	10.1	7.7	5.6	7.9	6.9	7.2	7.4	4.6	6.2	---	6.7
20	5.5	10.9	5.8	9.0	6.3	7.1	7.5	7.7	4.5	5.6	---	7.4
21	7.0	11.2	6.7	8.8	7.0	7.7	8.8	8.1	3.8	4.8	---	7.6
22	8.6	11.0	9.4	6.2	7.1	9.0	9.5	8.1	3.9	4.7	---	7.0
23	9.3	9.4	9.4	7.4	6.1	9.0	9.4	8.1	2.8	3.5	---	5.5
24	9.0	8.0	10.5	8.5	6.5	9.4	8.0	7.1	2.8	3.7	---	5.7
25	8.5	9.8	10.9	8.1	6.2	9.4	8.4	6.7	4.9	4.0	---	7.8
26	9.0	9.6	11.0	7.5	7.7	8.5	6.6	7.1	5.7	5.5	---	7.8
27	6.8	9.8	8.3	8.4	8.5	8.1	7.0	6.5	5.6	6.8	---	7.5
28	7.8	9.7	5.1	9.6	7.9	8.3	6.2	5.8	7.3	5.3	---	6.3
29	7.7	9.2	9.2	10.2	---	8.3	5.3	5.6	6.7	4.7	---	5.8
30	6.6	9.2	6.8	9.5	---	7.0	5.7	6.2	6.0	7.1	---	5.0
31	7.3	---	6.7	8.7	---	4.6	---	6.0	---	5.9	---	---
MEAN	---	9.1	9.0	7.3	7.7	---	7.8	7.2	5.3	5.4	---	---
MAX	---	11.2	11.7	10.4	9.5	---	10.1	8.6	7.7	8.2	---	---
MIN	---	7.5	5.1	2.3	6.0	---	4.2	5.6	2.6	2.9	---	---