LAKE NORMAN: 1994 SUMMARY

MAINTENANCE MONITORING PROGRAM

McGUIRE NUCLEAR STATION: NPDES No. NC0024392

DUKE POWER COMPANY

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HUNTERSVILLE, NORTH CAROLINA 28078

DECEMBER 1995

TABLE OF CONTENTS

EXECUTIVE SUMMARY

As required per the National Pollutant Discharge Elimination System (NPDES) permit number NC0024392 for McGuire Nuclear Station (MNS) issued by the North Carolina Department of Environment, Health and Natural Resources (NCDEHNR), the following annual report has been prepared. This report summarizes environmental monitoring of Lake Norman conducted during 1994. These results indicate that continuation of the alternative thermal limits to the water quality standard for temperature are warranted.

OPERATIONAL DATA

Monthly capacity factors averaged over 50% for all months except February, September, and October for Unit 1 and November and December for Unit 2 in 1994. The average monthly discharge temperature was below the permit limit for all months. During July, August, and September, when conservation of cool water and discharge temperatures are most critical, use of low level intake water was not necessary for compliance with the thermal limit for McGuire Nuclear Station (MNS). This helped to conserve habitat for cool water fish in Lake Norman.

WATER CHEMISTRY DATA

Temporal and spatial trends in water temperature and DO data collected monthly in 1994 were similar to those observed historically. Reservoir-wide isotherm and isopleth information for 1994, coupled with heat content and hypolimnetic oxygen data, illustrated that Lake Norman exhibited thermal and oxygen dynamics characteristic of historic conditions and similar to other Southeastern reservoirs of comparable size, depth, flow conditions, and trophic status.

Availability of suitable pelagic habitat for adult striped bass in Lake Norman in 1994 was generally similar to historic conditions. Reservoir-wide habitat existed throughout 1994, but was limited during the period 14 July to 10 August. These conditions were appreciably better than in 1993, and within the range observed historically. No mortalities of striped bass were observed or reported in 1994.

All chemical parameters measured in 1994 were within the concentration ranges previously reported for the lake during both MNS preoperational and operational years.

PHYTOPLANKTON DATA

Chlorophyll *a* concentrations at all locations during 1994 were within historical ranges and in the mesotrophic range. Lakewide, chlorophyll *a* concentrations were similar among Mixing Zone and other downlake locations and generally increased uplake. The maximum chlorophyll *a* value observed in 1994 (15.2 mg/l) was far below the NC State Water Quality Standard of 40 mg/l.

Significantly higher seston weights uplake in the riverine area than downlake in Lake Norman during 1994 were attributed to sediment inflows. Suspended material, as measured by seston weights decreased downlake presumably as particulate material settles out of the water column. This corresponded with secchi depth data, as secchi depths were deepest downlake near the dam and shallowest uplake in the riverine area.

Total phytoplankton densities and biovolumes remained similar to those observed in previous years, generally increasing from downlake to uplake in the reservoir. Phytoplankton taxonomic composition during 1994 was similar to that observed during the same months of 1993. Diatoms, green algae and cryptophytes were the most numerically abundant classes of algae observed. Blue-green algae were never a dominant at any location or time in 1994. The maximum total density and total biovolume observed in 1994 (6842 units/ml and 3460 mm^3/m^3, respectively) were both below the levels considered by NCDEM as algal blooms (10,000 units/ml and 5000 mm^3/m^3, respectively).

ZOOPLANKTON DATA

The range of total zooplankton densities observed during 1994 was similar to the ranges observed since 1987. Total zooplankton standing crops were generally highest in May and lowest in August. Zooplankton densities, in general, were slightly higher in eplimnetic samples than in whole column samples. Total zooplankton densities at Mixing Zone locations were not significantly different from at least one background locations during most quarters in 1994. The typical trend of increasing zooplankton densities from downlake to uplake was observed during all months except February in 1994 and appears to be related to higher algal production up reservoir.

Overall, rotifers dominated zooplankton standing crops in 1994, as they did in 1993, followed closely in importance by copepods. Cladocerans were dominant numerically on only one occasion in 1994. Major rotifer taxa observed in 1994 were *Keratella*, *Polyarthra* and *Synchaeta*. Copepod populations were dominated by immature forms (nauplii and cyclopoid copepodids). As in previous years, *Bosmina* was the most abundant cladoceran taxa observed at all locations. Overall, zooplankton taxonomic composition in 1994 was similar to that observed in previous years.

FISHERIES DATA

The MNS mixing zone was surveyed for striped bass mortalities through the summer during sampling trips on the lake, and during the last week of July through August of 1994 specifically to locate dead or dying fish. No dead or dying striped bass were reported in lower Lake Norman during summer 1994.

A creel survey was conducted March 1994 through February 1995 on Lake Norman to obtain information about the fishery. Statistical analyses of these data is on-going and a separate report will be forwarded to NCDEHNR for review in 1996.

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
McGUIRE NUCLEAR STATION
OPERATIONAL DATA

INTRODUCTION

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OPERATIONAL DATA FOR 1994

Monthly capacity factors averaged over 50% for all months except February, September, and October for Unit 1 and November and December for Unit 2 in 1994. During July, August, and September, when conservation of cool water and discharge temperatures are most critical, the thermal limit for MNS increases from a monthly average of 95°F to 99°F. The average monthly discharge temperature was 97.0°F (36.1°C) for July, 94.4°F (34.7°C) for August, and 91.0°F (32.8°C) for September 1994. Use of low level intake water was not necessary for compliance with the thermal limit for MNS. This helped to conserve habitat for cool water fish in Lake Norman. The volume of cool water in Lake Norman is tracked throughout the year to ensure that an adequate volume is available to comply with both the Nuclear Regulatory Commission Technical Specification requirements and the NPDES monthly discharge water temperature limit.

Table 1-1. **Average monthly capacity factors (%) calculated from daily unit capacity factors [Net Generation (Mwe per unit day) x 100 / 24 h per day x 1129 mw per unit] and monthly average discharge water temperatures for McGuire Nuclear Station during 1994.**

Month	CAPACITY FACTOR (%)			TEMPERATURE	
	Unit 1 Average	Unit 2 Average	Station Average	Monthly Average ^{o}F	^{o}C
January	70.8	80.7	75.8	58.2	14.6
February	11.8	101.9	56.9	56.1	13.4
March	95.6	102.5	99.0	68.1	20.1
April	98.8	102.0	100.4	76.8	24.9
May	95.6	100.8	98.2	84.7	29.3
June	97.2	99.8	98.5	90.3	32.4
July	95.8	97.9	96.8	97.0	36.1
August	54.9	97.5	76.2	94.4	34.7
September	0	98.6	49.1	91.0	32.8
October	8.2	100.0	54.1	77.9	25.5
November	100.2	71.3	85.7	76.5	24.7
December	100.6	0	50.1	69.3	20.7

CHAPTER 2
WATER CHEMISTRY

INTRODUCTION

The objectives of the water chemistry portion of the McGuire Nuclear Station (MNS) NPDES Maintenance Monitoring Program are to:

1) maintain continuity in Lake Norman's chemical data base so as to allow detection of any significant station-induced and/or natural change in the physicochemical structure of the lake; and

2) compare, where appropriate, these physicochemical data to similar data in other hydropower reservoirs and cooling impoundments in the Southeast.

This year's report focuses primarily on 1993 and 1994. Where appropriate, reference to pre-1993 data will be made by citing reports previously submitted to the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR).

METHODS AND MATERIALS

The complete water chemistry monitoring program, including specific variables, locations, depths, and frequencies is outlined in Table 2-1. Sampling locations are identified in Figure 2-1, whereas specific chemical methodologies, along with the appropriate references are presented in Table 2-2. Data were analyzed using two approaches, both of which were consistent with earlier studies (DPC 1985, 1987, 1988a, 1988b, 1989, 1990, 1991, 1992, 1993, 1994). The first method involved partitioning the reservoir into mixing, background, and discharge zones, and making comparisons among zones and years. In this report, the discharge includes only Location 4; the mixing zone encompasses Locations 1 and 5; the background zone includes Locations 8, 11, and 15. The second approach emphasized a much broader lake-wide investigation and encompassed the plotting of monthly isotherms and isopleths, and summer-time striped bass habitat. Several quantitative calculations were also performed. These included the calculation of the areal hypolimnetic oxygen deficit (AHOD), maximum whole-water column and hypolimnion oxygen content, maximum whole-water column and hypolimnion heat content, mean epilimnion and hypolimnion heating rates over the stratified period, and the Birgean heat budget.

Heat ($Kcal/cm^2$) and oxygen (mg/cm^2) content of the reservoir were calculated according to Hutchinson (1957), using the following equation:

$$Lt = A_o^{-1} \bullet \int TO \bullet Az \bullet dz$$

where;

Lt = reservoir heat ($Kcal/cm^2$) or oxygen (mg/cm^2) content
Ao = surface area of reservoir (cm^2)
TO = mean temperature (C) or oxygen content of layer z
Az = area (cm^2) at depth z
dz = depth interval (cm)
zo = surface
zm = maximum depth

RESULTS AND DISCUSSION

Precipitation Amount

Precipitation in the vicinity of MNS measured 47.1 inches in 1994, compared to 37.8 inches in 1993 (Figure 2-2.). The wettest month of 1994 was August in which 7.1 inches of precipitation fell.

Temperature and Dissolved Oxygen

Water temperatures measured in 1994 illustrated similar temporal and spatial trends in the background and mixing zones (Figures 2-3, 2-4). Water temperatures in the winter of 1994 were generally equal to or cooler throughout the water column as compared to 1993 in both zones (Figure 2-3, 2-4). Conversely, temperatures in the spring were slightly warmer in 1994 than in 1993, especially in the upper ten meters of the water column. Summer, fall and early-winter temperature profiles in both the mixing and background zones exhibited minimal interannual variability. The only exception to this occurred in September in the background zone where epilimnion temperatures were 3-5°C cooler in 1994 than in 1993. Despite some seasonal and spatial variability in temperature data between 1993 and 1994, the 1994 temperatures were well within the historic range (DPC 1985, 1989, 1991, 1993. 1994). Temperature data at the discharge location in 1994 were generally similar to that measured in 1993 (Figure 2-5) and historically (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993, 1994). The warmest discharge temperature of 1994 occurred in August and measured 35.7 C, or slightly less than the historic maximum of 36.3 C measured in August, 1991 (DPC 1992).

Seasonal and spatial patterns of DO in 1994 were reflective of the patterns exhibited for temperature, i. e., generally similar in both the mixing and background zones (Figures 2-6 and 2-7). Winter, and spring DO values generally ranged within 1.0 mg/L of the 1993 values throughout the water column in both zones, and were well within the historic range (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993, 1994). Summer DO values in 1994 were highly variable throughout the water column in both the mixing and background zones ranging from highs of 7 to 10 mg/L in the surface waters to lows of 0 to 2mg/L in the bottom waters. In comparison to 1993 values, summer DO levels in 1994 were slightly greater than the previous year. However, the differences between years were not significant and all values recorded were well within the historic range (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993,1994). Fall DO values were generally similar between the two years in both zones. Some interannual differences were observed in September profiles in the background zone and in November profiles in the mixing zone, but such variability was characteristic of the historic data (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993,1994). Interannual differences in DO are common in Southeastern reservoirs, particularly during the stratified period, and can reflect yearly differences in hydrological, meteorological, and limnological forcing variables (Cole and Hannon 1985; Petts 1984).

The seasonal pattern of DO in 1994 at the discharge location was similar to that measured historically, with the highest values observed during the winter and lowest observed in the summer and early-fall (Figure 2-5). Generally, DO values in 1994 were either equal to or slightly greater than in 1993, and within the historic range (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993, 1994). The lowest DO concentration measured at the discharge location in 1994 (5.6 mg/l) occurred in August and was slightly greater than the August, 1993 low of 4.1 mg/l (Figure 2-5).

Reservoir-wide Temperature and Dissolved Oxygen

The monthly reservoir-wide temperature and dissolved oxygen data for 1994 are presented in Figures 2-8 and 2-9. For the most part, the temporal and spatial distribution patterns of both temperature and dissolved oxygen are similar to other cooling impoundments and hydropower reservoirs in the Southeast (Cole and Hannon 1985; Petts 1984). During the winter cooling and mixing period, vertical rather than horizontal homogeneity in temperature predominated, with the shallower uplake 'riverine' zone exhibiting slightly cooler temperatures than the deeper downlake 'lacustrine' zone (Figure 2-8). These longitudinal differences in temperatures were clearly illustrated in January and February. The principal factors influencing this gradient in Lake Norman are thermal discharges from MSS and MNS, morphometric (depth) differences within the reservoir, and surface water inputs from the upper reaches of the reservoir.

The heating period in Lake Norman generally begins in March, as more heat is gained at the water's surface than is lost at night. During the initial stages of the heating period, buoyancy forces "smooth out" the horizontal differences in temperature, thereby reducing temperature differences between up-reservoir and down-reservoir locations. Due to the vertical instability of the water column during this period, temperature increases are observed at all depths. These points are illustrated by contrasting the January and February temperature data with the March and April data (Figure 2-8). As solar radiation and air temperatures increase, heating occurs at a greater rate in the upper waters than in the mid or bottom waters due to differential thermal absorption and vertical density differences (Wetzel 1975, Ford 1985). Eventually, differential heating at the surface leads to the formation of the classical epilimnion, metalimnion, and hypolimnion zones. These zones are clearly depicted in the July, 1994 data (Figure 2-8).

In contrast to most natural lakes, but not unlike many reservoirs in the Southeast, a distinct thermocline within the metalimnion was not observed in Lake Norman in 1994 and is consistent with that observed in previous years (DPC 1992, 1993, 1994). Rather, the metalimnion was more or less continuous with respect to vertical density differences within the lower water column, and even showed signs of merging with the hypolimnion, as illustrated in the August data (Figure 2-8).

Cooling of the water column began in early September as illustrated by decreases in surface temperatures compared to August data. Concurrent with decreases in surface temperatures were an increase in the depth of the epilimnion (caused by convective mixing) and a disruption of the horizontal homogeneity in epilimnion temperatures (caused by reservoir-wide differential heating and cooling, and advective inputs from upstream). Continuation of these differential vertical and horizontal processes led to even more pronounced thermal differences within the reservoir. For example, by October the uplake riverine zone had already 'turned over', while the downlake lacustrine zone was still strongly stratified. Not until early November was Lake Norman completely mixed vertically throughout the reservoir. Morphometric, and in particular, depth differences throughout the longitudinal reaches of the reservoir, coupled with seasonal variability in the volume and density of upstream inputs are major contributors to these horizontal gradients of heating and cooling in reservoirs (Ford 1985, Petts 1984).

Distribution patterns of dissolved oxygen in 1994 were similar to but not identical to temperature (Figure 2-9). Generally, dissolved oxygen concentrations were greatest during the winter cooling and mixing period when biological respiration was at a minimum and atmospheric reaeration was at a maximum. The highest reservoir-wide mean concentration of dissolved oxygen (11.4 mg/l) occurred in February when the reservoir exhibited a mean temperature of 7.4°C (Figure 2-8). Unlike the thermal regime, no major longitudinal differences existed in dissolved oxygen within the reservoir during the winter. Not until the lake became stratified, thereby isolating the metalimnion and hypolimnion from atmospheric reaeration and vertical water mass exchanges, were uplake-to-downlake gradients in dissolved oxygen observed. Longitudinal gradients in metalimnetic and hypolimnetic dissolved oxygen in 1994 were first observed in May. Differential dissolved oxygen depletion and eventual anoxia were first observed in the transitional zone (Locations 15 through 62) where hypolimnetic volume is small, water column and sediment organic matter high, and advective mixing minimal. This longitudinal and progressive display of oxygen depletion has been reported for many southern U.S. impoundments (Hannon et. al., 1979, Cole and Hannon 1985, Petts 1984). By August, the complete hypolimnion throughout the reservoir was anoxic; this zone represents approximately 19% of the entire volume of the lake at full pond. Complete hypolimnetic deoxygenation (below the thermocline) in natural lakes is generally indicative of the net effect of cultural eutrophication (Wetzel 1975). Alternatively, the occurrence of hypoxia in reservoirs is influenced by a combination of hydrologic, hydraulic, morphometric and limnological factors (Cole and Hannon 1985, Petts 1984).

Reaeration of the water column started in September concomitantly with the cooling and mixing of the reservoir. Decreasing air temperatures cooled the surface waters resulting in a convective deepening, aided by wind-induced mixing, of the epilimnion. As the oxygenated epilimnion eroded progressively deeper into the water column, the width of the anoxic zone decreased. Longitudinal differences in reaeration were also observed and apparently were related to differential mixing caused by MNS and MSS, and upstream advective inputs from Lookout Shoals Hydroelectric Facility. Reaeration of the reservoir was essentially complete by early November, except for the bottom waters in the downlake "lacustrine" zone.

The seasonal heat content of the complete water column and just the hypolimnion for Lake Norman in 1994 are presented in Figure 2-10a; additional information on the thermal regime in the reservoir for the years 1993 and 1994 are found in Table 2-3. Annual minimum heat content for the entire water column in 1994 (7.33 kcal/sq cm) occurred in February, whereas the maximum heat content (27.87 kcal/sq cm) occurred late-July. Heat content of the hypolimnion exhibited somewhat the same seasonal trend except that the maximum occurred in early-August, or about three weeks later than observed for the entire water column. Heating of both the entire water column and the hypolimnion occurred at approximately a linear rate from minimum to maximum heat content. The mean heating rate of the entire water column equaled 0.132 kcal/sq cm versus 0.062 kcal/sq cm for the hypolimnion. The 1994 heat content data were generally similar to that observed in 1993 and earlier years (DPC 1992, 1993, 1994).

The seasonal oxygen content and percent saturation of the whole water column and the hypolimnion are depicted in Figure 2-10b. Additional oxygen data can be found in Table 2-4 which presents the 1994 AHOD for Lake Norman and contrasts it with similar estimates for 18 TVA reservoirs. Reservoir oxygen content was greatest in mid-winter when DO content measured 11.3 mg/cm^2 for the whole water column and 7.2 mg/cm^2 for the hypolimnion. Percent saturation values at this time reached 96% for the entire water column and 94% for the hypolimnion. Beginning in early-spring, oxygen content began to decline, and continued to do so in a linear fashion until reaching a minimum in mid-summer. Minimum DO values for the entire water column measured 4.7 mg/cm^2 (59% saturation), whereas the annual minimum for the hypolimnion was 0.3 mg/cm^2 (4.6% saturation). The mean rate of DO decline in the hypolimnion over the stratified period, i.e., the AHOD, was 0.044 mg/cm^2/day (Figure 2-10b). This value is similar to that found in other Southeastern reservoirs of comparable depth, chlorophyll *a* status, and secchi depth (Table 2-4).

Striped Bass Habitat

Suitable pelagic habitat for adult striped bass, defined as that layer of water with temperatures ≤ 26°C and DO levels ≥ 2.0 mg/l, was found lake-wide from 15 September 1993 through June 1994. Beginning in late-June 1994, habitat reduction proceeded rapidly throughout the reservoir both as a result of deepening of the 26°C isotherm and metalimnetic and hypolimnetic deoxygenation (Figure 2-11). Habitat reduction was most severe from 14 July to 10 August; however complete elimination of suitable habitat did not appear to occur in 1994. No habitat was measured in the mid and downlake sections of the reservoir at this time; however, refugia of limited size for adult striped bass were recorded in the uplake, riverine sections of the reservoir just below the Lookout Shoals Hydroelectric facility. Physicochemical habitat was observed to expand appreciably in late-August, primarily as a result of epilimnion cooling and deepening, and in response to changing meteorological conditions The temporal and spatial pattern of striped bass habitat expansion and reduction observed in 1994 was similar to that previously reported in Lake Norman and many other Southeastern reservoirs (Coutant 1985, Matthews et al. 1980, DPC 1992, 1993, 1994). The severity and duration of habitat elimination in 1994 was appreciably less than observed in 1993, i.e., two months, but well within the historic range. No mortalities of striped bass were reported in 1994 by local fishermen or observed during weekly habitat assessments by DPC personnel in the summer. Mortalities in 1993 totaled 25 fish. (Please note that in the striped bass habitat section of the 1994 report, i.e, for year 1993, it was erroneously reported that no mortalities were observed in 1993). Hooking mortalitiy associated with the catch-and-release of fish by anglers was postulated to be the primary factor for the mortalities in 1993 rather than physiological stress induced by habitat depletion, (DPC 1994-Chapter 5).

Turbidity and Specific Conductance

Surface turbidity values were low at the MNS discharge, mixing zone, and mid-lake background locations during 1994, ranging from 2-6 NTUs (Table 2-5). Bottom turbidity values were also relatively low over the study period, ranging from 2-17 NTUs (Table 2-5). These values were similar to those measured in 1993 (Table 2-5), and well within the historic range (DPC 1989, 1990, 1991, 1992, 1993, 1994).

Specific conductance in Lake Norman in 1994 ranged from 55 to 92 umho/cm and was similar to that observed in 1993 (Table 2-5) and historically (DPC 1989,1992, 1993, 1994). Specific conductance in surface and bottom waters was generally similar throughout the year except in late-fall at several of the deeper locations when bottom waters averaged about 20-40 umhos/cm higher than surface values. These increases in conductance were undoubtedly related primarily to the release of soluble iron and manganese from the lake bottom under anoxic conditions (Table 2-5). This phenomenon is common in both natural lakes and reservoirs that exhibit hypolimnetic oxygen depletion (Hutchinson 1957, Wetzel 1975).

pH and Alkalinity

During 1994, pH and alkalinity values were similar among MNS discharge, mixing and background zones (Table 2-5); they were also similar to values measured in 1993 (Table 2-5) and historically (DPC 1989,1992, 1993, 1994). Individual pH values in 1994 ranged from 6.2 to 7.6, whereas alkalinity ranged from 11.5 to 17.0 mg-$CaC0^3$/l.

Major Cations and Anions

The concentrations (mg/l) of major ionic species in the MNS discharge, mixing, and mid-lake background zones are provided in Table 2-5. The overall ionic composition of Lake Norman during 1994 was similar to that reported for 1993 (Table 2-5) and previously (DPC 1989, 1992, 1993, 1994). Lake-wide, the major cations were sodium, calcium, magnesium, and potassium; major anions were bicarbonate, sulfate, and chloride.

Nutrients

Nutrient concentrations in the discharge, mixing, and mid-lake background zones of Lake Norman are provided in Table 2-5. Overall, nitrogen and phosphorus levels in 1994 were similar to those measured in 1993 and historically (DPC 1989, 1990, 1991, 1992, 1993, 1994); they are also characteristic of the lake's oligo-mesotrophic status. Ammonia nitrogen concentrations increased in bottom waters in each of the three zones during the summer and fall, concurrent with the development of anoxic conditions. Total and soluble phosphorus concentrations in 1994 were similar to values recorded in 1993 and historically (DPC 1989, 1990, 1991, 1992 , 1993, 1994).

Metals

Metal concentrations in the discharge, mixing, and mid-lake background zones of Lake Norman for 1994 were similar to that measured in 1993 (Table 2-5) and historically (DPC 1989, 1990, 1991, 1992, 1993, 1994). Iron concentrations near the surface were generally low (≤ 0.1 mg/l) during 1993 and 1994, whereas iron levels near the bottom were slightly higher during the stratified period, particularly in early-fall. Similarly, manganese concentrations in the surface and bottom waters were generally low (≤ 0.1 mg/l) in both 1993 and 1994, except during the summer and fall when bottom waters were anoxic (Table 2-5). This phenomenon, i.e., the release of iron and manganese from the bottom sediments due to solubility changes induced by low redox conditions (low oxygen levels) is common in stratified waterbodies (Wetzel 1975). Manganese concentrations near the bottom rose above the NC water quality standard (0.5 mg/l) at various locations throughout the lake in summer and fall of both years, and is characteristic of historic conditions (DPC 1989, 1990, 1991, 1992, 1993, 1994). Heavy metal concentrations in Lake Norman never approached NC water quality standards, and there were no consistent appreciable differences between 1993 and 1994.

FUTURE STUDIES

No changes are planned for the Water Chemistry portion of the Lake Norman maintenance monitoring program during 1995 or 1996.

SUMMARY

Temporal and spatial trends in water temperature and DO data collected monthly in 1994 were similar to those observed historically. Temperature and DO data collected in 1994 were within the range of previously measured values.

Reservoir-wide isotherm and isopleth information for 1994, coupled with heat content and hypolimnetic oxygen data, illustrated that Lake Norman exhibited thermal and oxygen dynamics characteristic of historic conditions and similar to other Southeastern reservoirs of comparable size, depth, flow conditions, and trophic status.

Availability of suitable pelagic habitat for adult striped bass in Lake Norman in 1994 was generally similar to historic conditions. Reservoir-wide habitat elimination did not appear to occur in 1994, but habitat was limited during the period 14 July to 10 August. These conditions were appreciably better than observed in 1993 and within the range observed historically. No mortalities of striped bass were observed or reported in 1994.

All chemical parameters measured in 1994 were within the concentration ranges previously reported for the lake during both MNS preoperational and operational years. As has been observed historically, manganese concentrations in the bottom waters in the summer and fall of 1994 often exceeded the NC water quality standard. This is characteristic of waterbodies that experience hypolimnetic deoxygenation during the summer.

These results indicate that continuation of the alternative thermal limits to the water quality standard for temperature are warranted.

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Table 2-1. Water chemistry program for the McGuire Nuclear Station NPDES long-term maintenance monitoring on Lake Norman.

McGUIRE NPDES SAMPLING PROGRAM
Sample Collection Schedule for 1993

PARAMETERS	LOCATIONS	1.0	2.0	4.0	5.0	8.0	9.5	11.0	13.0	14.0	15.0	15.9	62.0	69.0	72.0	80.0	16.0
	DEPTH (m)	33	33	5	20	32	23	27	21	10	23	23	15	7	5	4	3
	SAM CODE	IN-SITU ANALYSIS															
Temperature	Hydrolab																
Dissolved Oxygen	Hydrolab	In-situ measurements are collected monthly at the above locations at 1m intervals from 0.3m to 1m above bottom. Measurements are taken weekly from July-August for striped bass habitat.															
pH	Hydrolab																
Conductivity	Hydrolab																
NUTRIENT ANALYSES																	
Ammonia	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Nitrate+Nitrite	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Orthophosphate	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Total Phosphorus	AA-TP,DG-P	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Silica	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Cl	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
TKN	AA-TKN	S/T,B												S/T,B			
ELEMENTAL ANALYSES																	
Aluminum	ICP-24		S/T,B	S/T		Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Calcium	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Iron	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Magnesium	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Manganese	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Potassium	306-K	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Sodium	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Zinc	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Cadmium	HGA-CD		S/T,B	S/T		S/T,B	S/T,B			S/T		S/T,B					S/T
Copper	HGA-CU		S/T,B	S/T		S/T,B	S/T,B			S/T		S/T,B					S/T
Lead	HGA-PB		S/T,B	S/T		S/T,B	S/T,B			S/T		S/T,B					S/T
ADDITIONAL ANALYSES																	
Alkalinity	T-ALKT	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Turbidity	F-TURB	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Sulfate	UV_SO4		S/T,B	S/T		S/T,B				S/T		S/T,B					S/T
Total Solids	S-TSE		S/T,B	S/T		S/T,B				S/T		S/T,B					S/T
Total Suspended Solid	S-TSSE		S/T,B	S/T		S/T,B				S/T		S/T,B					S/T

CODES: Frequency Q = Quarterly (Feb, May, Aug, Nov) S = Semi-annually (Feb,Aug)
T = Top (0.3m) B = Bottom (1m above bottom)

Table 2-2. Water chemistry methods and analyte detection limits for the McGuire Nuclear Station NPDES long-term maintenance program for Lake Norman.

Variables	Method	Preservation	Detection Limit
Alkalinity, total	Electrometric titration to a pH of 5.1[2]	4°C	1mg-$CaCO_3 \cdot l^{-1}$*
Aluminum	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.3 $mg \cdot l^{-1}$
Ammonium	Automated phenate[1]	4°C	0.050 $m \cdot gl^{-1}$
Cadmium	Atomic absorption/graphite furnace-direct injection[2]	0.5% HNO_3	0.1 $\mu g \cdot l^{-1}$
Calcium	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.04 $mg \cdot l^{-1}$
Chloride	Automated ferricyanide[1]	4°C	1.0 $mg \cdot l^{-1}$
Conductance, specific	Temperature compensated nickel electrode[1]	In-situ	1 $\mu mho \cdot cm^{-1}$*
Copper	Atomic absorption/graphite furnace-direct injection[3]	0.5% HNO_3	0.5 $\mu g \cdot l^{-1}$
Fluoride	Potentiometric[2]	4°C	0.10mg.l^{-1}
Iron	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.1 $mg \cdot l^{-1}$
Lead	Atomic absorption graphite furnace-direct injection[2]	0.5% HNO_3	2.0 $\mu g \cdot l^{-1}$
Magnesium	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.001 $mg \cdot l^{-1}$
Manganese	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.003 $mg \cdot l^{-1}$
Nitrite + Nitrate	Automated cadmium reduction[1]	4°C	0.050 mg.l^{-1}
Orthophosphate	Automated ascorbic acid reduction,	4°C	0.005 mg.l^{-1}
Oxygen, dissolved	Temperature compensated polarographic cell[1]	In-situ	0.1 $mg \cdot l^{-1}$*
pH	Temperature compensated glass electrode[1]	In-situ	0.1 std. units*
Phosphorus, total	Persulfate digestion followed by automated ascorbic acid reduction[1]	4°C	0.005 $mg \cdot l^{-1}$** 0.015 $mg \cdot l^{-1}$**
Potassium	Atomic absorption graphite furnace-direct injection[2]	0.5% HNO_3	0.1 $mg \cdot l^{-1}$
Silica	Automated molydosilicate[1]	4°C	0.5 $mg \cdot l^{-1}$
Sodium	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.3 $m \cdot gl^{-1}$
Sulfate	Turbidimetric, using a spectrophotometer[3]	4°C	1.0 $mg \cdot l^{-1}$
Temperature	Thermistor/thermometer[1]	In-situ	0.1°C*
Turbidity	Nephelometric turbidity[1]	4°C	1 NTU*
Zinc	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	4 $\mu g \cdot l^{-1}$

[1] United States Environmental Protection Agency 1979. Methods for chemical analysis of water and wastes. Environmental Monitoring and Support Laboratory. Cincinnati, OH.

[2] USEPA. 1982.

[3] USEPA. 1984

*Instrument sensitivity used instead of detection limit.

**Detection limit changed during 1989.

Table 2-3. Heat content calculations for the thermal regime in Lake Norman in 1993 and 1994.

	1993	1994
Maximum areal heat content (g cal/cm^2)	28,141	27,873
Minimum areal heat content (g cal/cm^2)	8,890	7,336
Maximum hypolimnetic (below 11.5 m) areal heat content (g cal/cm^2)	15,106	15,130
Birgean heat budget (g cal/cm^2)	19,251	20,537
Epilimnion (above 11.5 m) heating rate (C/day)	0.114	0.138
Hypolimnion (below 11.5 m) heating rate (C/day)	0.087	0.105

Table 2-4. A comparison of areal hypolimnetic oxygen deficits (AHOD), summer chlorophyll a (chl a), secchi depth (SD), and mean depth of Lake Norman and 18 TVA reservoirs.

Reservoir	AHOD (mg/cm^2/day)	Summer Chl a (ug/L)	Secchi Depth (m)	Mean Depth (m)
Lake Norman	0.044	7.6	3.0	10.3
TVA [a]				
Mainstem				
Kentucky	0.012	9.1	1.0	5.0
Pickwick	0.010	3.9	0.9	6.5
Wilson	0.028	5.9	1.4	12.3
Wheelee	0.012	4.4		5.3
Guntersville	0.007	4.8	1.1	5.3
Nickajack	0.016	2.8	1.1	6.8
Chickamauga	0.008	3.0	1.1	5.0
Watts Bar	0.012	6.2	1.0	7.3
Fort London	0.023	5.9	0.9	7.3
Tributary				
Chatuge	0.041	5.5	2.7	9.5
Cherokee	0.078	10.9	1.7	13.9
Douglas	0.046	6.3	1.6	10.7
Fontana	0.113	4.1	2.6	37.8
Hiwassee	0.061	5.0	2.4	20.2
Norris	0.058	2.1	3.9	16.3
South Holston	0.070	6.5	2.6	23.4
Tims Ford	0.059	6.1	2.4	14.9
Watauga	0.066	2.9	2.7	24.5

[a] Data from Higgins et al. (1980), and Higgins and Kim (1981)

Table 2-5. Quarterly surface (0.3 m) and bottom (bottom minus 1 m) water chemistry for the MNS discharge, mixing zone, and background locations on Lake Norman during 1993 and 1994. Values less than detection were assumed to be the detection limit for calculating a mean.

LOCATION:	Mixing Zone 1.0				Mixing Zone 2.0				MNS Discharge 4.0		Mixing Zone 5.0				Background 8.0				Background 11.0			
DEPTH:	Surface		Bottom		Surface		Bottom		Surface		Surface		Bottom		Surface		Bottom		Surface		Bottom	
PARAMETERS YEAR:	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94
Turbidity (ntu)																						
Feb	4	2	6	4	4	3	5	4	3	3	4	3	4	4	4	3	7	NS	10	6	11	8
May	6	2	10	3	5	2	9	5	7	2	5	2	9	7	5	2	12	9	12	3	8	14
Aug	2	4	6	17	2	5	7	10	2	2	3	2	11	5	2	2	8	4	3	5	9	7
Nov	3	4	6	8	2	3	7	6	2	4	2	3	4	8	2	3	2	9	4	3	2	10
Annual Mean	3.75	3	7	7.5	3.25	3.25	7	6.25	3.5	2.75	3.5	2.5	7	6	3.25	2.5	7.25	7.33	7.25	4.25	7.5	9.75
Specific Conductance (umho/cm)																						
Feb	56	63	54	66	56	NS	55	NS	57	64	56	59	55	60	55	68	52	72	50	76	50	76
May	51	66	51	67	51	68	51	67	50	66	53	66	54	68	51	66	51	65	48	63	49	64
Aug	51	65	63	80	51	65	60	80	52	64	51	65	61	80	51	64	59	77	52	64	61	75
Nov	55	55	88	92	54	56	89	61	53	57	52	56	51	56	51	55	84	55	55	54	55	57
Annual Mean	53.3	62.3	64	76.3	53	62.3	63.8	69.3	53	62.8	53	61.5	55.3	66	52	63.3	61.5	67.3	51.3	64.3	53.8	68
pH (units)																						
Feb	6.8	7.6	6.8	6.8	6.8	NS	6.8	NS	6.7	6.9	6.8	6.9	6.8	6.9	6.9	6.9	6.8	6.8	6.9	7	6.8	6.8
May	6.6	6.9	6.3	6.6	6.6	6.9	6.3	6.5	6.4	6.6	6.8	6.8	6.3	6.6	6.9	7.1	6.3	6.5	7.1	6	6.3	6.5
Aug	6.5	6.7	6.1	6.4	6.3	6.8	6	6.3	6	6.5	6.4	6.7	6.1	6.2	6.5	7	6	6.4	6.5	7.5	6.1	6.3
Nov	6.9	7.2	6.8	6.6	6.7	7	6.9	6.6	6.6	6.9	6.7	7.1	6.8	6.6	6.9	7.4	6.8	6.4	6.8	7.3	6.8	6.5
Annual Mean	6.7	7.1	6.5	6.6	6.6	6.9	6.5	6.47	6.43	6.73	6.68	6.88	6.5	6.58	6.8	7.1	6.48	6.53	6.83	7.45	6.5	6.53
Alkalinity (mg CaCO3/l)																						
Feb	11.1	13.1	11.3	13.6	11.6	13.2	11.3	12.7	11.5	12	11.3	12.4	11.6	12.9	11.5	13.4	10.9	NS	10.8	13.9	10.6	14.5
May	10.8	11.6	10.6	11.7	11.1	12	10.8	11.5	10.9	11.7	11.4	12	11.4	11.8	10.7	11.5	10.3	12.1	10.8	11.5	10.1	11.5
Aug	11.7	12.5	15.9	16.5	11.8	12.2	15.8	17	11.8	12.9	11.9	12.6	16.2	13.3	11.8	12.4	16	13.8	12.3	12.9	16.4	13
Nov	12.5	14.2	23.8	14.6	12.7	12.6	24.8	13.6	13.3	12.4	12.7	12.4	12.5	12.6	13.1	12.4	13.1	12.4	13.3	12.1	13.6	12.4
Annual Mean	11.5	12.9	15.4	14.1	11.8	12.5	15.7	13.7	11.9	12.3	11.8	12.4	12.9	12.7	11.8	12.4	12.6	12.8	11.8	12.6	12.7	12.9
Chloride (mg/l)																						
Feb	2.6	6.1	2.5	6.8	2.7	6.6	2.3	6.7	2.8	6.5	2.9	5.5	2.5	5.5	2.6	6.5	2.3	NS	2.2	8.4	2	8
May	4.1	5.7	4	5.8	3.5	7.4	4.2	6.1	3.7	6.1	3.7	6.3	3.8	6.2	4.3	6.5	4.2	6.2	3.2	5.2	3.2	4.4
Aug	4.5	6.3	4.7	7.3	4	6	3.5	6.2	4	7.7	5	6.7	4.1	5.6	5	7	5.2	7	7	6	4	6.2
Nov	4.1	5.8	4.1	5.9	4.2	5.7	4.2	5.9	4.2	6	4.4	5.9	4.3	6	4.3	6	4.3	6	5.1	5.7	4.1	6.3
Annual Mean	3.83	5.98	3.83	6.45	3.6	6.43	3.55	6.23	3.63	6.58	4	6.1	3.66	5.83	4.05	6.5	4	6.4	4.38	6.33	3.33	6.23
Sulfate (mg/l)																						
Feb	NS	NS	NS	NS	13.9	6.7	4.1	7.7	3.7	7.2	NS	NS	NS	NS	4.1	7.4	3.6	NS	NS	NS	NS	NS
Aug	NS	NS	NS	NS	5	5	5.5	4	5.3	4.3	NS	NS	NS	NS	6	4.3	5.6	5.1	NS	NS	NS	NS
Annual Mean					9.45	5.85	4.8	5.85	4.5	5.75					5.05	5.85	4.6	5.1				
Calcium (mg/l)																						
Feb	2.5	NS	2.6	NS	2.5	NS	2.6	NS	2.5	NS	2.5	NS	2.6	NS	2.5	NS	2.6	NS	2.7	NS	2.7	NS
May	2.5	2.7	2.6	2.8	2.5	2.8	2.6	2.9	2.5	2.8	2.6	2.8	2.7	2.9	2.6	2.8	2.6	3	2.6	2.7	2.5	3
Aug	2.7	2.8	3.3	3.3	2.7	2.8	3.3	3.4	2.8	2.9	2.8	2.9	3.1	3	2.8	2.7	3.4	3	2.9	2.9	3.4	3
Nov	2.7	2.9	3.5	3	2.6	2.8	3.6	2.9	2.6	2.8	2.7	2.8	2.6	2.8	2.6	2.8	2.6	2.7	2.6	2.7	2.6	2.7
Annual Mean	2.6	2.8	3	3.03	2.58	2.8	3.03	3.07	2.6	2.83	2.65	2.83	2.75	2.9	2.63	2.77	2.8	2.9	2.7	2.77	2.8	2.9
Magnesium (mg/l)																						
Feb	1.2	NS	1.2	NS	1.2	NS	1.2	NS	1.2	NS	1.2	NS	1.2	NS	1.2	NS	1.2	NS	1.2	NS	1.2	NS
May	1.1	1.3	1.1	1.3	1.1	1.3	1.1	1.3	1.1	1.3	1.1	1.3	1.2	1.3	1.1	1.3	1.1	1.3	1.1	1.3	1.1	1.3
Aug	1.2	1.2	1.3	1.3	1.2	1.2	1.3	1.4	1.3	1.3	1.2	1.3	1.3	1.3	1.3	1.2	1.3	1.3	1.3	1.3	1.4	1.3
Nov	1.3	1.3	1.4	1.3	1.2	1.3	1.4	1.3	1.2	1.3	1.3	1.3	1.3	1.3	1.2	1.3	1.3	1.3	1.2	1.3	1.2	1.3
Annual Mean	1.2	1.27	1.25	1.3	1.18	1.27	1.25	1.33	1.2	1.3	1.2	1.3	1.25	1.3	1.2	1.27	1.23	1.3	1.2	1.3	1.23	1.3

NS = Not Sampled

Table 2-5. (Continued)

LOCATION:	Mixing Zone 1.0				Mixing Zone 2.0				MNS Discharge 4.0		Mixing Zone 5.0				Background 8.0				Background 11.0			
DEPTH:	Surface		Bottom		Surface		Bottom		Surface		Surface		Bottom		Surface		Bottom		Surface		Bottom	
PARAMETERS YEAR:	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94
Potassium (mg/l)																						
Feb	1.5	1.6	1.7	1.6	1.8	NS	1.7	NS	1.8	NS	1.7	1.5	1.7	1.5	1.8	NS	1.7	NS	1.7	1.7	1.6	1.6
May	1.7	1.7	1.6	1.3	1.7	1.4	1.6	1.5	1.5	1.4	1.4	1.4	1.7	1.5	1.7	1.5	1.7	1.5	1.8	1.4	1.8	1.5
Aug	1.4	1.5	1.6	1.5	1.4	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nov	1.5	2.9	1.7	1.6	1.6	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.4	1.6	1.5	1.7	1.6	1.6	1.5	1.7	1.5	1.7
Annual Mean	1.6	1.93	1.65	1.5	1.63	1.53	1.6	1.53	1.58	1.5	1.55	1.5	1.55	1.53	1.63	1.57	1.63	1.53	1.63	1.58	1.6	1.58
Sodium (mg/l)																						
Feb	5.4	NS	5	NS	5.3	NS	5.2	NS	5.3	NS	5.5	NS	5.2	NS	5	NS	4.4	NS	4.1	NS	4	NS
May	3.9	5.5	3.8	5.5	3.8	5.7	3.8	5.8	3.8	5.6	3.9	5.6	4	5.8	3.9	5.8	3.8	5.7	3.8	4.8	3.5	5.2
Aug	4.2	4.7	4	4.8	4.2	4.9	4.1	5.1	4.2	4.9	4.2	4.6	4.1	4.4	4.2	4.6	4	4.7	4.3	4.5	4	4.5
Nov	5	5.7	4.3	5.6	4.9	5.3	4.2	5.5	4.8	5.5	4.9	5.3	4.8	5.4	5	5.2	5	5.2	5.3	5.5	5.3	5.4
Annual Mean	4.63	5.3	4.28	5.3	4.55	5.3	4.33	5.47	4.53	5.33	4.63	5.17	4.53	5.2	4.53	5.2	4.3	5.2	4.38	4.93	4.2	5.03
Aluminum (mg/l)																						
Feb	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS	< 0.2	NS
May	< 0.2	0.1	< 0.2	0.1	< 0.2	0.1	< 0.2	0.1	< 0.2	0.1	< 0.2	0.1	< 0.2	0.1	< 0.2	0.1	< 0.2	0.1	< 0.2	< 0.1	< 0.2	0.2
Aug	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1
Nov	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	0.1
Annual Mean	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.1	< 0.2	< 0.13
Iron (mg/l)																						
Feb	0.1	NS	0.1	NS	< 0.1	NS	0.1	NS	< 0.1	NS	< 0.1	NS	0.1	NS	0.1	NS	0.1	NS	0.1	NS	0.1	NS
May	0.1	0.1	0.2	0.1	0.1	< 0.1	0.2	0.1	0.1	< 0.1	0.1	< 0.1	0.1	0.1	0.1	< 0.1	0.2	0.2	0.2	< 0.1	0.1	0.2
Aug	0.1	0.1	0.4	0.5	< 0.1	< 0.1	0.8	0.7	0.1	< 0.1	< 0.1	< 0.1	0.8	0.1	< 0.1	< 0.1	0.8	0.2	0.1	< 0.1	0.7	0.1
Nov	0.1	< 0.1	4.5	0.2	0.1	< 0.1	5.9	0.1	0.1	< 0.1	0.1	< 0.1	0.1	0.2	0.1	< 0.1	0.1	0.2	0.1	< 0.1	0.1	0.2
Annual Mean	0.1	< 0.1	1.3	0.27	< 0.1	< 0.1	1.7	0.3	< 0.1	< 0.1	< 0.1	< 0.1	0.28	0.13	< 0.1	< 0.1	0.3	0.2	0.13	< 0.1	0.25	0.17
Manganese (mg/l)																						
Feb	0.01	NS	0.03	NS	0.01	NS	0.02	NS	0.01	NS	0.01	NS	0.02	NS	0.01	NS	0.02	NS	0.02	NS	0.02	NS
May	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0.05	0.06	0.01	0.01	0.02	0.05	1.93	< 0.01	0.01	0.07
Aug	< 0.01	0.02	1.58	1.54	0.02	0.02	1.64	1.68	0.07	0.05	0.03	0.03	1.25	0.4	0.01	0.02	1.59	0.41	0.05	0.02	1.9	0.27
Nov	0.11	0.04	3.63	0.78	0.13	0.05	3.52	0.42	0.15	0.05	0.13	0.04	0.1	0.15	0.06	0.03	0.08	0.23	0.09	0.04	0.09	0.16
Annual Mean	0.04	0.02	1.32	0.78	0.04	0.03	1.3	0.71	0.06	0.04	0.05	0.03	0.36	0.2	0.02	0.02	0.43	0.23	0.52	0.02	0.51	0.17
Cadmium (ug/l)																						
Feb	< 0.1	NS	0.1	NS	< 0.1	NS	< 0.1	NS	< 0.1	NS	< 0.1	NS	0.5	NS	< 0.1	NS	< 0.1	NS	< 0.1	NS	0.1	NS
Aug	NS	NS	NS	NS	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	NS	NS	NS	NS	< 0.1	< 0.1	< 0.1	< 0.1	NS	NS	NS	NS
Annual Mean	< 0.1		0.1		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1		0.5		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1		0.1	
Copper (ug/l)																						
Feb	1.3	NS	1.2	NS	1.2	1.3	1.1	1.9	1.2	2	1	NS	1.8	NS	1.1	1.6	1.4	NS	1.8	NS	1.3	NS
Aug	NS	NS	NS	NS	2.9	2.4	0.6	0.8	1.5	1.4	NS	NS	NS	NS	1.2	2.4	0.5	1.1	NS	NS	NS	NS
Annual Mean	1.3		1.2		2.05	1.85	0.85	1.35	1.35	1.7	1		1.6		1.15	2	0.95	1.1	1.8		1.3	
Lead (ug/l)																						
Feb	NS	NS	NS	NS	< 2	NS	< 2	NS	< 2	NS	NS	NS	NS	NS	< 2	NS	< 2	NS	NS	NS	NS	NS
Aug	NS	NS	NS	NS	< 2	< 2	< 2	< 2	< 2	< 2	NS	NS	NS	NS	< 2	< 2	< 2	< 2	NS	NS	NS	NS
Annual Mean					< 2	< 2	< 2	< 2	< 2	< 2					< 2	< 2	< 2	< 2				
Zinc (ug/l)																						
Feb	< 10	NS	< 10	NS	< 10	NS	< 10	NS	< 10	NS	< 10	NS	< 10	NS	< 10	NS	< 10	NS	< 10	NS	< 10	NS
May	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5
Aug	< 10	7	< 10	< 5	< 10	6	< 10	7	< 10	7	< 10	20	< 10	6	< 10	42	< 10	< 5	20	25	< 10	< 5
Nov	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	< 10	< 5	12	< 5	< 10	< 5
Annual Mean	< 10	5.67	< 10	< 5	< 10	5.33	< 10	5.67	< 10	5.67	< 10	10	< 10	5.33	< 10	17.3	< 10	< 5	13	11.7	< 10	< 5

NS = Not Sampled

Table 2-5. (Continued)

	Mixing Zone				Mixing Zone				MNS Discharge		Mixing Zone				Background				Background			
LOCATION:	1.0				2.0				4.0		5.0				8.0				11.0			
DEPTH:	Surface		Bottom		Surface		Bottom		Surface		Surface		Bottom		Surface		Bottom		Surface		Bottom	
PARAMETERS YEAR:	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94	93	94
Nitrate (ug/l)																						
Feb	143	302	158	329	140	352	148	243	148	229	140	210	148	212	142	245	188	NS	203	320	205	325
May	270	307	366	385	< 296	305	359	390	292	315	268	307	329	355	265	288	358	418	237	260	356	287
Aug	83	140	327	250	305	140	95	190	128	140	114	140	66	200	66	130	288	130	67	NS	223	NS
Nov	86	160	< 50	140	89	170	< 50	160	85	160	107	160	83	160	91	150	94	210	104	200	149	210
Annual Mean	146	227	225	276	208	242	163	246	163	211	157	204	157	232	141	203	232	253	153	260	233	274
Ammonia (ug/l)																						
Feb	< 50	76	< 50	125	< 50	141	< 50	60	< 50	111	< 50	59	< 50	33	< 50	59	< 50	NS	< 50	117	< 50	106
May	< 50	2	< 50	5	< 50	36	< 50	30	< 50	34	< 50	23	< 50	44	< 50	49	11	< 50	< 50	< 50	< 50	0
Aug	< 50	< 50	82	110	99	< 50	< 50	80	< 50	< 50	< 50	< 50	168	< 50	< 50	< 50	117	< 50	76	< 50	101	< 50
Nov	191	50	661	150	119	< 50	729	90	151	70	129	60	101	90	96	50	105	120	145	< 50	153	80
Annual Mean	85.3	44.5	211	97.5	79.5	69.3	220	65	75.3	66.3	69.8	48	92.3	54.3	61.5	52	70.8	73.3	80.3	66.8	88.5	59
Total Phosphorous (ug/l)																						
Feb	16	9	9	9	16	8	13	9	12	11	9	5	11	9	15	10	14	NS	26	11	19	15
May	11	9	14	7	12	6	14	8	13	7	10	6	10	13	13	8	17	11	16	13	20	13
Aug	< 5	5	5	5	7	12	7	5	7	9	6	10	7	8	7	< 5	8	< 5	7	8	8	< 5
Nov	6	28	8	11	6	8	11	10	5	5	8	14	6	7	6	9	8	13	7	7	6	17
Annual Mean	9.5	12.8	9	8	10.3	8.5	11.3	8	9.25	8	7.75	8.75	8.5	9.25	10.3	8	11.8	9.67	14	9.75	13.3	12.5
Orthophosphate (ug/l)																						
Feb	5	15	19	6	< 5	22	5	8	< 5	20	5	11	< 5	13	< 5	15	7	NS	8	14	6	12
May	5	3	10	5	< 5	4	7	6	10	3	7	3	8	6	5	6	8	11	12	10	13	< 5
Aug	< 5	< 5	7	9	5	< 5	< 5	< 5	< 5	5	< 5	6	< 5	< 5	< 5	< 5	4	5	< 5	5	5	< 5
Nov	7	20	8	13	5	10	8	38	5	9	< 5	18	< 5	17	5	5	6	8	7	14	11	15
Annual Mean	5.5	10.8	11	8.25	< 5	10.3	6.25	14.3	8.25	9.25	5.5	9.5	5.75	10.3	< 5	7.75	6.25	8	8	10.8	8.75	9.25
Silica (mg/l)																						
Feb	4.2	4.8	4.3	5.1	4.2	4.9	4.2	5.1	4.2	4.8	4.1	4.8	4.2	4.8	4.2	5	4.5	NS	4.5	4.6	4.6	5.4
May	4.2	4.7	4.5	5	4.1	4.6	4.3	5	4.3	4.7	4.2	4.7	4.4	5.1	4.1	4.6	4.3	5	4.1	4.5	4.5	4.5
Aug	3.5	3.3	4.5	4.7	4.7	3.4	3.4	4.7	3.6	3.3	3.5	3.3	4.4	3.8	3.4	3.4	4.8	3.7	3.9	3.4	4.6	3.7
Nov	4.4	4.1	5.6	4.1	4.4	4.1	5.7	4.3	4.4	4	4.4	4	4.4	4.2	4.3	4	4.4	4.7	4.9	4.4	5	4.7
Annual Mean	4.08	4.23	4.73	4.73	4.35	4.25	4.4	4.78	4.13	4.2	4.05	4.2	4.35	4.48	4	4.25	4.5	4.47	4.35	4.23	4.68	4.58

NS = Not Sampled

Figure 2-1. Sampling locations on Lake Norman, North Carolina during maintenance monitoring program for McGuire Nuclear Station.

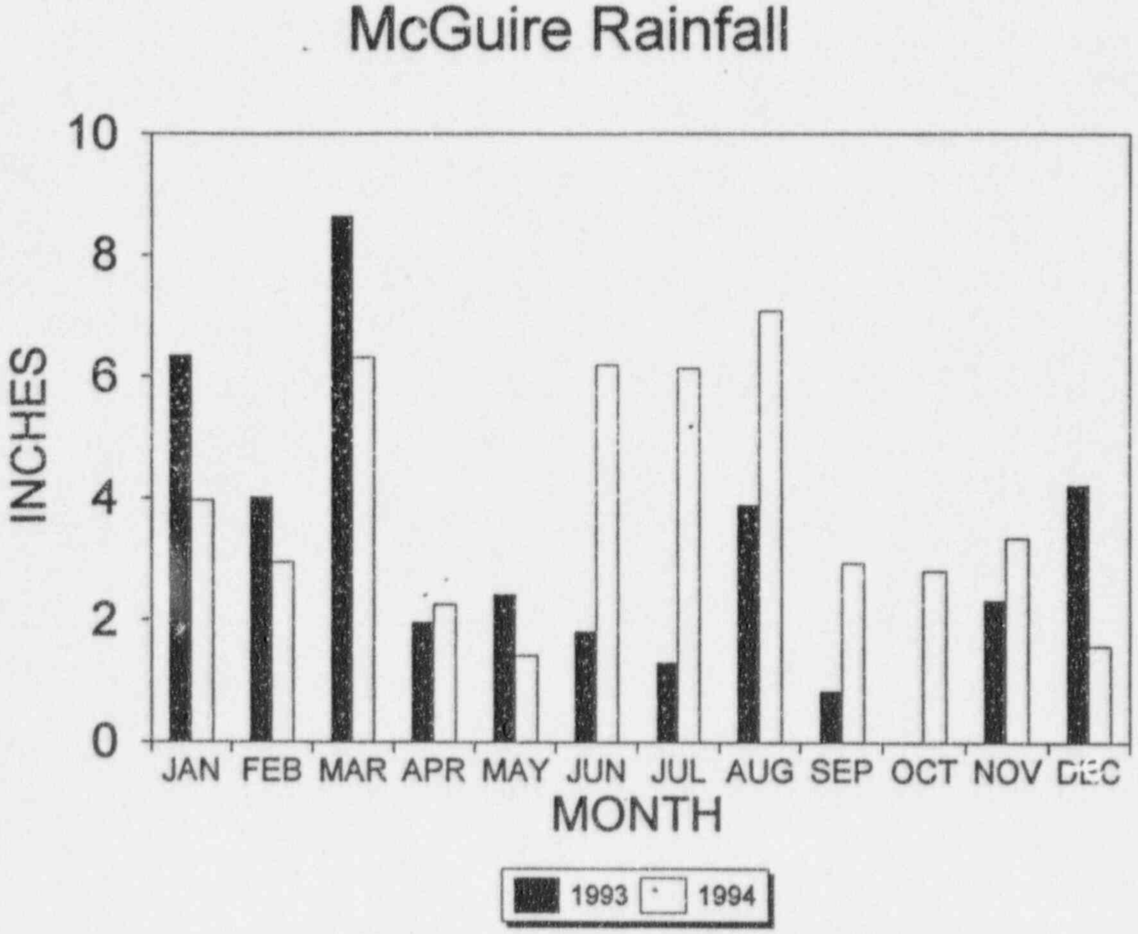


Figure 2-2. Monthly precipitation in the vicinity of McGuire Nuclear Station.

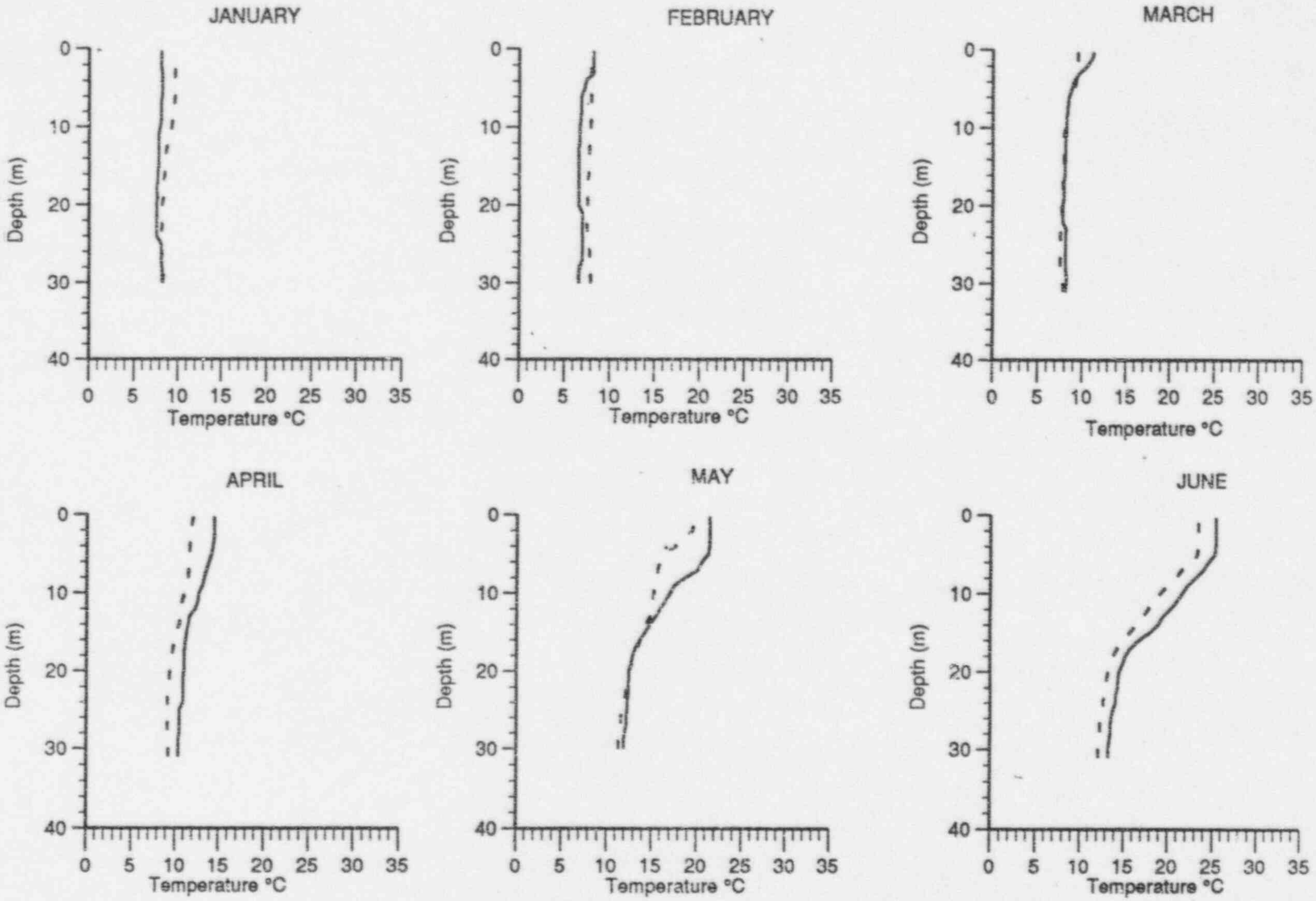


Figure 2-3. Monthly mean temperature profiles for the McGuire Nuclear Station background zone in 1993 (---) and 1994 (—).

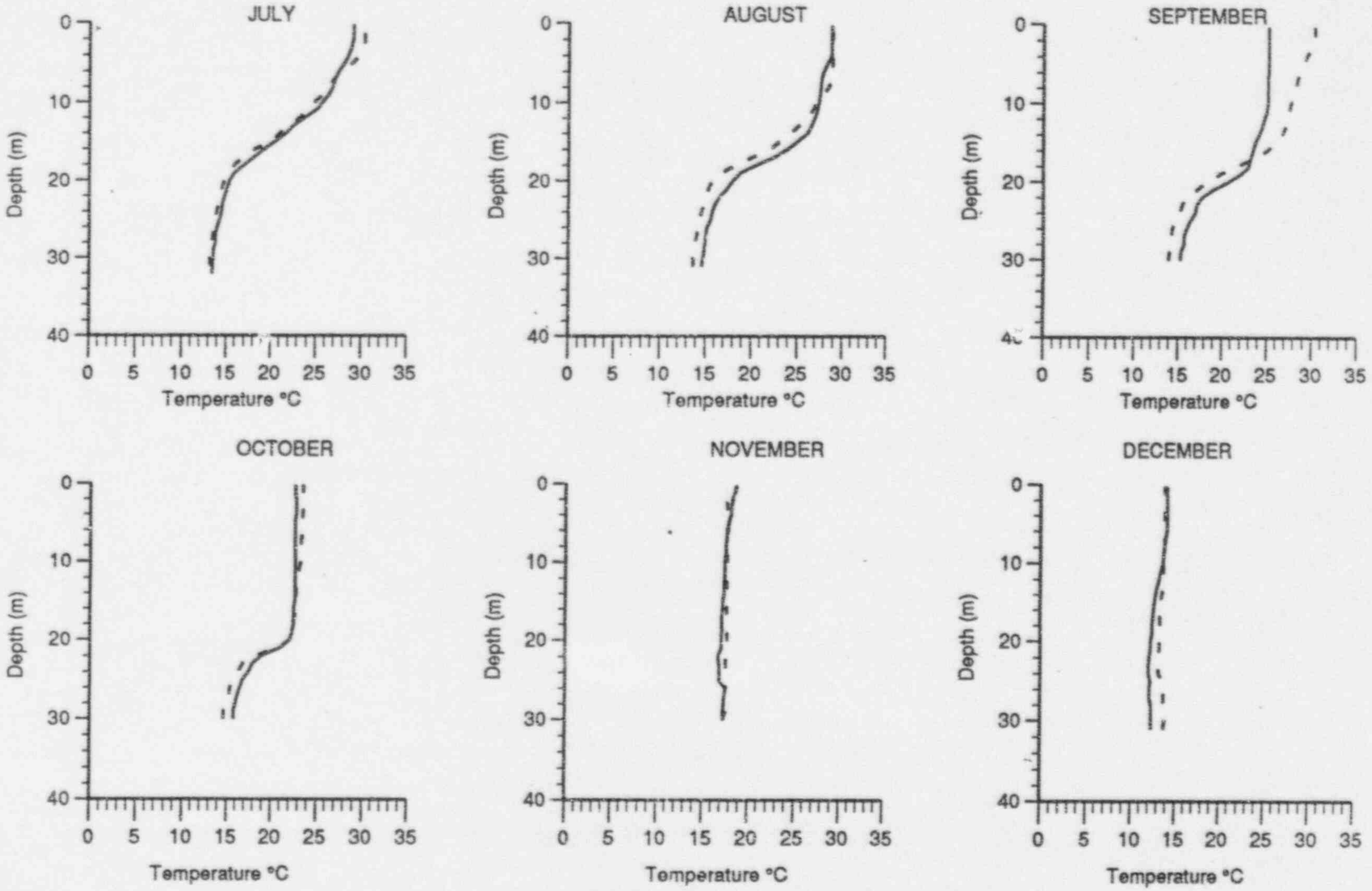


Figure 2-3. Continued.

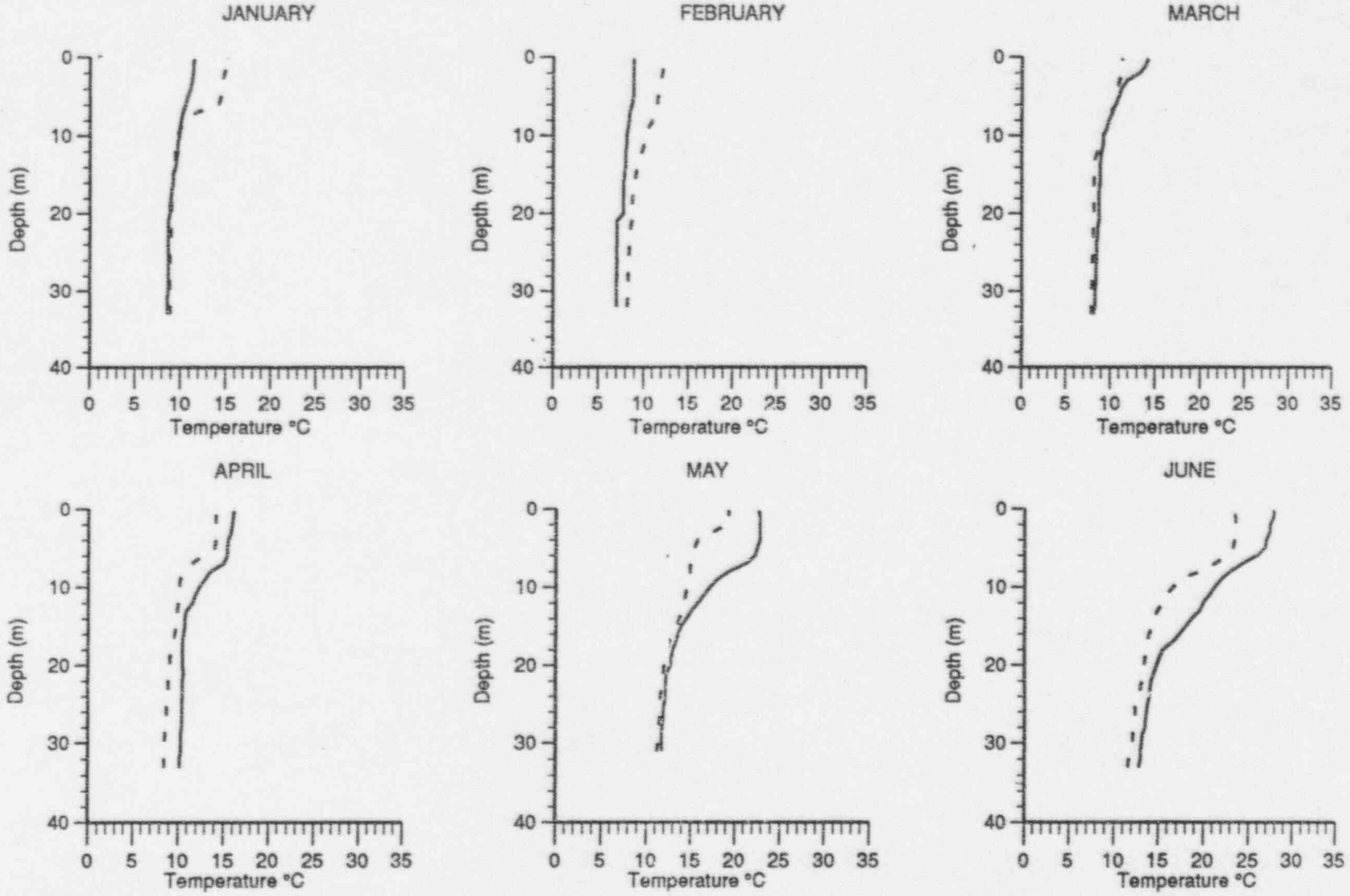


Figure 2-4. Monthly mean temperature profiles for the McGuire Nuclear Station mixing zone in 1993 (---) and 1994 (—).

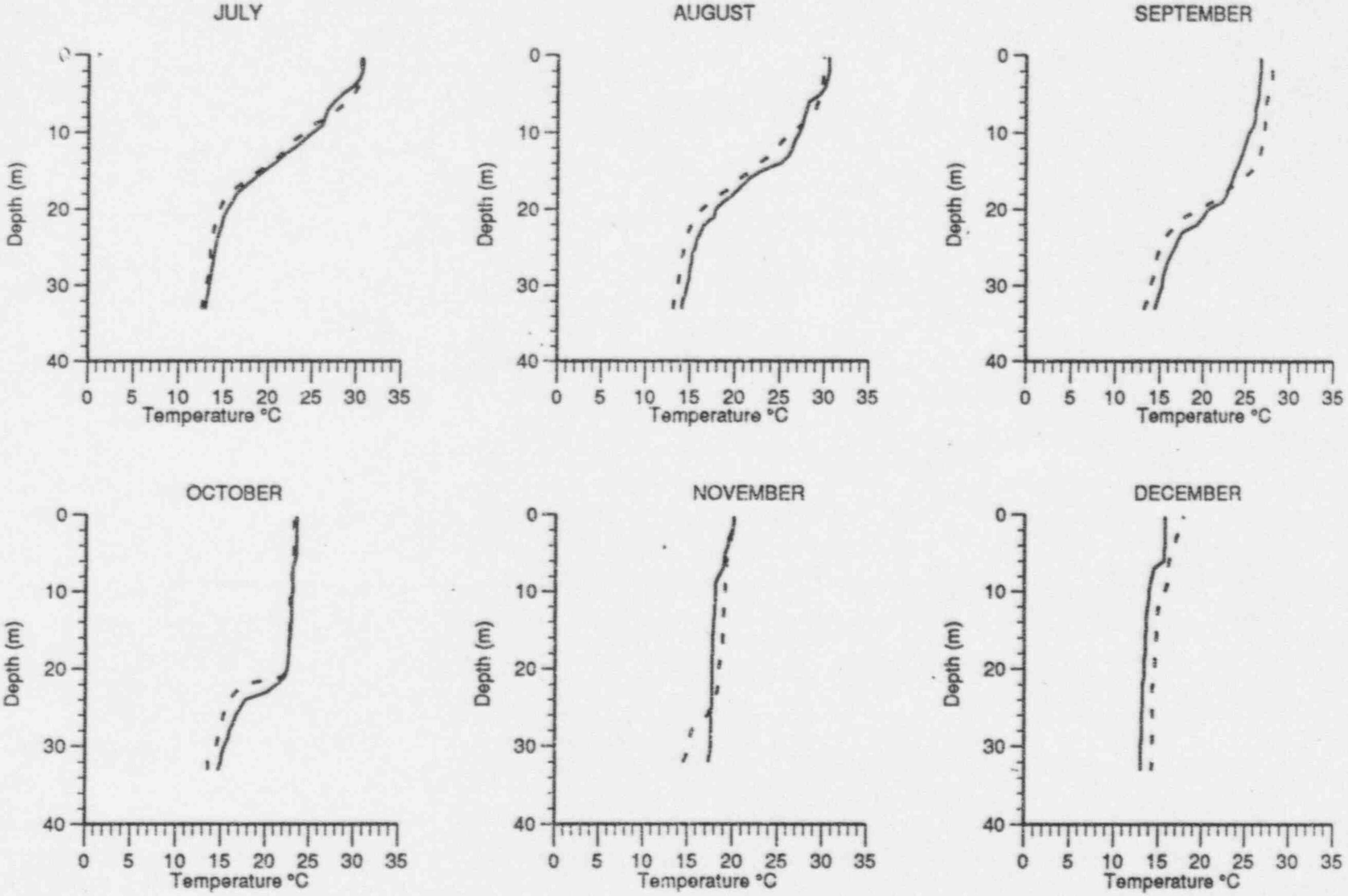


Figure 2-4. Continued.

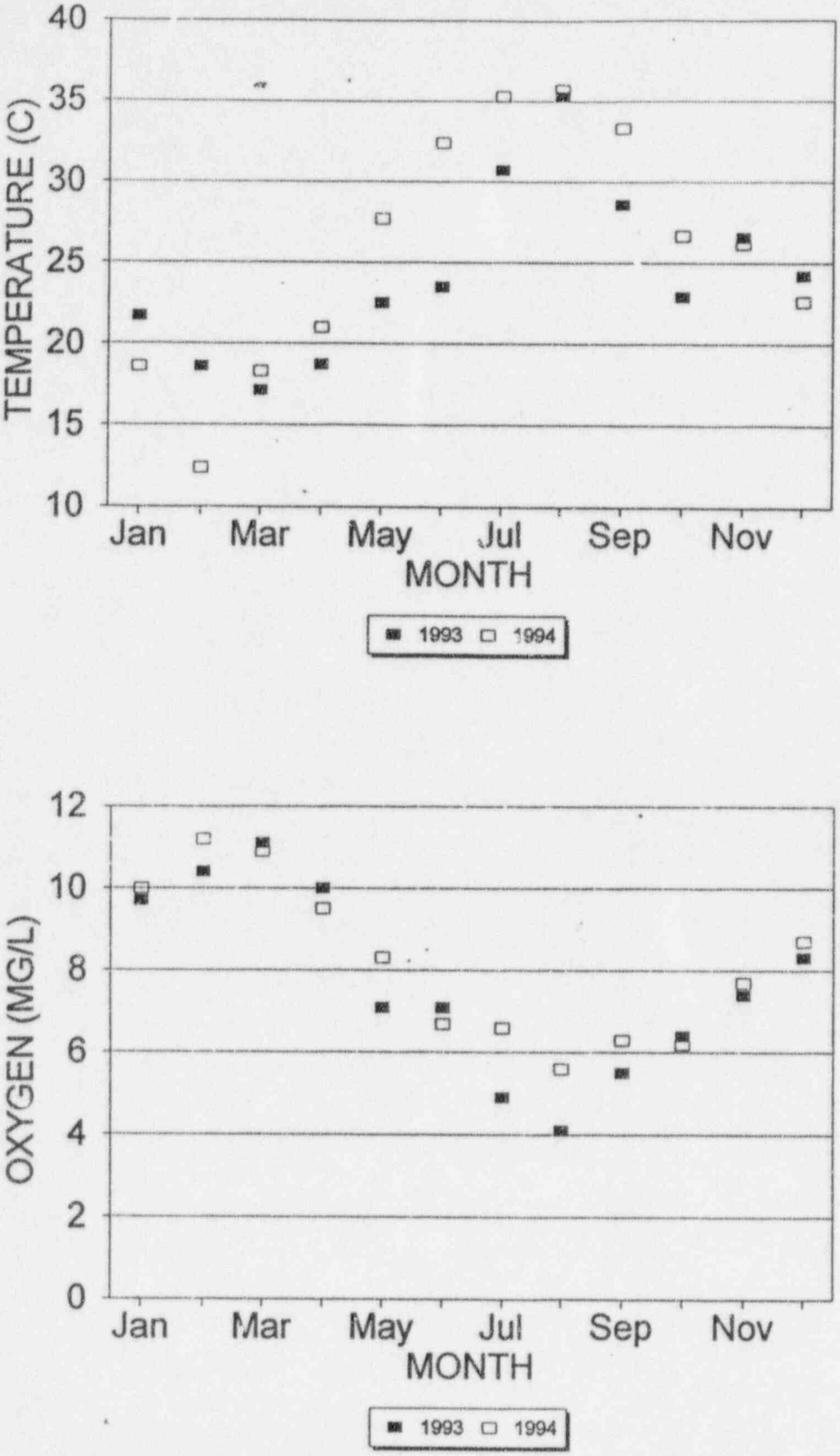


Figure 2-5. Monthly temperature and dissolved oxygen data at the discharge location in 1993 and 1994.

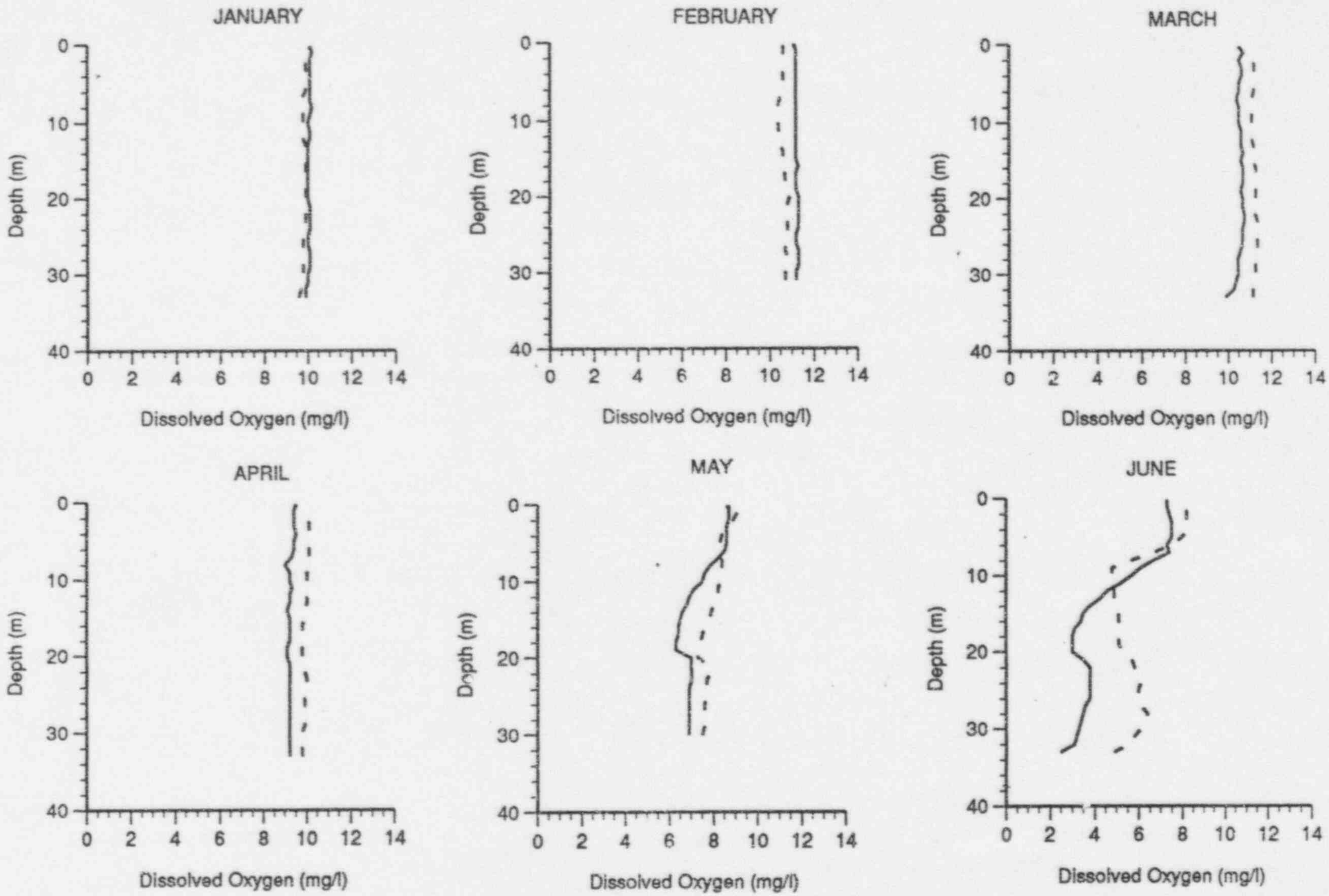
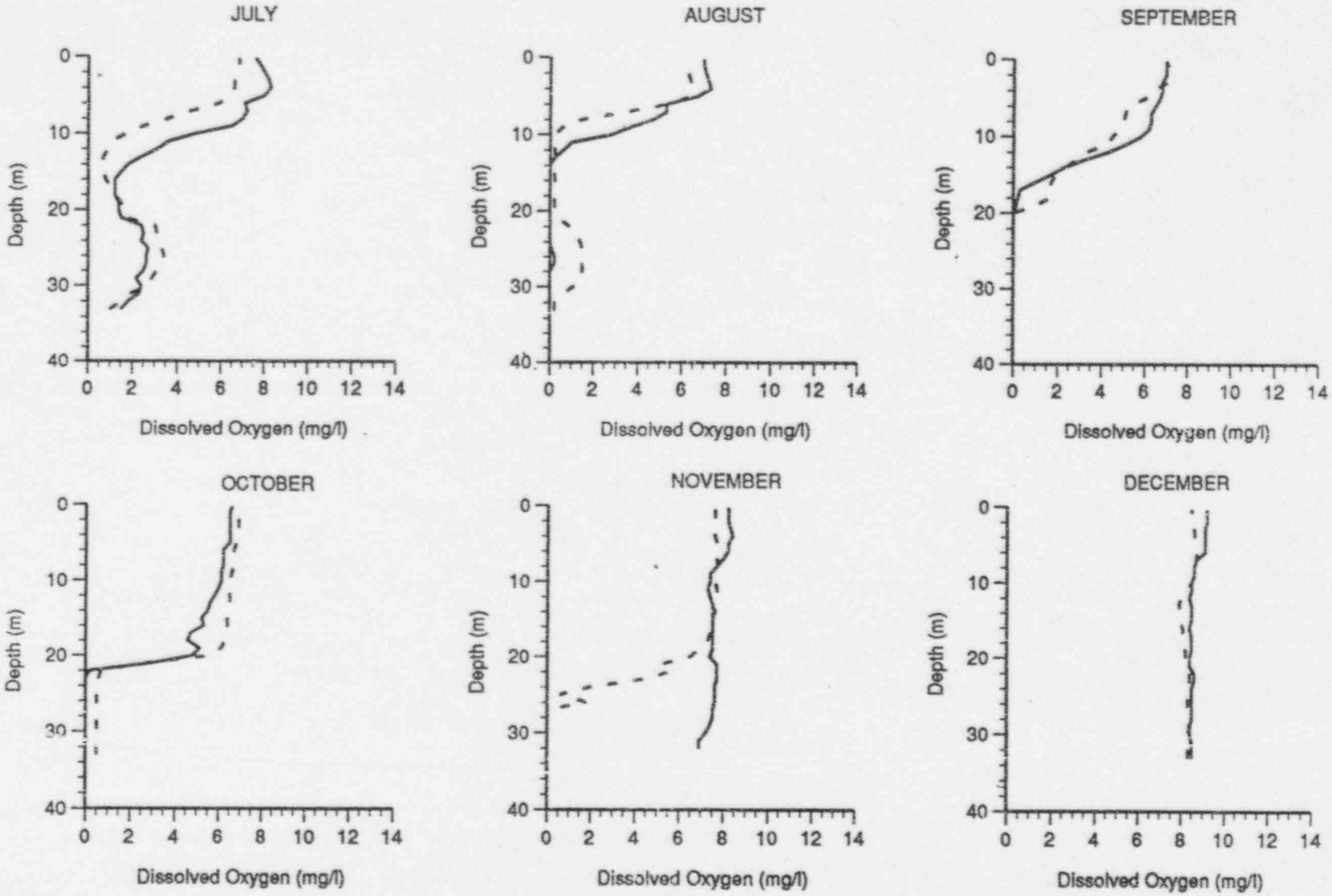


Figure 2-6. Monthly mean dissolved oxygen profiles for the McGuire Nuclear Station mixing zone in 1993 (---) and 1994 (—).



JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER

DECEMBER

Figure 2-6. Continued.

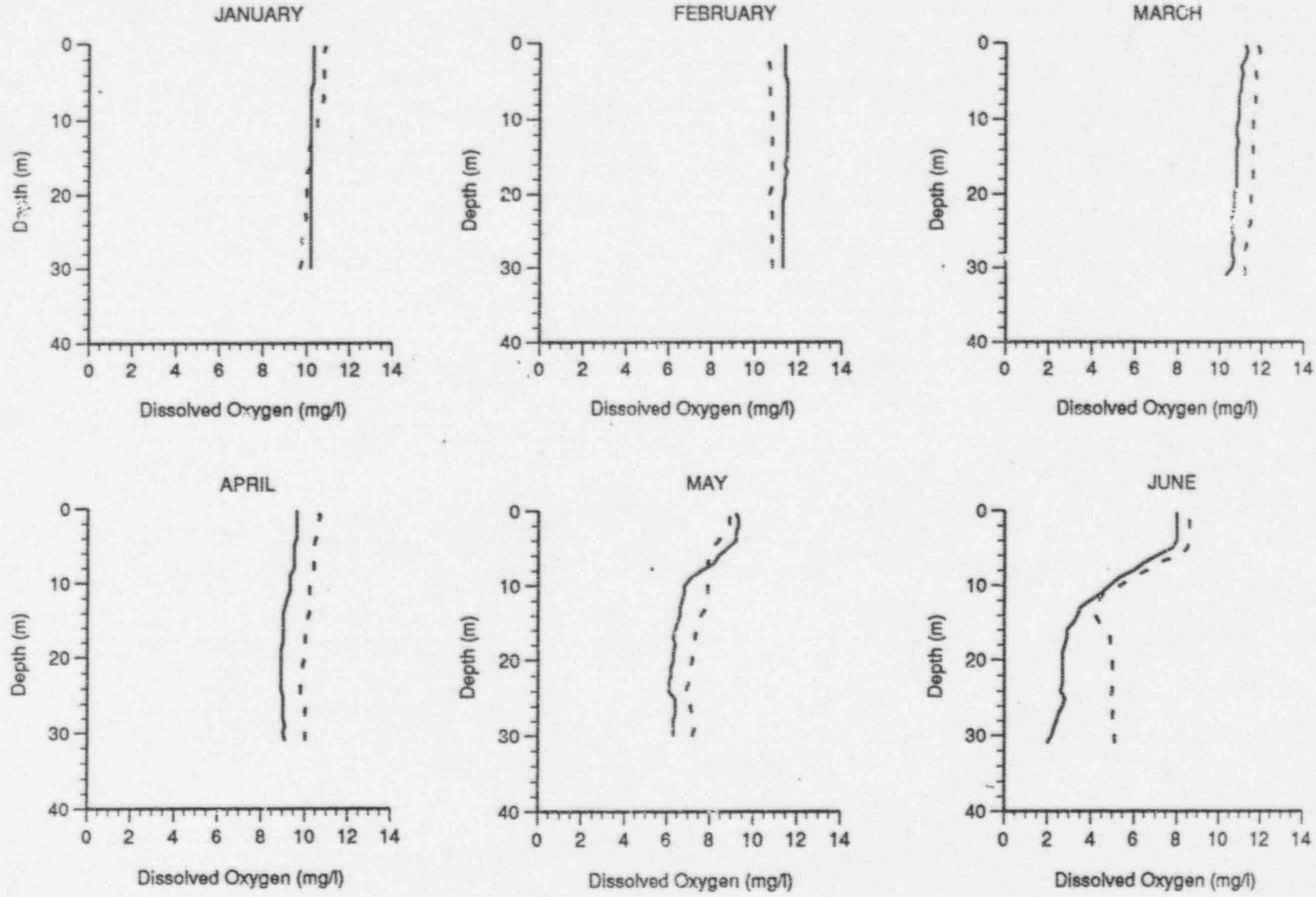


Figure 2-7. Monthly mean dissolved oxygen profiles for the McGuire Nuclear Station background zone in 1993 (---) and 1994 (—).

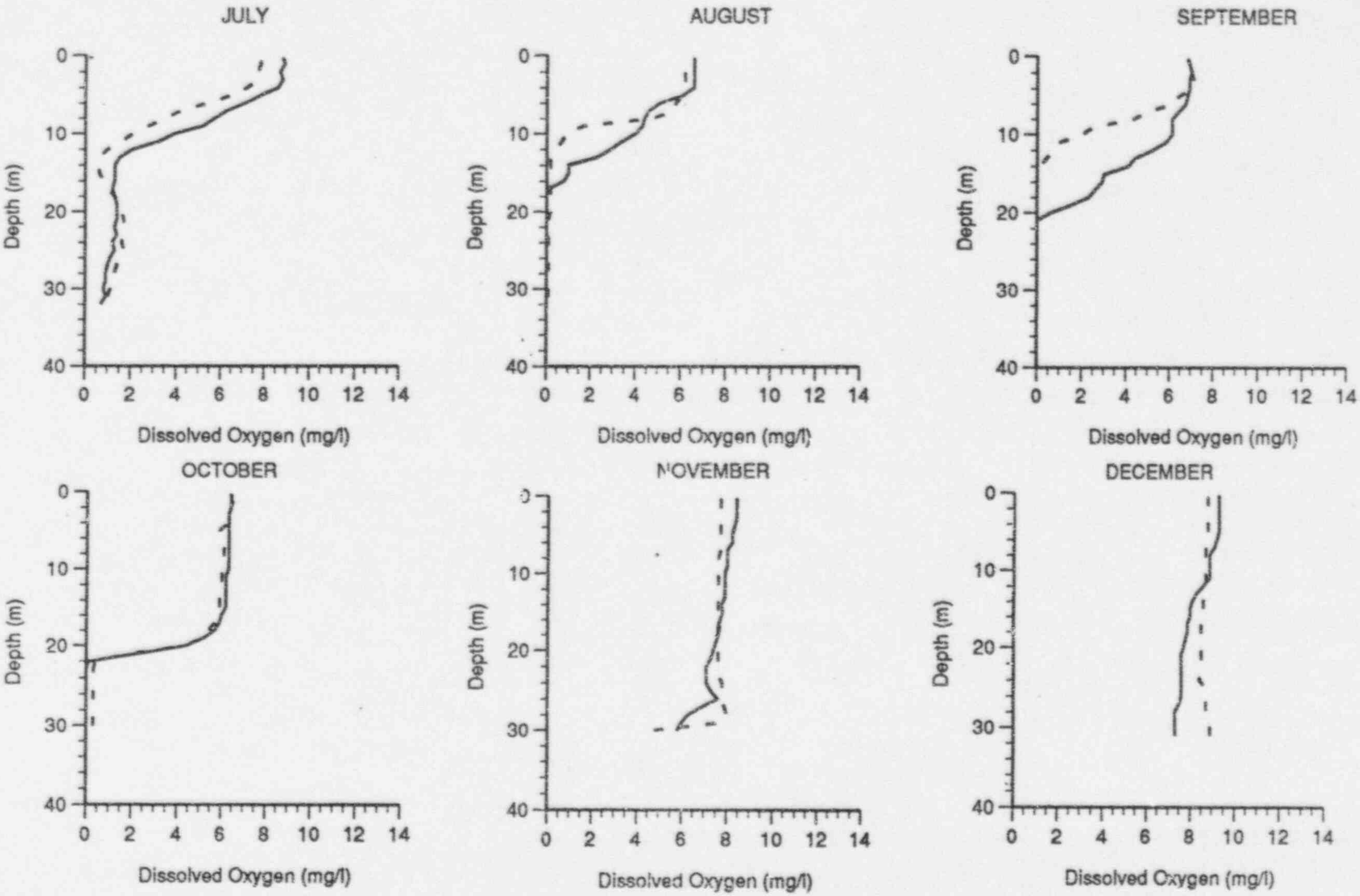


Figure 2-7. Continued.

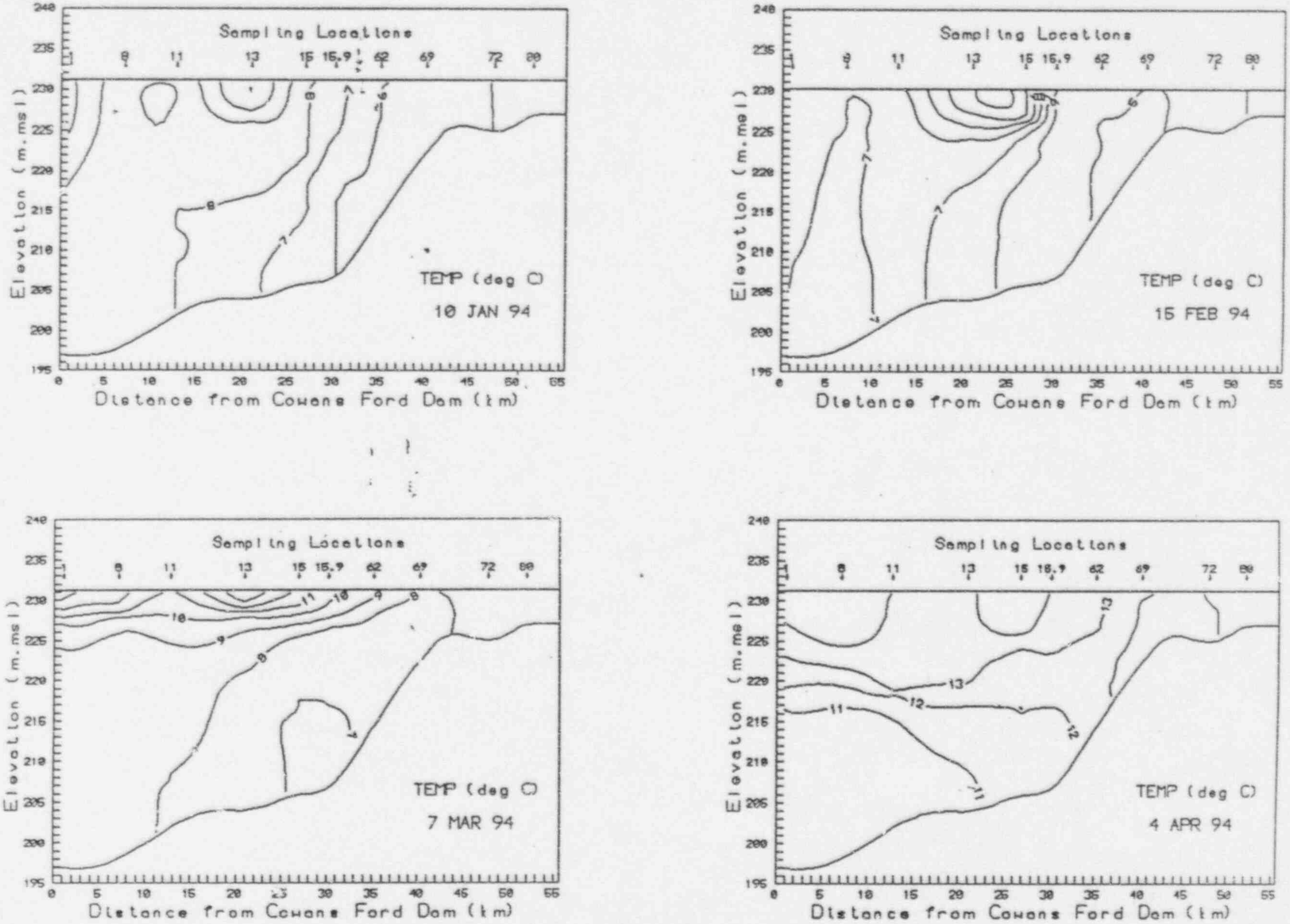


Figure 2-8. Monthly reservoir-wide temperature isotherms for Lake Norman in 1994.

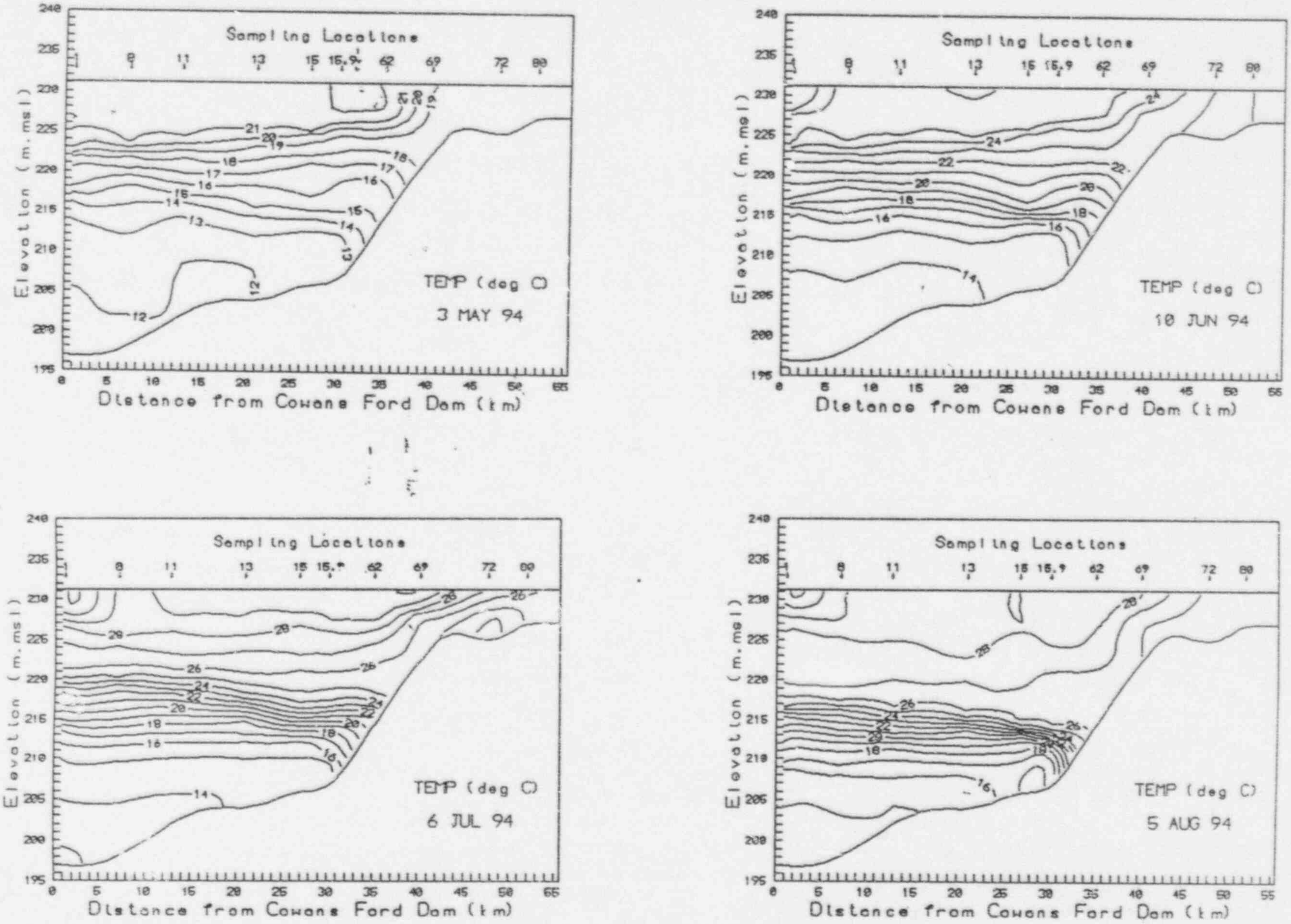


Figure 2-8. Continued.

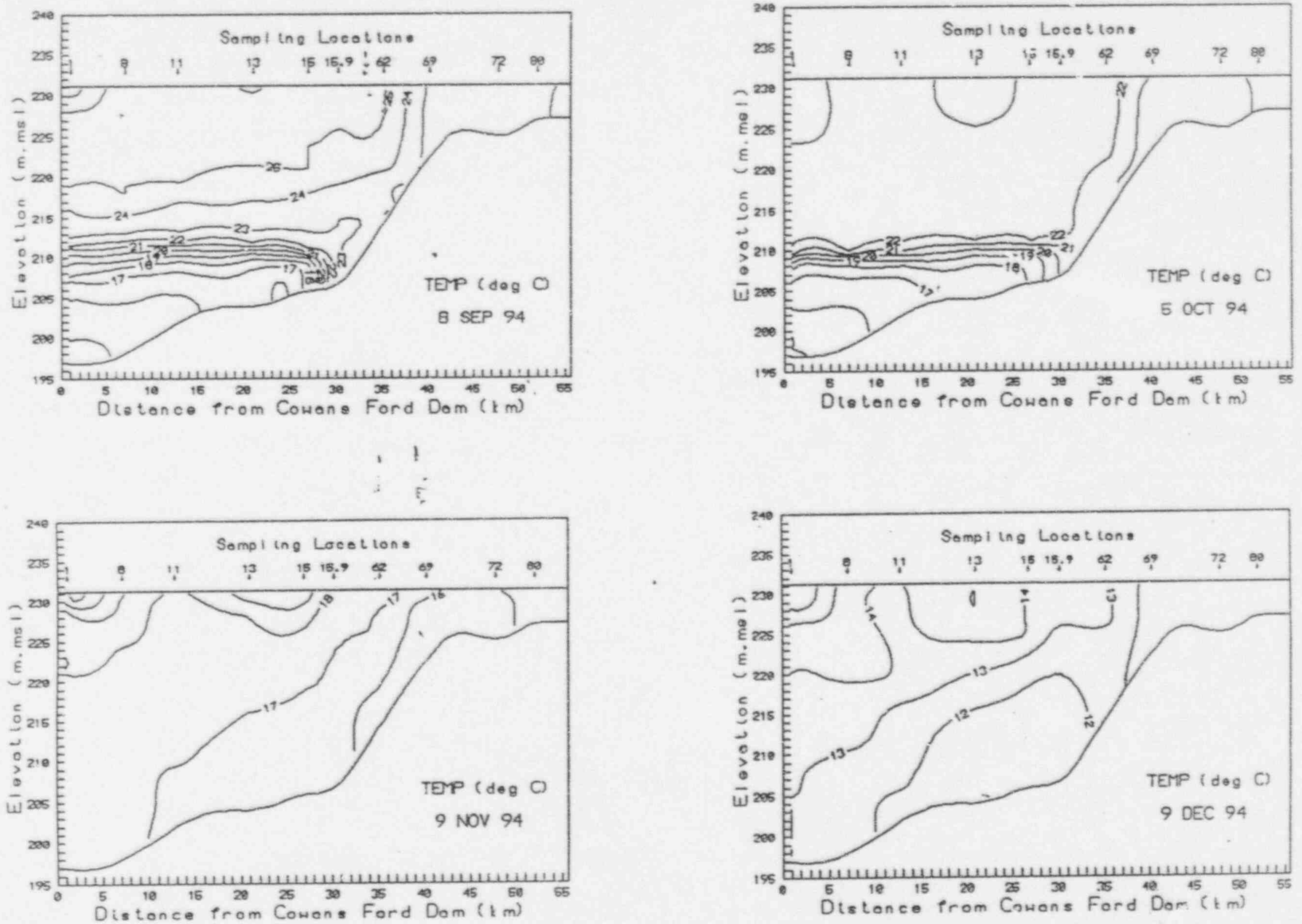


Figure 2-8. Continued.

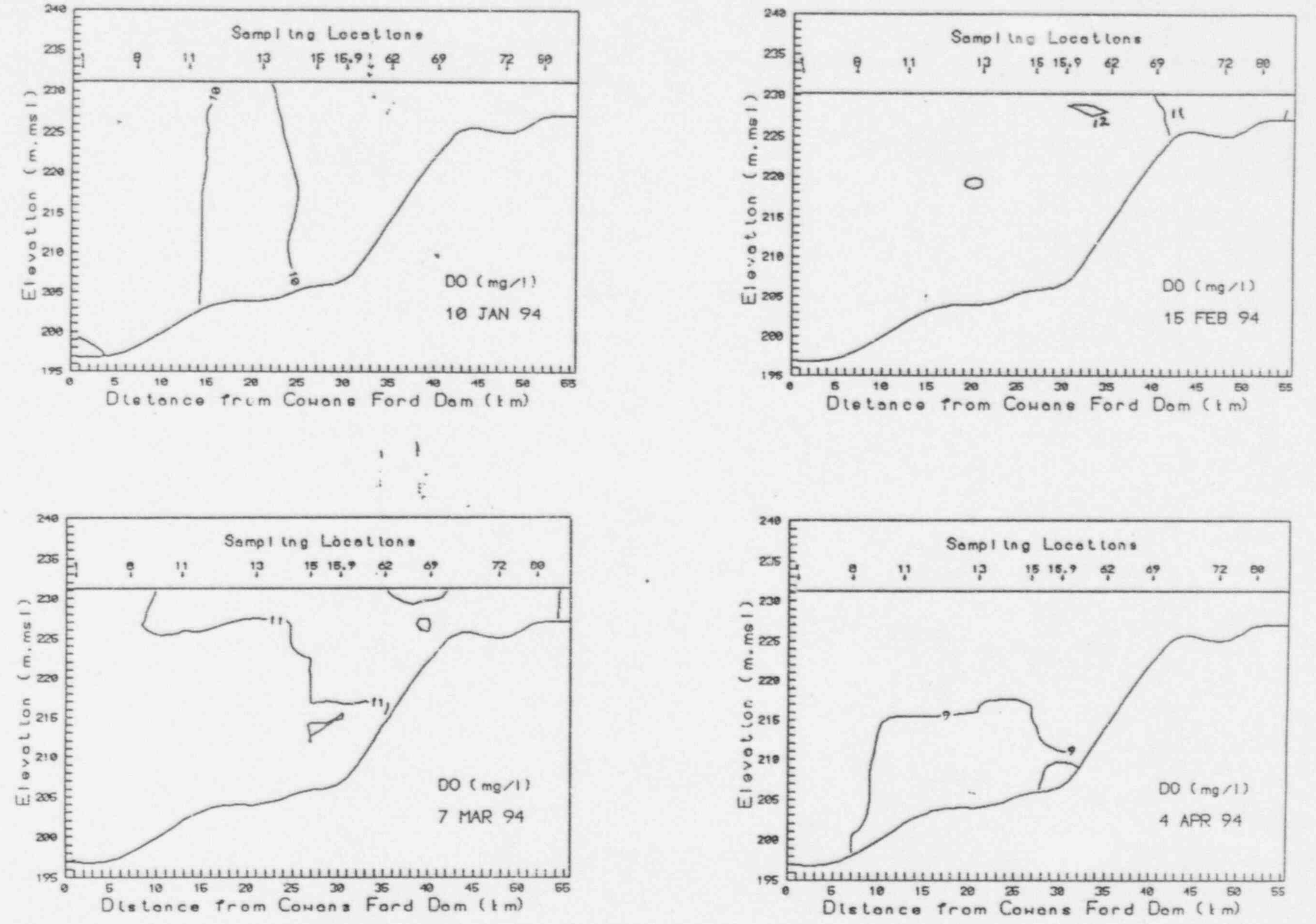


Figure 2-9. Monthly reservoir-wide dissolved oxygen isopleths for Lake Norman in 1994.

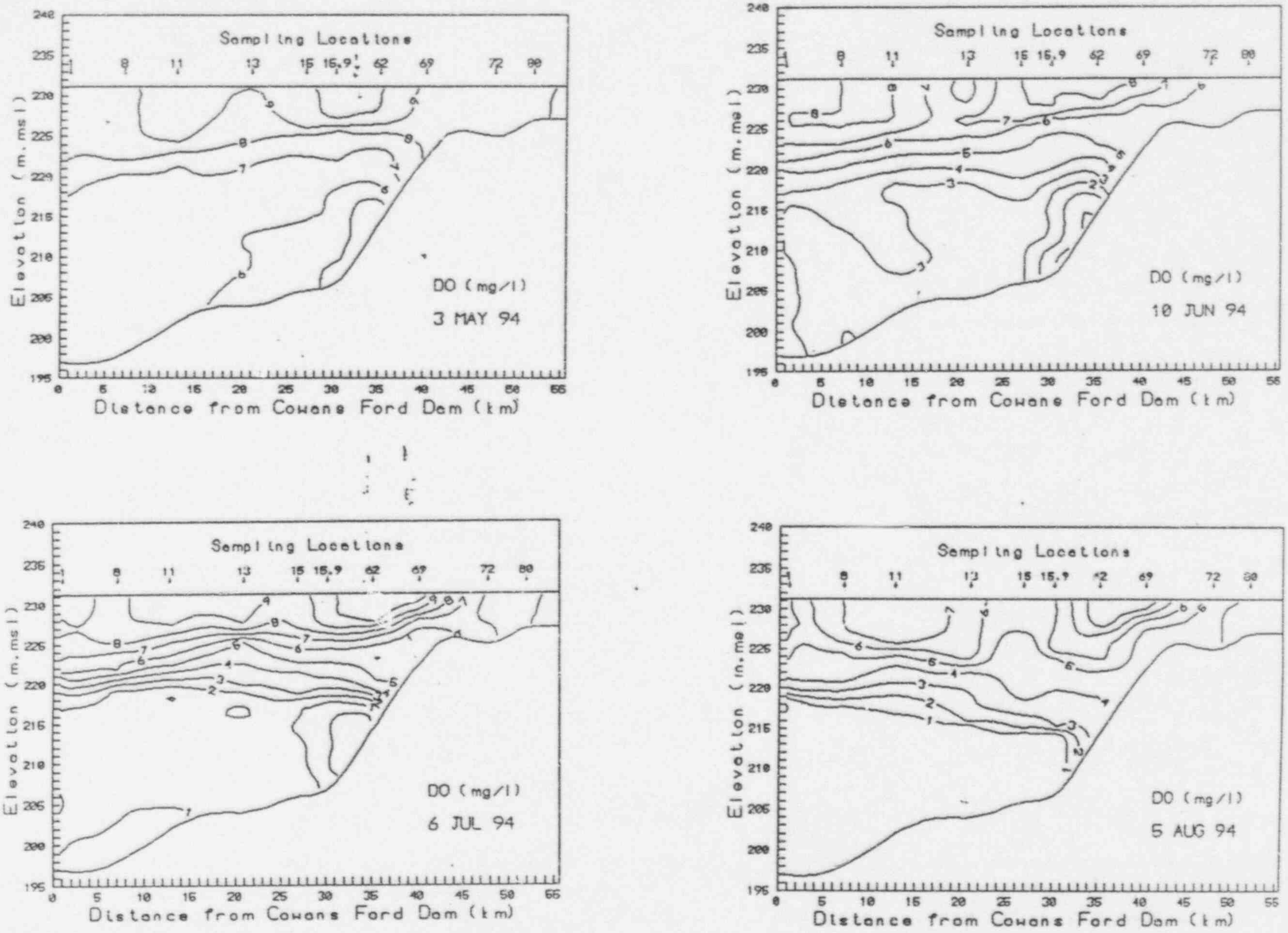


Figure 2-9. Continued.

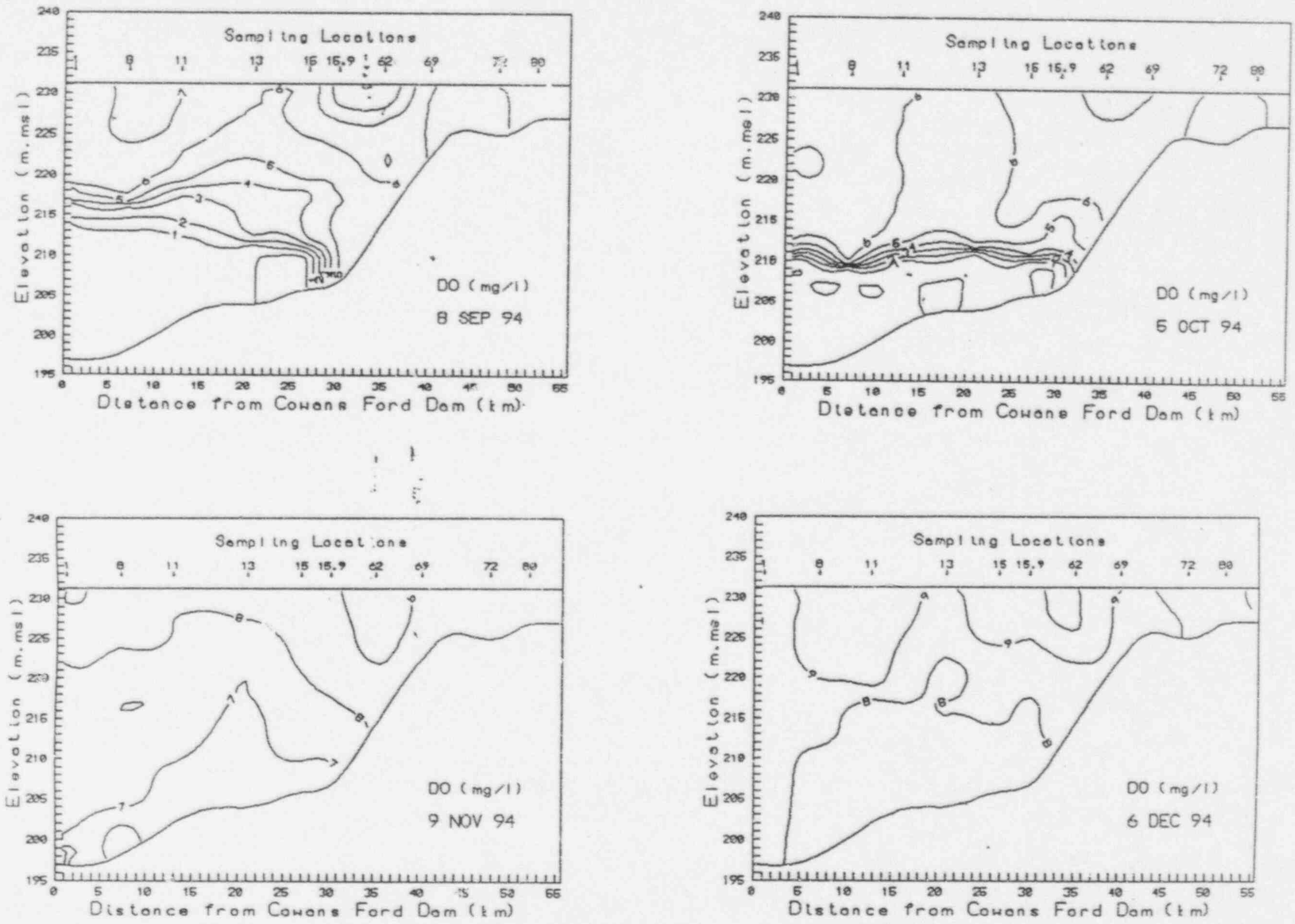


Figure 2-9. Continued.

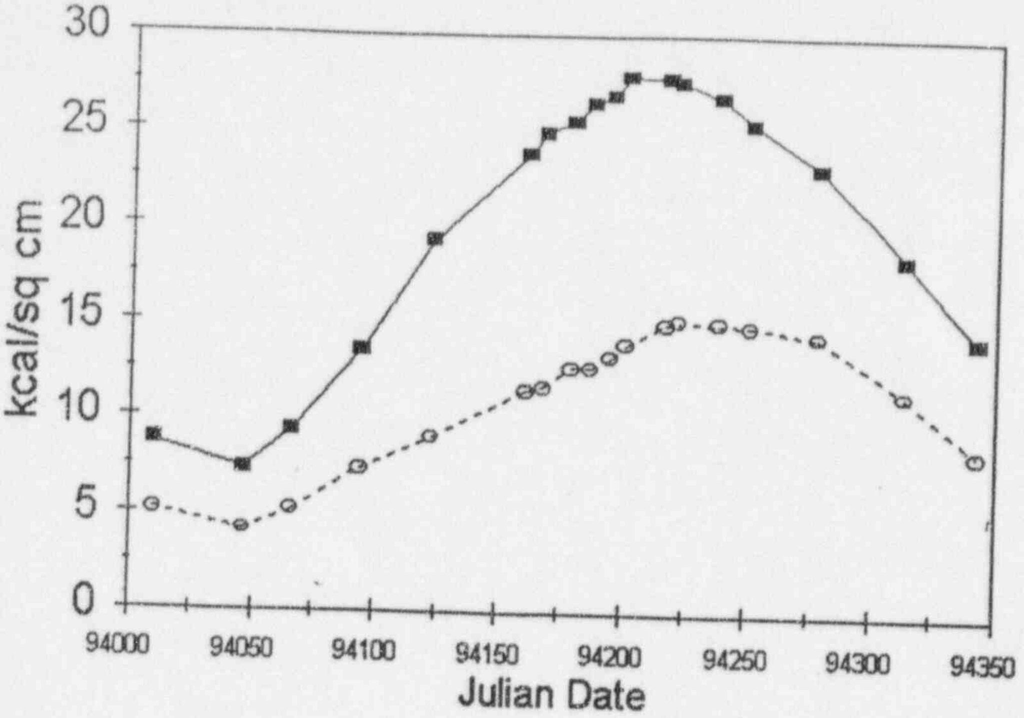


Figure 2-10a. Heat content of the entire water column (■) and the hypolimnion (O) in Lake Norman in 1994.

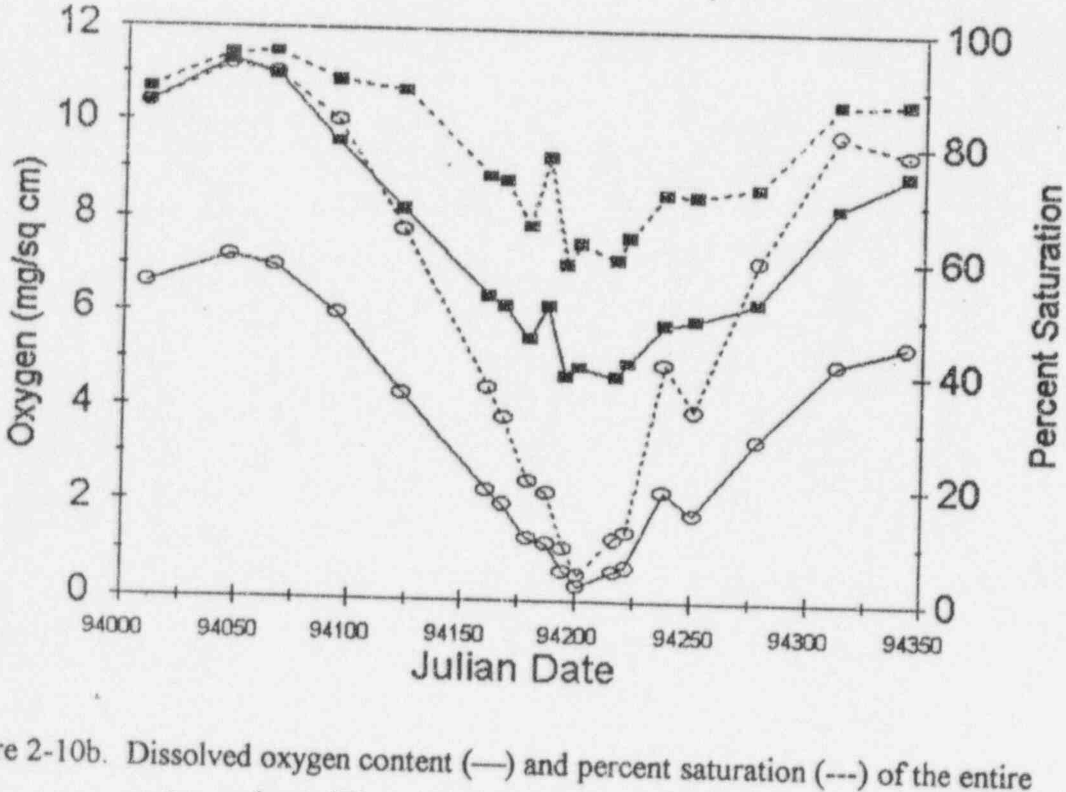


Figure 2-10b. Dissolved oxygen content (—) and percent saturation (---) of the entire water column (■) and hypolimnion (O) of Lake Norman in 1994.

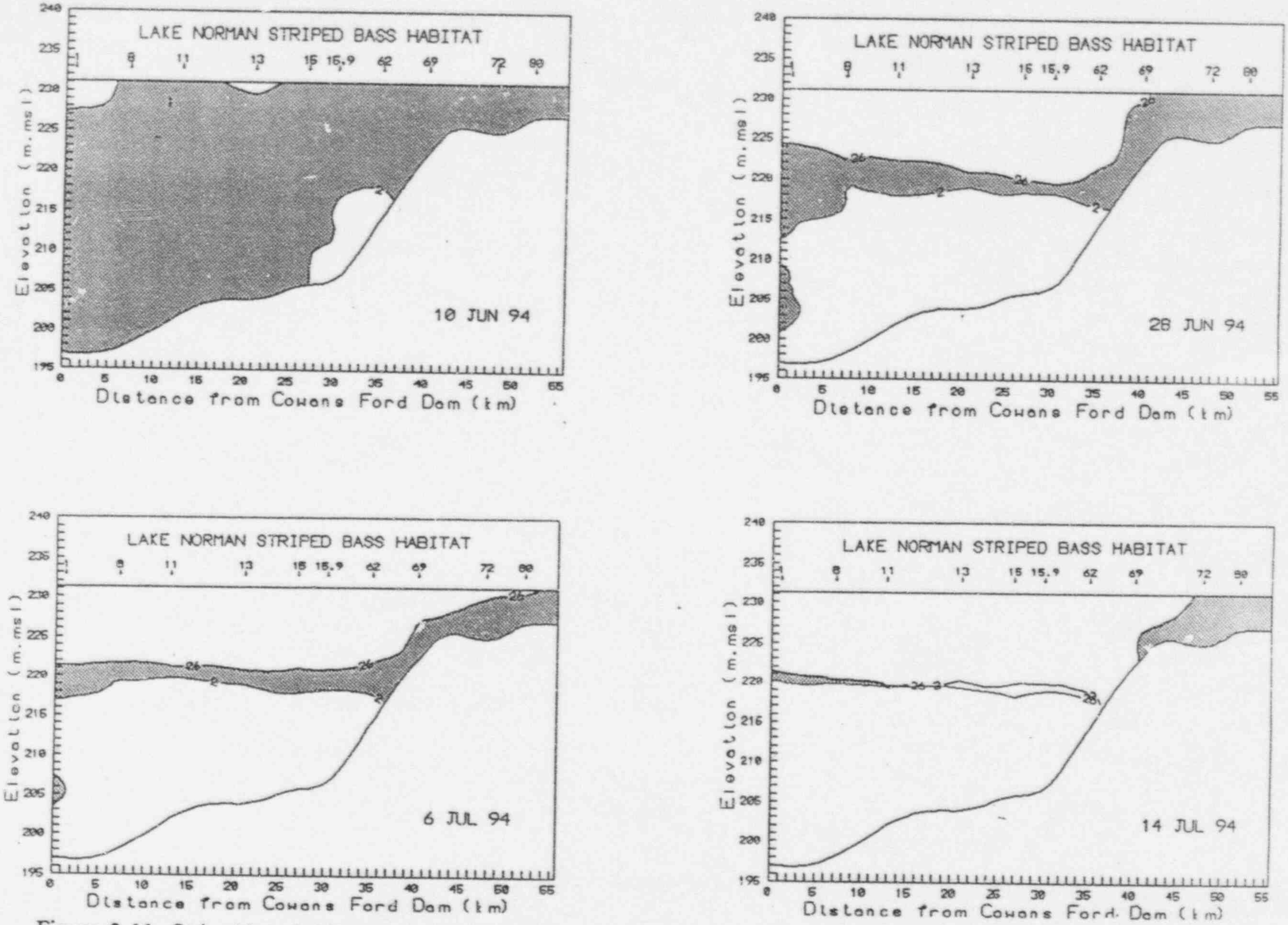


Figure 2-11. Striped bass habitat (temperatures ≤ 26 C and dissolved oxygen ≥ 2.0 mg/L in Lake Norman in June, July, August and September 1994.

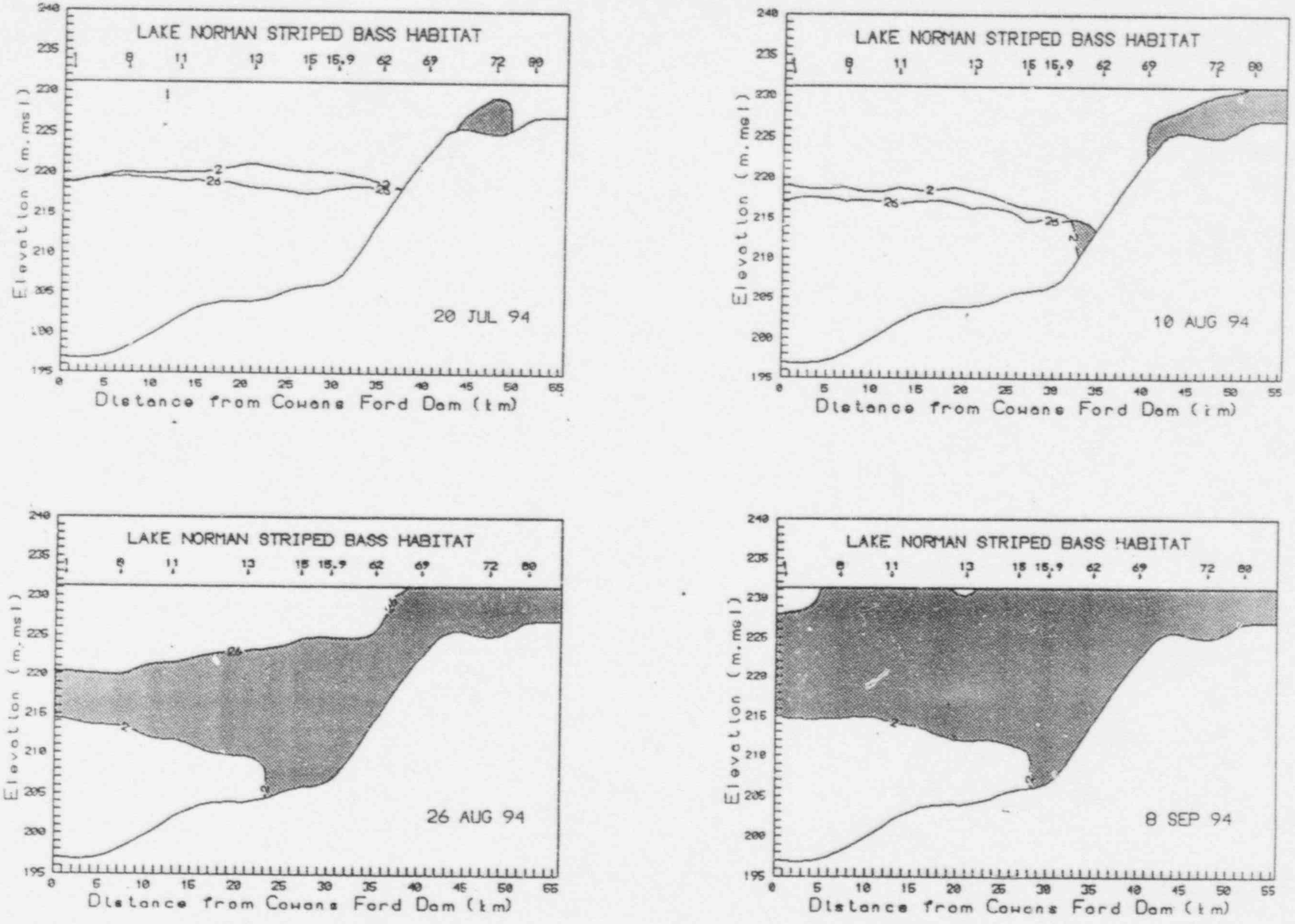


Figure 2-11. Continued.

CHAPTER 3
PHYTOPLANKTON

INTRODUCTION

Phytoplankton population parameters were monitored in 1994 in accordance with the NPDES permit for McGuire Nuclear Station. The objectives of the phytoplankton section for the Lake Norman Maintenance Monitoring Program are to:

1. Describe quarterly patterns of phytoplankton standing crop and species composition throughout Lake Norman; and
2. Compare phytoplankton data collected during this study (February, May, August, November 1994) with historical data collected during these same months.

Previous studies on Lake Norman have reported considerable spatial and temporal variability in phytoplankton standing crops and taxonomic composition (Duke Power Company 1976, 1985; Menhinick and Jensen 1974; Rodriguez 1982). Rodriguez (1982) classified the lake as oligo-mesotrophic based on phytoplankton abundance, distribution, and taxonomic composition.

METHODS AND MATERIALS

Quarterly phytoplankton sampling was conducted at Locations 2.0, 5.0, 8.0, 9.5, 11.0, 13.0, 15.9, and 69.0 in Lake Norman (see map of locations in Chapter 2, Figure 2-1). Duplicate composite grabs from 0.3, 4.0, and 8.0 m (i.e., the euphotic zone) were taken at all locations. Sampling was conducted on 25 February, 28 May, 23 August, and 22 November 1994. Phytoplankton density, biovolume and taxonomic composition were determined for samples collected at Locations 2.0, 5.0, 9.5, [illegible] and 15.9; chlorophyll *a* concentrations and seston dry and ash-free dry weights were determined for samples from all locations. Chlorophyll *a* and total phytoplankton densities and biovolumes are used in determining phytoplankton standing crop. Field sampling methods, and laboratory methods used for chlorophyll *a*, seston dry weights and population identification and enumeration were identical to those used by Rodriguez (1982). Data collected in 1994 were compared with corresponding data from quarterly monitoring beginning in August 1987.

A one way ANOVA was performed on chlorophyll *a* concentrations, phytoplankton densities and seston dry and ash free dry weights by quarter. This was followed by a Duncan's Multiple Range Test to determine which location means were significantly different.

RESULTS AND DISCUSSION

Standing Crop

Chlorophyll *a*

Chlorophyll *a* concentrations from all locations in 1994 ranged from 2.1 mg/m^3 at Location 9.5 in February to 15.2 mg/m^3 at Location 15.9 in May (Table 3-1; Figure 3-1). All chlorophyll values were well below the N. C. Water Quality Standard of 40 mg/m^3 (NCDEHNR 1991). Overall, the range of chlorophyll *a* values observed in Lake Norman in 1994 was similar to that observed since quarterly monitoring began in August 1987 and continue to place this reservoir in the mesotrophic range.

Within reservoir, chlorophyll *a* concentrations generally exhibited a trend of increasing concentration from downlake to uplake. Chlorophyll *a* values in fact were significantly higher at either uplake location 15.9 or 69.0 each month sampled in 1994 (Table 3-2). Chlorophyll *a* concentrations at the transitional zone Location 15.9 were significantly higher than other locations in February, May and November of 1994. The transitional zone is typically the area of a reservoir with highest algal production (Thornton 1992). While chlorophyll *a* values at Location 15.9 were consistently higher than other locations by month, values at Location 69.0 the furthest uplake or riverine location varied widely. The highest chlorophyll value observed in August was found at Location 69.0 in August while the lowest value seen in Lake Norman was found at this location. The riverine zone of a reservoir is subject to flucuations in inflow depending on meteorological conditions (Thornton 1992). Typically, algal production would be suppressed during periods of high flow, due in part to washout; production would increase during periods of low flow when retention time is greater and washout is decreased. Apparently the former conditions prevailed in November and the latter conditions prevailed in August. Few other consistent patterns in chlorophyll *a* concentrations were observed in 1994. In general, chlorophyll *a* concentrations observed at Mixing Zone Locations (2.0 and 5.0) were similar to those observed at other main body locations in Lake Norman.

Historically, the trend of increasing chlorophyll a concentrations observed most distinctly at mid and downlake locations from 1989 through 1992 did not continue in 1994 and appears to have reversed itself. Chlorophyll *a* lake means by month were about 4 to 8 mg/ml in 1994 putting this year in the middle of the range of lake means observed since 1987 (Figure 3-2). Note that chlorophyll values observed in 1994 at downlake locations were similar to those observed in 1987 and about half of those observed in 1991 and 1992 (Figure 3-3). This long term cycle in the reservoir is unexplained.

Total Abundance

Lakewide, phytoplankton abundance as measured by total density and total biovolume was lowest in February and highest in May. The minimum total phytoplankton density and biovolume observed in 1994 was found at Location 9.5 in February (876 units/ml and 235 mm^3/m^3, respectively) and the maximum was found at Location 15.9 in May (6842 units/ml and 3460 mm^3/m^3, respectively)(Table 3-3, Figure 3-1). Total phytoplankton densities at the two locations in the Mixing Zone (Locations 2.0 and 5.0) were not significantly different from each other during any quarter in 1994 (Table 3-4). Total phytoplankton densities also generally showed an increase from down lake to uplake, as previously explained for chlorophyll concentrations.. Either total densities at uplake Location 15.9 or densities at midlake Location 11.0 were significantly higher than other locations for all quarters. In May and November the ranking of total phytoplankton density placed the locations exactly in order from the low near the dam (Location 2.0) to the high furthest uplake (Location 15.9). This is further evidence of a longitudinal gradient of nutrient concentration from highest near the inflow of the Catawba River to lowest near Cowan's Ford Dam.

Seston

Seston dry weights represent either algal matter or inorganic suspended material or both. Not surprisingly, then, seston dry weights at the riverine Location 69.0 were significantly higher than all other locations in all quarters (Table 3-5). Seston dry weights at Location 69.0 were 2 to 4 times higher than other locations down reservoir. This was due, no doubt, to allothonus inputs of inorganic material in inflows from the Catawba River. Seston dry weights then gradually decreased downlake as this suspended material settled out of the water column with increasing water residence time in the reservoir. Seston dry weights in 1994 ranged from a low of 1.25 mg/l at Location 8.0 in February to a high of 20.05 mg/l at Location 69.0 in August (Figure 3-1). Seston ash free dry weights represent organic material and more closely track algal standing crop. While following the same uplake downlake pattern as seston dry weights, seston ash free dry weights at Location 69.0 were only significantly higher than other locations in August when chlorophyll *a* at Location 69.0 was also significantly higher than other locations. Seston ash free dry weights ranged from a low of 0.71 mg/l at Location 2.0 in May to a high of 4.35 mg/l at Location 69.0 in August.

Secchi Depths

Secchi depth is a measure of light penetration. Secchi depths were generally the inverse of suspended sediment (seston dry weight), lowest at uplake Location 69.0 and highest downlake near the dam at Location 2.0 (Table 3-1). Secchi depths ranged from a low of 0.5 m at Location 69.0 in November to a high of 2.38 m at Location 2.0 in August.

Community Composition

Eleven classes comprising 104 genera and 263 taxa of phytoplankton have been identified from samples collected in Lake Norman since 1987. The distribution of taxa within classes is as follows: Chlorophyceae (Green algae), 133; Bacillariophyceae (Diatoms), 49; Chrysophyceae, 21; Haptophyceae, 1; Xanthophyceae, 2; Cryptophyceae, 7; Myxophyceae (Blue-green algae), 23; Euglenophyceae, 9; Dinophyceae, 14; Chloromonadophyceae, 3; and 1 Unidentified taxon (see DPC 1992 for species list). Only one new taxa, (*Euastrum verrucosum* Prescott), a green alga in the desmid order was identified in 1994 which had not previously been recorded in the Maintenance Monitoring Program.

Species Composition and Seasonal Succession

Lake Norman supports a rich community of phytoplankton species. This community varies both seasonally and spatially within the reservoir. In addition, variation is also often found between years for the same months sampled.

Cryptophytes numerically dominated phytoplankton assemblages in February due to the abundance of *Rhodomonas minuta* which comprised 40.0% or more of the total density at all locations. This is similar to 1993. *Rhodomonas minuta* is the most frequent numerical dominant observed in Lake Norman (DPC 1992). Diatoms dominated the biovolume in February due primarily to *Melosira ambigua* which comprised more than 15.0% of the total biovolume at all locations. *Melosira ambigua*, formerly called *Melosira italica*, is typically abundant during the unstratified period in Lake Norman, often reaching a peak in abundance in late winter/early spring and declines at the onset of stratification where it will spend the summer months in a resting stage on the sediments (Buetow 1988).

By May, phytoplankton abundance had increased at every location with the total density and biovolume more than doubling at most locations (Figure 3-4). Phytoplankton species composition in the Mixing Zone in May was numerically dominated by cryptophytes followed closely by diatoms which dominated the biovolume. Diatoms dominated the density and biovolume at all other locations especially mid and uplake Locations 11.0 and 15.9 where they comprised more than 50% of each. Chrysophytes were also important in May in terms of density. *Rhodomonas minuta* was again numerically important comprising 10 to 30% of the total density at all locations. *Melosira ambigua* made up less than 15% of the total biovolume at all locations and declined in proportion to the total phytoplankton community. Other diatoms species became important components of the phytoplankton in May: *Tabellaria fenestrata*, which comprised more than 20% of the total biovolume uplake at Locations 11.0 and 15.9, *Fragilaria crotonensis*, also an important component of the biovolume uplake and *Cyclotell comta* which was important downlake.

As in past years, the phytoplankton community in August consisted of a diverse assemblage dominated by chlorophyceae (green algae) species. Green algae were numerically dominant at all locations in August followed closely by diatoms. Green algae, diatoms and dinoflagellates generally dominated the algal biovolume. Small coccoid greens were an important part of the phytoplankton assemblage comprising about 10% of the total density at all locations. In terms of biovolume, dinoflagellates (*Peridinium* spp.) were dominant at all locations in August. While not dominant, blue green algae (Myxophyceae) were more abundant at the transition zone Location 15.9 in August than at any other location. Blue-green algae comprised 22.9% of the total density at Location 15.9 in August compared with about 5% of the total density at all other locations. Typically, the highest numbers of blue green algae observed in the Maintenance Monitoring Study are found at Location 15.9 in August (DPC 1988, 1989, 1990, 1991, 1992, 1993, 1994).

Diatoms were the dominant class of algae in November due primarily to the abundance of *Melosira ambigua*. *Melosira ambigua* comprised more than 35% of the biovolume at Locations 2.0, 5.0 and 9.5 and more than 25% of the biovolume at Location 11.0. As previously mentioned *Melosira*, a large filamentous diatom, is typically most abundant during the unstratified period in lakes and reservoirs. Typically, when the lake turns over in the fall (usually September/October), filaments of *Melosira* are resuspended from the bottom sediments and resume growth in the upper lighted layers of the reservoir. Since *Melosira* species, such as *ambigua,* are generally adapted to growth at low temperatures and low light conditions this would explain the abundance of this taxa in samples collected in November. The phytoplankton community at the mid and uplake Locations 11.0 and 15.9 were numerically dominated by the cryptophyte, *Rhodomonas minuta*, which comprised more than 25% of the total density at each location. .

In 1994, other species comprising more than 10% of the total density or biovolume were: *Erkenia* spp., *Achnanthes* spp., *Fragiliaria crotonensis*,.*Melosira granulata* v. *angustissima*, *Synedra* spp. and unidentified chrysophyceae in terms of density, and *Cosmarium contractum*, *Cryptomonas erosa*, *Cryptomonas ovata*, *Cylotella comta*, *Fragiliaria crotonensis*, *Rhizosolenia* spp., *Peridinium pusillum* and *Peridinium umbonatum* in terms of biovolume. All major taxa observed in 1994 have been common in previous years.

FUTURE STUDIES

No changes are planned for the phytoplankton portion of the Lake Norman maintenance monitoring program during 1995.

SUMMARY

Chlorophyll *a* concentrations at all locations during 1994 were within historical ranges and in the mesotrophic range. Lakewide, chlorophyll *a* concentrations were similar among Mixing Zone and other downlake locations and generally increased uplake. Highest chlorophyll *a* values each month were found uplake: at Location 15.9 in February, May and November and at Location 69.0 in August. The maximum chlorophyll a value observed in 1994 (15.2 mg/l) was far below the NC State Water Quality Standard of 40 mg/l.

Seston weights were significantly higher uplake at the riverine Location 69.0 than other locations in 1994 due to sediment inflows from the Catawba River. Suspended material, as measured by seston weights, then decreased downlake presumably as particulate material settles out of the water column. Secchi depths showed the opposite trend from seston weights. Secchi depths were deepest near the dam (Location 2.0) and shallowest uplake at Location 69.0.

Total phytoplankton densities and biovolumes observed in 1994 were within the range of those observed in previous years. Total densities and biovolumes also generally showed an increase from downlake to uplake in the reservoir. The maximum total density and total biovolume observed in 1994 (6842 units/ml and 3460 mm^3/m^3, respectively) were both below the levels considered by NCDEM as algal blooms (10,000 units/ml and 5000 mm^3/m^3, respectively).

Phytoplankton taxonomic composition during 1994 was similar to that observed during the same months of 1993. Diatoms, green algae and cryptophytes were the most numerically abundant classes of algae observed. Diatoms and cryptophytes generally dominated the phytoplankton biovolumes in all months except August when the phytoplankton community consisted of a diverse assemblage dominated by small green algae. Dinoflagellates were sporadically dominant in terms of biovolume at some locations during all months except November. Blue-green algae were never a dominant part at any location or time in 1994.

Major taxa observed in 1994 were similar to those observed in 1993. *Rhodomonas minuta* was the most frequent numerical dominant during 1994 as in previous years. *Melosira ambigua* dominated the algal biovolume at most locations during the unstratified periods (February and November).

These results indicate that continuation of the alternative thermal limits to the water quality standard for temperature are warranted.

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Table 3-1. Mean chlorophyll *a* concentrations (mg/m^3) in euphotic zone composite samples (0.3, 4 and 8m depth) collected from Lake Norman, NC in 1994.

Chlorophyll *a*

Location	FEB	MAY	AUG	NOV
2.0	2.50	3.17	4.64	4.94
5.0	3.40	3.95	6.97	5.80
8.0	3.54	5.32	6.77	6.48
9.5	2.06	5.08	6.70	7.19
11.0	4.53	8.43	8.52	9.14
13.0	4.58	8.94	5.60	4.46
15.9	7.70	15.22	7.89	12.28
69.0	2.54	6.81	14.15	4.15

Secchi Depths

Location	FEB	MAY	AUG	NOV
2.0	2.55	2.3	2.0	*
5.0	1.4	1.8	1.7	*
8.0	2.3	2.1	2.0	*
9.5	2.5	1.9	1.9	*
11.0	1.3	1.6	1.7	*
13.0	1.1	1.5	0.7	*
15.9	0.95	1.7	1.2	*
69.0	0.50	0.9	0.4	*

* No data

Table 3-2 . Duncan's Multiple Range Test on chlorophyll *a* concentrations (mg/m^3) Lake Norman, NC during 1994. (Means connected by the same line are not significantly different.)

February	Location	**9.5**	**2.0**	**69.0**	**5.0**	**8.0**	**11.0**	**13.0**	**15.9**
	Mean	2.06	2.50	2.54	3.40	3.54	4.53	4.58	7.70
		———	———	———	———	———	———	———	———
May	Location	**2.0**	**5.0**	**9.5**	**8.0**	**69.0**	**11.0**	**13.0**	**15.9**
	Mean	3.17	3.95	5.08	5.32	6.81	8.43	8.94	15.22
		———	———	———	———	———	———	———	———
August	Location	**2.0**	**13.0**	**9.5**	**8.0**	**5.0**	**15.9**	**11.0**	**69.0**
	Mean	4.64	5.60	6.70	6.77	6.97	7.89	8.52	14.15
							———	———	———
				———	———	———	———		
			———	———	———	———			
		———	———						
November	Location	**69.0**	**13.0**	**2.0**	**5.0**	**8.0**	**9.5**	**11.0**	**15.9**
	Mean	4.15	4.46	4.94	5.80	6.48	7.19	9.14	12.28
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Table 3.3 Total phytoplankton densities and biovolumes from samples collected in Lake Norman, NC in February, May, August and November 1994.

Total Phytoplankton - Lake Norman - 1994

Density (No./ml)

	Locations					
	2.0	5.0	9.5	11.0	15.9	Mean
FEB	1102	1199	876	1887	2221	1457
MAY	1551	1668	1886	4961	6842	3382
AUG	1166	1186	1642	2261	1332	1517
NOV	1276	1280	1733	2040	3143	1894

Biovolume (mm^3/m^3)

	Locations					
	2.0	5.0	9.5	11.0	15.9	Mean
FEB	338	553	235	694	1039	572
MAY	1097	745	1021	3014	3460	1867
AUG	656	994	1053	1370	744	963
NOV	688	690	1086	1003	1129	919

Table 3-4 . Duncan's Multiple Range Test on phytoplankton densities in Lake Norman, NC during 1994. (Means connected by the same line are not significantly different.)

February	Location	**9.5**	**2.0**	**5.0**	**11.0**	**15.9**
	Mean	919	1102	1191	1900	2238
		———	———	———	———	———
May	Location	**2.0**	**5.0**	**9.5**	**11.0**	**15.9**
	Mean	1824	2045	3612	3766	4373
			———	———	———	———
		———	———			
August	Location	**2.0**	**15.9**	**5.0**	**9.5**	**11.0**
	Mean	1175	1214	1250	1663	2995
		———	———	———	———	———
November	Location	**2.0**	**5.0**	**9.5**	**11.0**	**15.9**
	Mean	1274	1306	1729	2036	3138
		———	———	———	———	———

Table 3-5 . Duncan's Multiple Range Test on seston dry and ash free dry weight concentrations (mg/l) in Lake Norman, NC during 1994. (Means connected by the same line are not significantly different.)

<table>
<tr><td></td><td></td><td colspan="8">Dry Weight</td></tr>
<tr><td>February</td><td>Location</td><td>8.0</td><td>9.5</td><td>2.0</td><td>5.0</td><td>11.0</td><td>13.0</td><td>15.9</td><td>69.0</td></tr>
<tr><td></td><td>Mean</td><td>1.25</td><td>1.63</td><td>2.67</td><td>2.69</td><td>2.76</td><td>3.18</td><td>3.75</td><td>9.23</td></tr>
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<tr><td>May</td><td>Location</td><td>2.0</td><td>8.0</td><td>5.0</td><td>9.5</td><td>11.0</td><td>13.0</td><td>15.9</td><td>69.0</td></tr>
<tr><td></td><td>Mean</td><td>2.76</td><td>3.24</td><td>3.28</td><td>3.52</td><td>3.68</td><td>4.06</td><td>4.37</td><td>8.60</td></tr>
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<tr><td>August</td><td>Location</td><td>2.0</td><td>8.0</td><td>5.0</td><td>11.0</td><td>9.5</td><td>13.0</td><td>15.9</td><td>69.0</td></tr>
<tr><td></td><td>Mean</td><td>2.56</td><td>2.61</td><td>2.91</td><td>2.99</td><td>3.19</td><td>4.87</td><td>5.48</td><td>20.05</td></tr>
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<tr><td>November</td><td>Location</td><td>2.0</td><td>8.0</td><td>11.0</td><td>9.5</td><td>15.9</td><td>5.0</td><td>13.0</td><td>69.0</td></tr>
<tr><td></td><td>Mean</td><td>3.30</td><td>3.35</td><td>3.44</td><td>3.72</td><td>3.93</td><td>3.96</td><td>4.57</td><td>8.11</td></tr>
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<table>
<tr><td></td><td></td><td colspan="8">Ash Free Dry Weight</td></tr>
<tr><td>February</td><td>Location</td><td>9.5</td><td>5.0</td><td>8.0</td><td>13.0</td><td>11.0</td><td>15.9</td><td>2.0</td><td>69.0</td></tr>
<tr><td></td><td>Mean</td><td>0.72</td><td>0.95</td><td>0.95</td><td>1.11</td><td>1.17</td><td>1.32</td><td>1.39</td><td>1.81</td></tr>
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<tr><td>May</td><td>Location</td><td>2.0</td><td>5.0</td><td>8.0</td><td>9.5</td><td>11.0</td><td>13.0</td><td>69.0</td><td>15.9</td></tr>
<tr><td></td><td>Mean</td><td>0.71</td><td>0.92</td><td>1.11</td><td>1.15</td><td>1.47</td><td>1.63</td><td>1.91</td><td>2.14</td></tr>
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<tr><td>August</td><td>Location</td><td>2.0</td><td>5.0</td><td>8.0</td><td>9.5</td><td>13.0</td><td>11.0</td><td>15.9</td><td>69.0</td></tr>
<tr><td></td><td>Mean</td><td>1.06</td><td>1.16</td><td>1.27</td><td>1.36</td><td>1.52</td><td>1.56</td><td>1.77</td><td>4.35</td></tr>
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<tr><td></td><td></td><td colspan="4">——————————</td><td></td><td></td><td></td><td></td></tr>
<tr><td>November</td><td>Location</td><td>11.0</td><td>9.5</td><td>13.0</td><td>2.0</td><td>15.9</td><td>8.0</td><td>5.0</td><td>69.0</td></tr>
<tr><td></td><td>Mean</td><td>0.84</td><td>0.87</td><td>0.91</td><td>0.99</td><td>1.15</td><td>1.18</td><td>1.23</td><td>1.30</td></tr>
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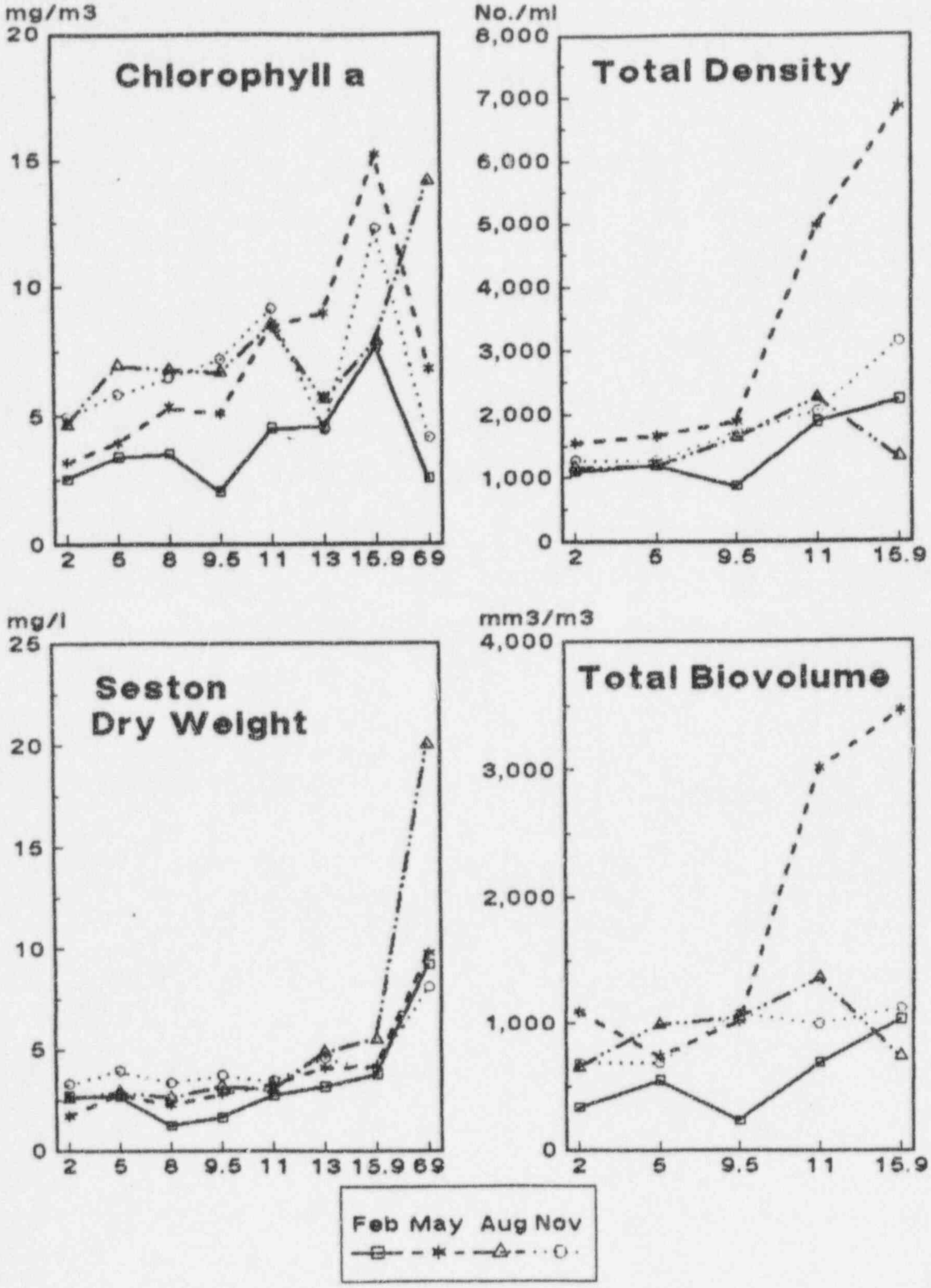

Figure 3-1. Chlorophyll *a* dry weights, total densities and total biovolumes for locations in Lake Norman, North Carolina, in February, May, August, and November 1994.

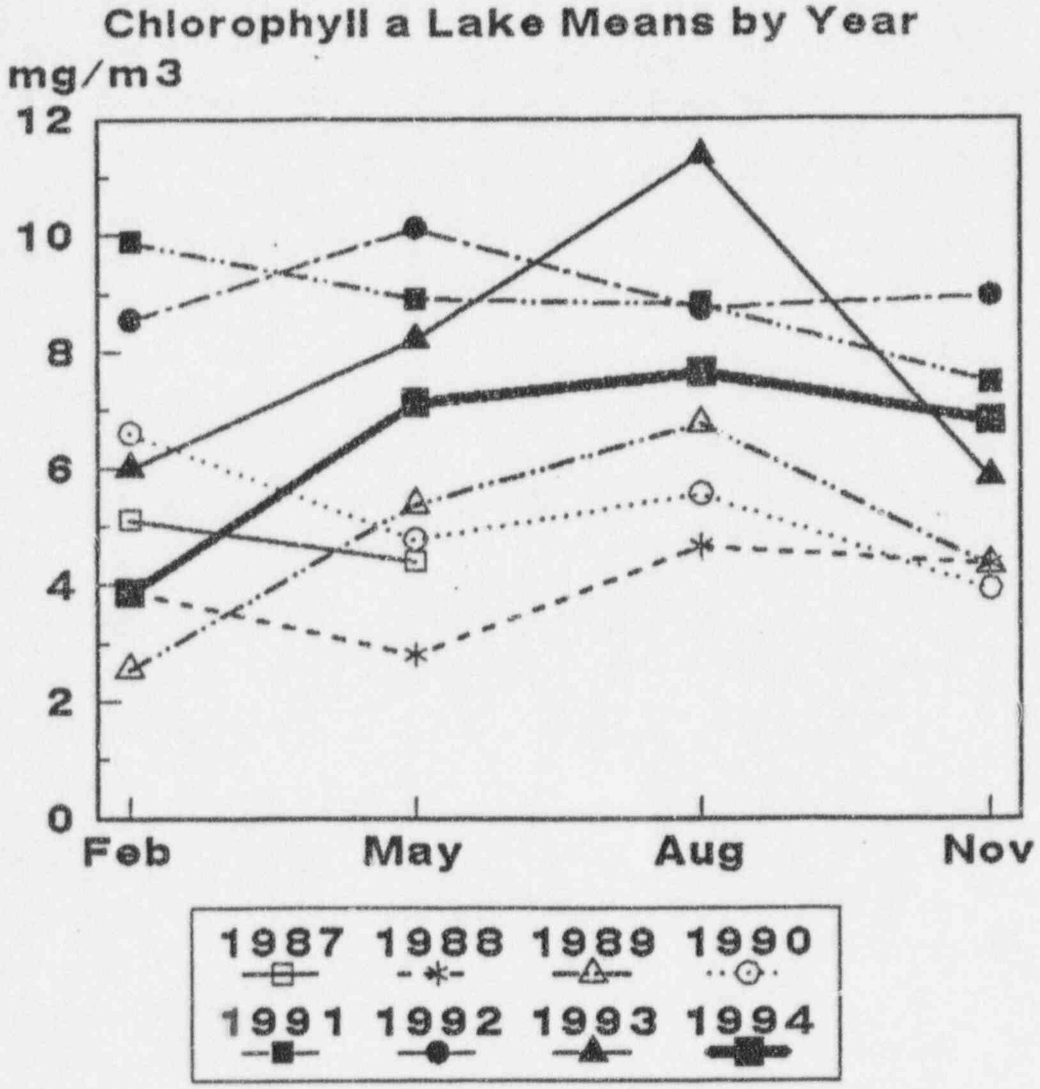

Figure 3-2. Chlorophyll *a* lake means by year for samples collected in Lake Norman, North Carolina, from August 1987 through November 1994.

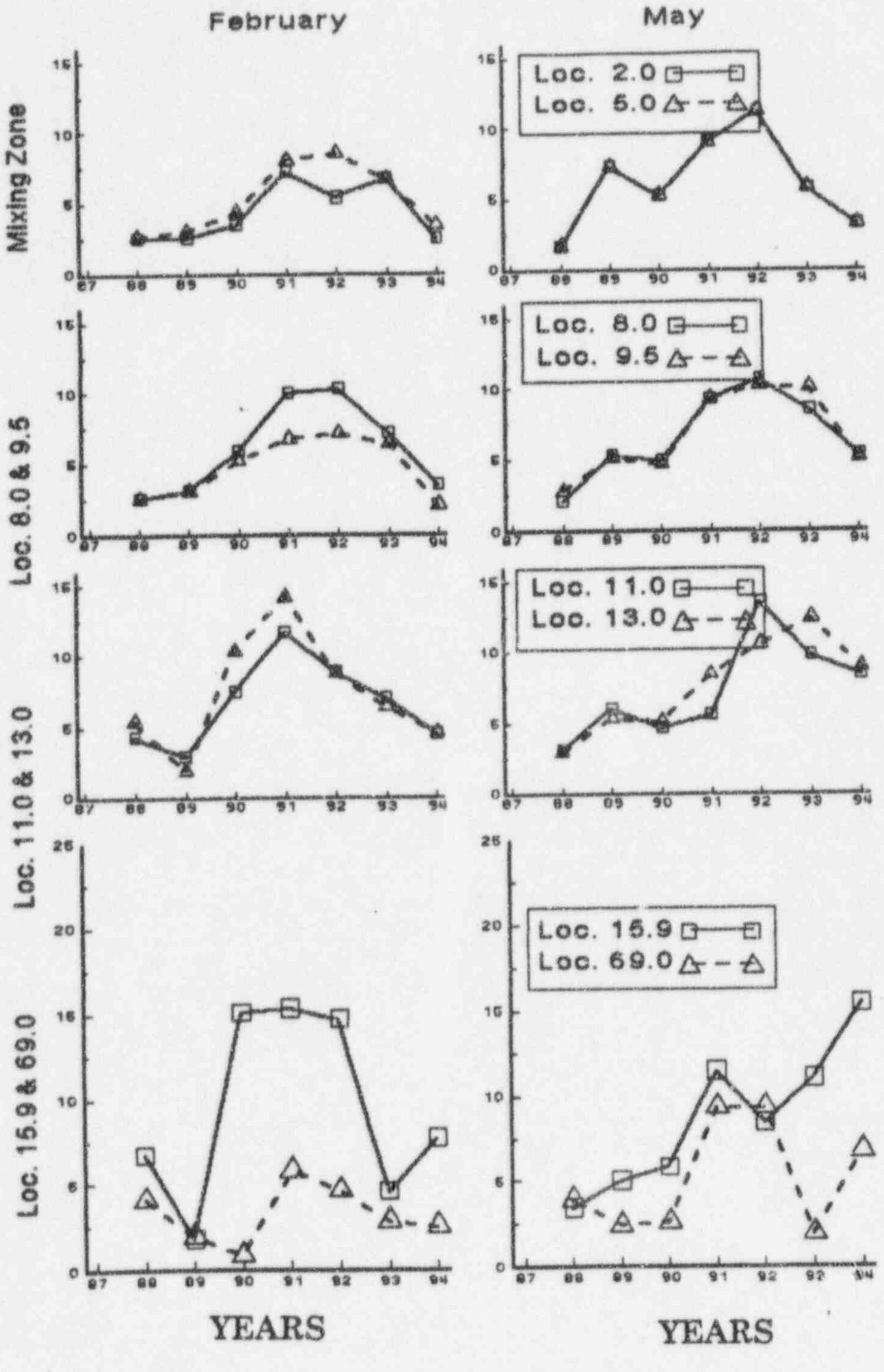

Figure 3-3. Chlorophyll *a* concentrations (mg/m^3) by location for samples collected in Lake Norman, North Carolina, from August 1987 through November 1994.

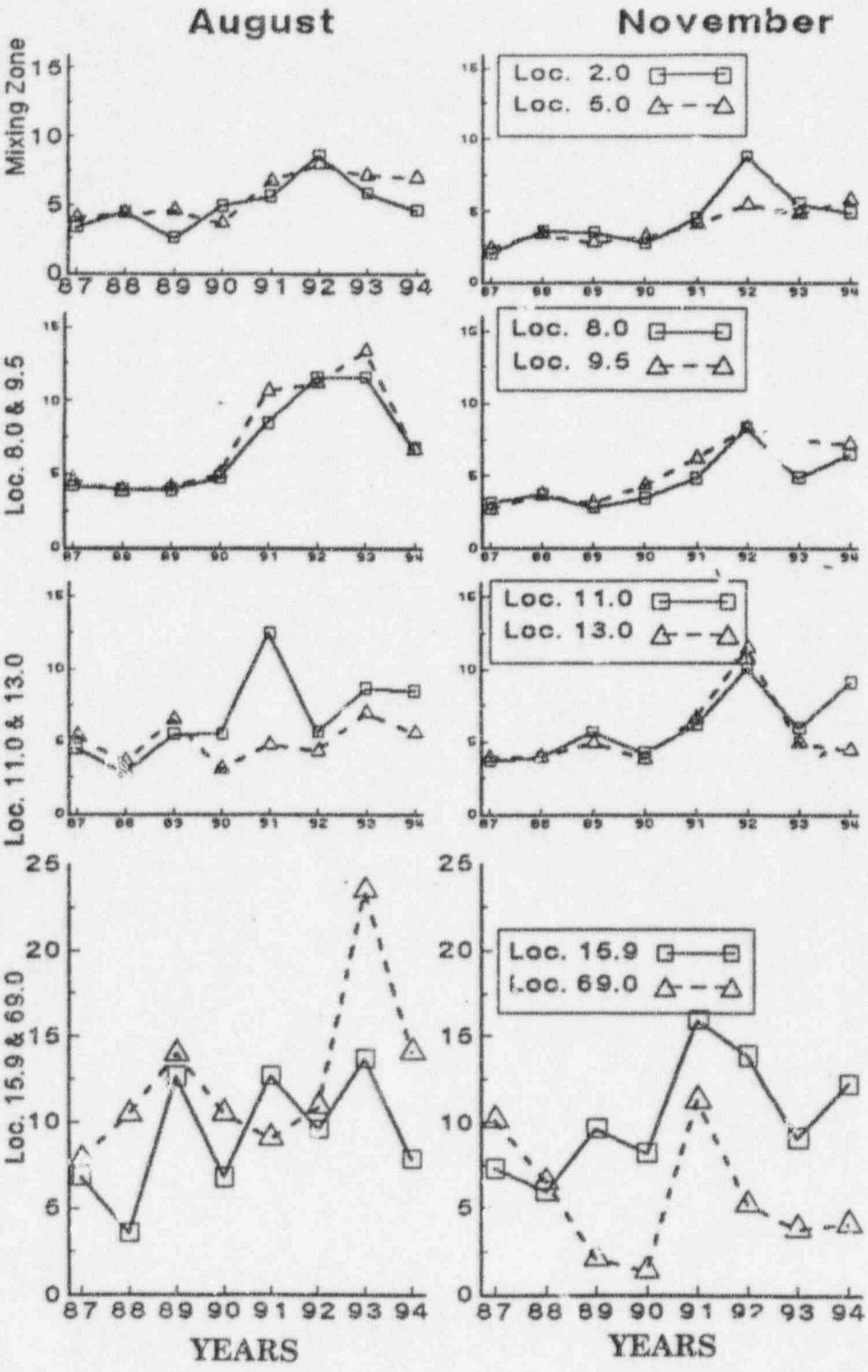

Figure 3-3. (Continued).

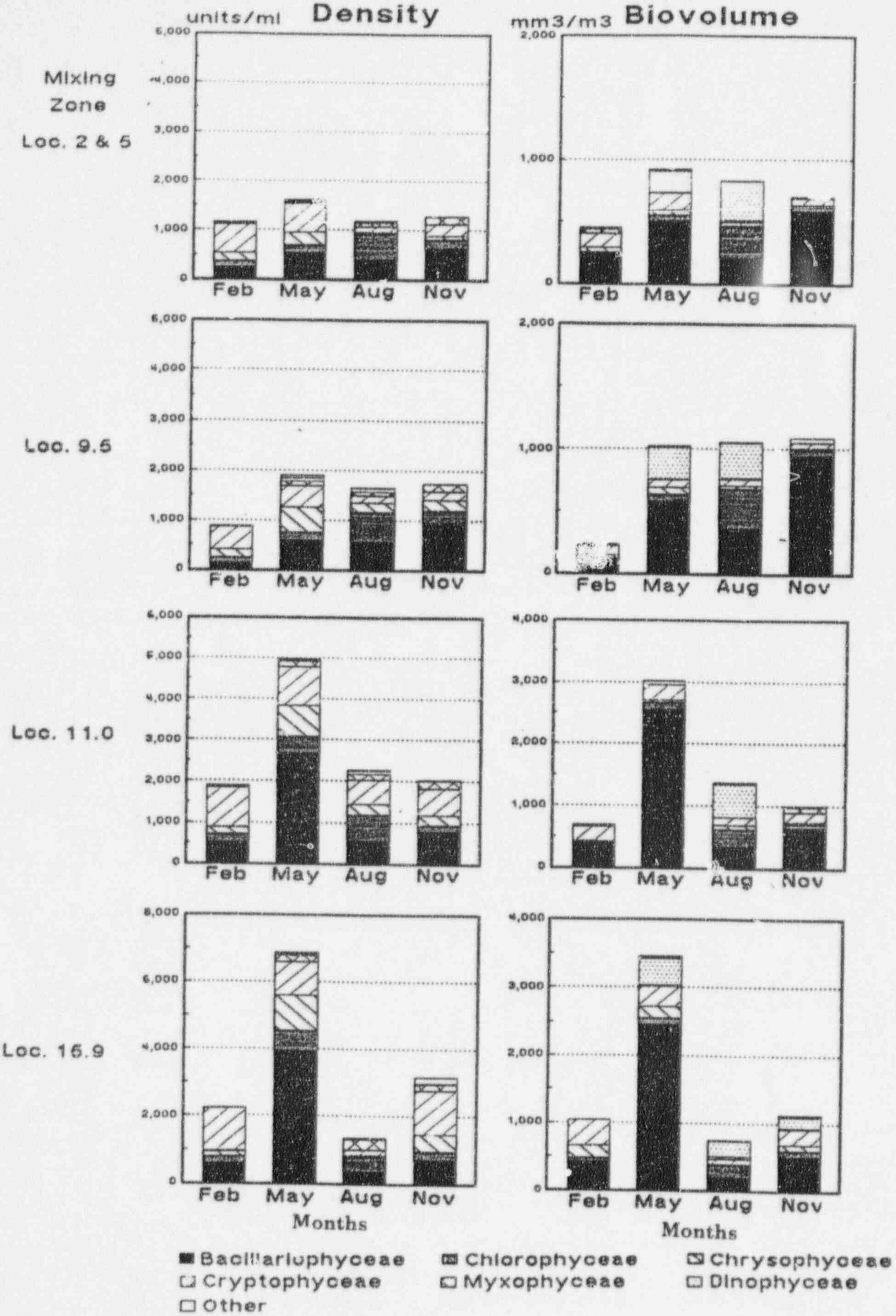

Figure 3-4. Class composition of phytoplankton from euphotic zone composite samples collected at locations in lake Norman, North Carolina, during 1994.

CHAPTER 4

ZOOPLANKTON

INTRODUCTION

The objectives of the Lake Norman Maintenance Monitoring Program for zooplankton are to:

1. Describe quarterly patterns of zooplankton standing crops at selected locations on Lake Norman and
2. Compare zooplankton data collected during this study (February, May, August, and November 1994) with historical data collected for this Program during the period 1987-1993 for these same months.

Previous studies of Lake Norman zooplankton populations have demonstrated a bimodal seasonal distribution with highest recorded values occurring in spring and a less pronounced fall peak. Considerable spatial and year to year variability has been observed in zooplankton abundance in Lake Norman (Duke Power Company 1976, 1985; Hamme 1982; Menhinick and Jensen 1974).

METHODS AND MATERIALS

Duplicate 10 m to surface and bottom to surface net tows were taken at Locations 2.0, 5.0, 9.5, 11.0, and 15.9 in Lake Norman (Chapter 2, Figure 2-1) on February 25, May 28, August 23, and November 22, 1994. For discussion purposes the 10 m to surface tow samples will be referred to as eplimnetic samples and the bottom to surface net tow samples will be referred to as whole column samples. Locations 2.0 and 5.0 are defined as the Mixing

Zone and Locations 9.5, 11.0 and 15.9 are defined as Background locations. Field and laboratory methods for zooplankton standing crop analysis were the same as those reported in Hamme (1982). Zooplankton standing crop data from 1994 were compared with corresponding data from quarterly monitoring begun in August 1987.

A one way ANOVA was performed on epilimnetic total zooplankton densities by quarter. This was followed by a Duncan's Multiple Range Test to determine which location means were significantly different.

RESULTS AND DISCUSSION

Total Abundance

Lakewide, total zooplankton densities in both epilimnetic and whole column samples in 1994 were highest in May and lowest in August (Table 4-1). Spring is historically the time of maximum zooplankton standing crop in Lake Norman (Hamme 1982). The greatest observed zooplankton densities in 1994 for eplimnetic samples were observed at Location 11.0 in May (146,600/m^3) and for whole column samples were observed at Location 9.5 in February (108,200/m^3). The lowest zooplankton densities were observed in August; at Location 9.5 (18,600/m^3) for epilimnetic samples and at Location 2.0 (13,100/m^3) for whole column samples.

Total zooplankton densities were generally greater in epilimnetic samples than in whole column samples in 1994 as in previous years (Duke Power Company 1990, 1991, 1992 and 1993). This phenomenon is related to the ability of zooplankton to orient vertically in the water column in response to a variety of physical and chemical gradients and the distribution of food sources, primarily phytoplankton (Hutchinson 1967).

The general trend of increasing zooplankton population densities from downlake to uplake observed in previous years was also observed in 1994 (Figure 4-1). Total zooplankton density in eplimnetic samples was significantly higher at the uplake Location 15.9 than other locations in August and November (Table 4-2). The highest densities observed for 1994 were found at mid and uplake Locations 11.0 and 15.9 in May where they were significantly higher than locations downlake. Mixing Zone Locations were not significantly different from each other during any quarter and grouped with at least one background location in every quarter except February. Total zooplankton densities from eplimnetic samples collected during February, May, August and November of 1994 were generally within the range of those reported for these months in previous years (Figure 4-2).

Community Composition

Fifty-seven zooplankton taxa have been identified in samples collected since the Lake Norman Maintenance Monitoring Program was initiated in August 1987 (Table 4-3). No new zooplankton taxa were identified in samples collected in 1994. Rotifers most often dominated zooplankton assemblages in Lake Norman during 1994 as in previous years, followed by copepods (Table 4-1; Figure 4-3). Cladocerans were numerically dominant only at Location 2.0 in August. Except for February, rotifers exhibited increasing densities from downlake to uplake in eplimnetic samples each month. Hamme (1982) found that the highest rotifer densities generally occurred at uplake locations.

Polyarthra and *Synchaeta* were the major constituents of rotifer populations during February 1994. In May, *Polyarthra* was the dominant rotifer at all locations although rotifers made up smaller portion of the zooplankton community overall. Rotifer taxa were more diverse in August with *Conochilus*, *Trichocerca*, *Keratella* and *Ptygura* comprising more than 10% of the total density at least one location. *Polyarthra* was the major component of the rotifers in November comprising 14 to 35% of the total density at all locations followed by *Keratella* which increased in abundance from downlake to uplake. Major rotifer taxa observed in 1994 were also the most abundant rotifers observed in previous years (Duke Power Company 1988, 1989, 1990, 1991, 1992, 1993, 1994; Hamme 1982).

Copepod populations were dominated by immature forms (primarily nauplii and cyclopoid copepodids with some calanoid copepodids) during all sampling periods of 1994 as was the case in 1993. *Mesocyclops* spp. was the only major adult copepod taxon observed in 1994, comprising just over 5% of the total density in both the epilimnetic and whole column samples at Location 5.0 in May. No distinct spatial trend in copepod abundance was noted for samples collected in 1994 (Figure 4-3).

Bosmina was the most abundant cladoceran observed in samples collected in 1994, as in 1993 (Duke Power Company 1994) and in previous years (Hamme 1982). *Bosmina* frequently comprised more than 5% of the total zooplankton density in both epilimnetic and whole column samples in all quarters. The only other major cladoceran taxa observed in 1994 was *Bosminopsis deitersi* which comprised greater than 10% of the total zooplankton density in eplimnetic samples at Mixing Zone Locations in August. No consistent spatial trend in cladoceran abundance was observed in 1994 (Figure 4-3).

Only one noticeable difference was evident in group composition during 1994 compared with the past four years (Figure 4-4). Copepod densities at locations throughout Lake Norman in May were the highest for this month since 1990. Cladoceran and rotifer densities for 1994, on the other hand, are within historical ranges.

FUTURE STUDIES

No changes are planned for the zooplankton portion of the Lake Norman maintenance monitoring program.

SUMMARY

Total zooplankton standing crops were generally highest in May and lowest in August. zooplankton densities, in general, were slightly higher in eplimnetic samples than in whole column samples. Total zooplankton densities at Mixing Zone locations were not significantly different from at least one background locations during most quarters in 1994. The typical trend of increasing zooplankton densities from downlake to uplake was observed during all months except February in 1994 and appears to be related to higher algal production up reservoir. The range of total zooplankton densities observed during 1994 was similar to the ranges observed since 1987.

Overall, rotifers dominated zooplankton standing crops in 1994, as they did in 1993, followed closely in importance by copepods. Cladocerans were dominant numerically on only one occasion in 1994. Major rotifer taxa observed in 1994 were *Keratella*, *Polyarthra* and *Synchaeta*. Copepod populations were dominated by immature forms (nauplii and cyclopoid copepodids). As in previous years, *Bosmina* was the most abundant cladoceran taxa observed at all locations. Overall, zooplankton taxonomic composition in 1994 was similar to that observed in previous years.

These results indicate that continuation of the alternative thermal limits to the water quality standard for temperature are warranted.

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Table 4-1. Total zooplankton densities (no. x 1000/m^3) , densities of major zooplankton taxonomic groups, and percent composition (in parentheses) of major taxa in 10m to surface (10-S) and bottom to surface (B-S) net tow samples collected from Lake Norman in February, May, August, and November 1994.

	Sample		Locations				
Date	Type	Taxon	2.0	5.0	9.5	11.0	15.9
02/25/94	10-S	COPEPODA	17.3	14.2	68.0	49.0	36.5
			(29.4)	(27.7)	(48.0)	(48.3)	(38.7)
		CLADOCERA	3.9	2.0	12.8	8.9	13.6
			(6.6)	(3.8)	(9.0)	(8.8)	(14.4)
		ROTIFERA	37.5	35.2	60.8	43.5	44.3
			(64.0)	(68.5)	(43.0)	(42.9)	(46.9)
		TOTAL	**58.6**	**51.3**	**141.6**	**101.4**	**94.4**
	B-S	COPEPODA	7.3	9.4	59.8	20.2	32.6
	depth(m)		(27.6)	(22.6)	(55.3)	(41.0)	(40.3)
	of tow						
	for each	CLADOCERA	1.9	3.1	6.6	6.3	9.0
	location		(7.1)	(7.3)	(6.1)	(12.9)	(11.1)
	2.0=30						
	5.0=18	ROTIFERA	17.3	29.2	41.8	22.6	39.3
	9.5=18		(65.3)	(70.1)	(38.6)	(46.1)	(48.6)
	11.0=25						
	15.9=19	**TOTAL**	**26.5**	**41.7**	**108.2**	**49.1**	**80.8**
05/28/94	10-S	COPEPODA	57.0	43.0	70.3	90.9	68.9
			(68.7)	(70.4)	(67.7)	(62.0)	(47.8)
		CLADOCERA	15.4	8.2	4.4	19.3	12.8
			(18.6)	(13.4)	(4.2)	(13.2)	(8.9)
		ROTIFERA	10.6	9.9	29.2	36.3	62.3
			(12.7)	(16.2)	(28.1)	(24.8)	(43.3)
		TOTAL	**82.9**	**61.1**	**103.8**	**146.6**	**144.0**
	B-S	COPEPODA	20.9	46.3	46.2	48.9	25.3
	depth(m)		(74.7)	(68.1)	(66.5)	(67.7)	(49.6)
	of tow						
	for each	CLADOCERA	5.1	10.6	3.8	10.8	4.1
	location		(18.1)	(15.6)	(5.4)	(15.0)	(8.0)
	2.0=31						
	5.0=18	ROTIFERA	2.0	11.1	19.5	12.6	21.6
	9.5=19		(7.2)	(16.3)	(28.1)	(17.4)	(42.4)
	11.0=26						
	15.9=19	**TOTAL**	**28.0**	**67.9**	**69.5**	**72.3**	**51.0**

Table 4-1 (continued)

Page 2 of 2

	Sample		Locations				
Date	Type	Taxon	2.0	5.0	9.5	11.0	15.9
08/23/94	10-S	COPEPODA	10.5	8.3	4.1	11.2	35.6
			(32.6)	(34.3)	(21.9)	(32.8)	(40.8)
		CLADOCERA	12.2	6.2	3.1	7.6	11.6
			(38.0)	(25.4)	(16.7)	(22.3)	(13.3)
		ROTIFERA	9.5	9.8	11.4	15.3	40.0
			(29.4)	(40.4)	(61.4)	(44.9)	(45.9)
		TOTAL	**32.2**	**24.2**	**18.6**	**34.2**	**87.3**
	B-S	COPEPODA	6.5	9.0	13.3	8.7	13.0
	depth(m)		(49.6)	(50.1)	(55.8)	(37.7)	(42.7)
	of tow						
	for each	CLADOCERA	3.3	4.0	4.0	4.5	3.9
	location		(25.6)	(22.5)	(17.1)	(19.4)	(12.9)
	2.0=30						
	5.0=19	ROTIFERA	3.2	4.9	6.3	9.9	13.5
	9.5=20		(24.8)	(27.4)	(27.1)	(42.9)	(44.4)
	11.0=26						
	15.9=20	**TOTAL**	**13.1**	**17.9**	**23.3**	**23.2**	**30.5**
11/22/94	10-S	COPEPODA	12.8	13.4	17.7	39.0	24.1
			(61.5)	(48.3)	(41.7)	(45.9)	(20.6)
		CLADOCERA	2.0	1.6	0.7	6.9	1.6
			(9.6)	(5.9)	(1.7)	(8.2)	(1.4)
		ROTIFERA	6.0	12.7	23.1	39.0	91.2
			(28.9)	(45.7)	(56.6)	(45.9)	(78.0)
		TOTAL	**20.8**	**27.7**	**40.8**	**85.0**	**116.9**
	B-S	COPEPODA	7.8	16.4	18.8	32.0	13.0
	depth(m)		(53.3)	(51.6)	(35.8)	(46.2)	(30.6)
	of tow						
	for each	CLADOCERA	3.0	3.2	2.4	3.5	2.5
	location		(20.6)	(10.2)	(4.6)	(5.0)	(5.9)
	2.0=30						
	5.0=18	ROTIFERA	3.8	12.2	31.4	33.8	27.0
	9.5=20		(26.2)	(38.2)	(59.7)	(48.7)	(63.5)
	11.0=18						
	15.9=20	**TOTAL**	**14.7**	**31.8**	**52.7**	**69.3**	**42.6**

Table 4-2. Duncan's Multiple Range Test on zooplankton densities in Lake Norman, NC during 1994. (Means connected by the same line are not significantly different.)

February	Location	**5.0**	**2.0**	**15.9**	**11.0**	**9.5**
	Mean	51.3	58.6	94.4	101.4	141.6
		———	———	———	———	———
May	Location	**5.0**	**2.0**	**8.0**	**15.9**	**11.0**
	Mean	61.1	82.9	103.8	144.0	146.6
			———	———	———	———
		———	———			
August	Location	**9.5**	**5.0**	**2.0**	**11.0**	**15.9**
	Mean	18.6	24.2	32.2	34.2	87.3
				———	———	———
			———	———		
		———	———			
November	Location	**2.0**	**5.0**	**9.5**	**11.0**	**15.9**
	Mean	20.8	27.7	40.8	85.0	116.9
			———	———	———	———
		———	———			

Table 4-3. Zooplankton taxa identified from samples collected on Lake Norman quarterly from August 1987 through November 1994.

COPEPODA

Cyclops thomasi S. A. Forbes
C. spp. Fischer
Diaptomus birgei Marsh
D. mississippiensis Marsh
D. pallidus Herick
D. spp. Marsh
Mesocyclops edax (S. A. Forbes)
M. spp. Sars
Tropocyclops prasinus (Fischer)
T. spp. Kiefer
Calanoid copepodites
Cyclopoid copepodites
Nauplii

CLADOCERA

Bosmina longirostris (O. F. Muller)
B. spp. Baird
Bosminopsis dietersi Richard
Ceriodaphnia spp. Dana
Daphnia ambigua Scourfield
D. lumholzi Sars
D. parvula Fordyce
D. spp. Mullen
Diaphanosoma spp. Fischer
Holopedium amazonicum Stingelin
H. spp. Stingelin
Leptodora kindtii (Focke)
Ilyocryptus sordidus (Lieven)
Sida crystallina O. F. Muller

ROTIFERA

Anuraeopsis spp. Lauterborne
Asplanchna spp. Gosse
Brachionus caudata Barrois and Daday
B. havanaensis Rousselet
B. patulus O. F. Muller
Chromogaster spp. Lauterborne
Collotheca spp. Harring
Conochiloides spp. Hlava
Conochilus unicornis (Rousselet)
C. spp. Hlava
Gastropus spp. Imhof
Hexarthra spp. Schmada
Kellicotia bostoniensis (Rousselet)
K. spp. Rouselet
Keratella spp. Bory de St. Vincent
Lecane spp. Nitzsch
Macrocheatus spp. Perty
Monostyla stenroosi (Meissener)
M. spp. Ehrenberg
Ploeosoma truncatum (Levander)
P. spp. Herrick
Polyarthra euryptera (Weirzeijski)
P. vulgaris Carlin
P. spp. Ehrenberg
Ptygura spp. Ehrenberg
Synchaeta spp. Ehrenberg
Trichocerca capucina (Weireijski)
T. cylindrica (Imhof)
T. spp. Lamark
Unidentified Bdelloidea

INSECTA

Chaoborus spp. Lichtenstein

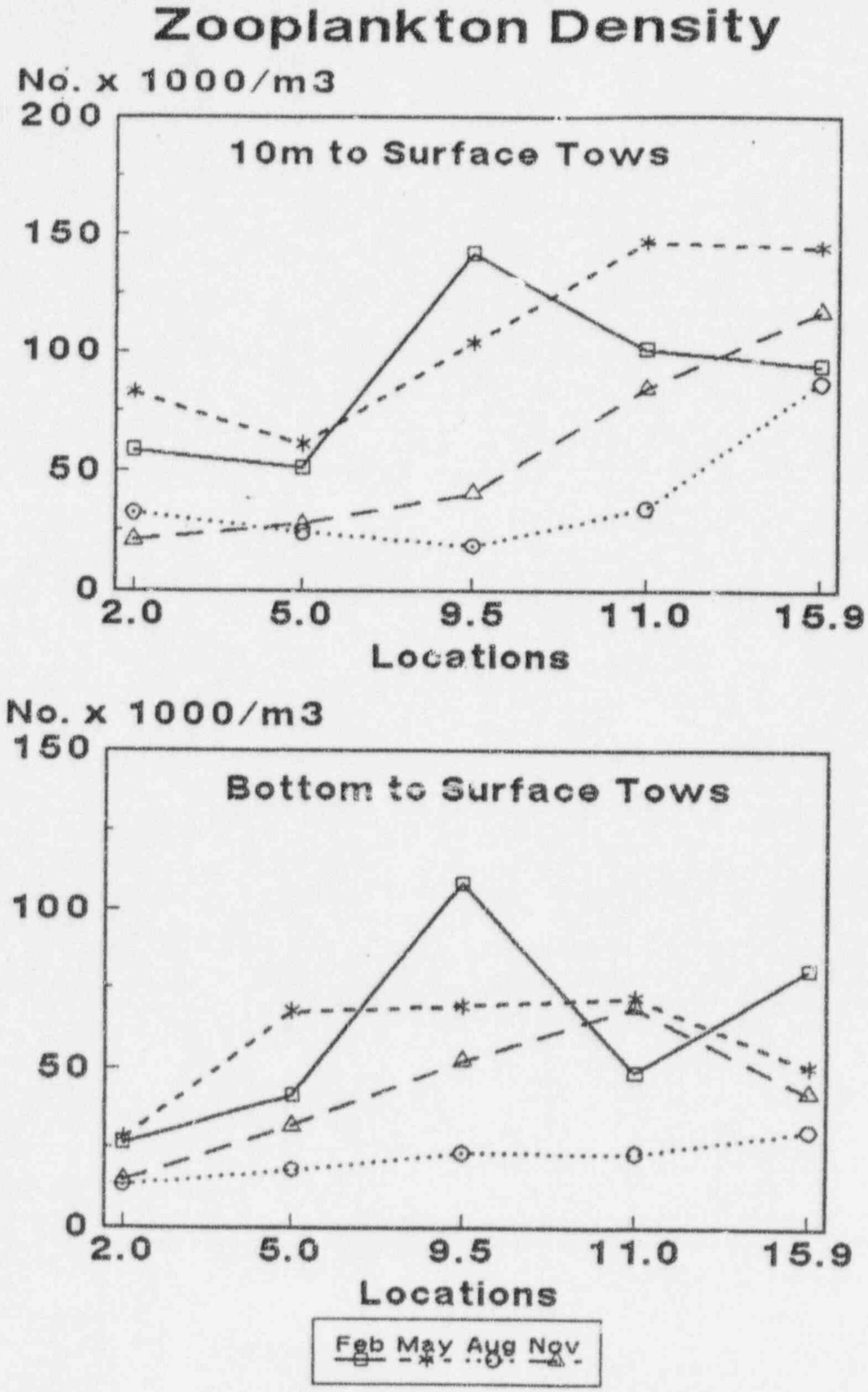

Figure 4-1. Total zooplankton density (units x1000/m^3) by location for samples collected in Lake Norman, North Carolina in 1994.

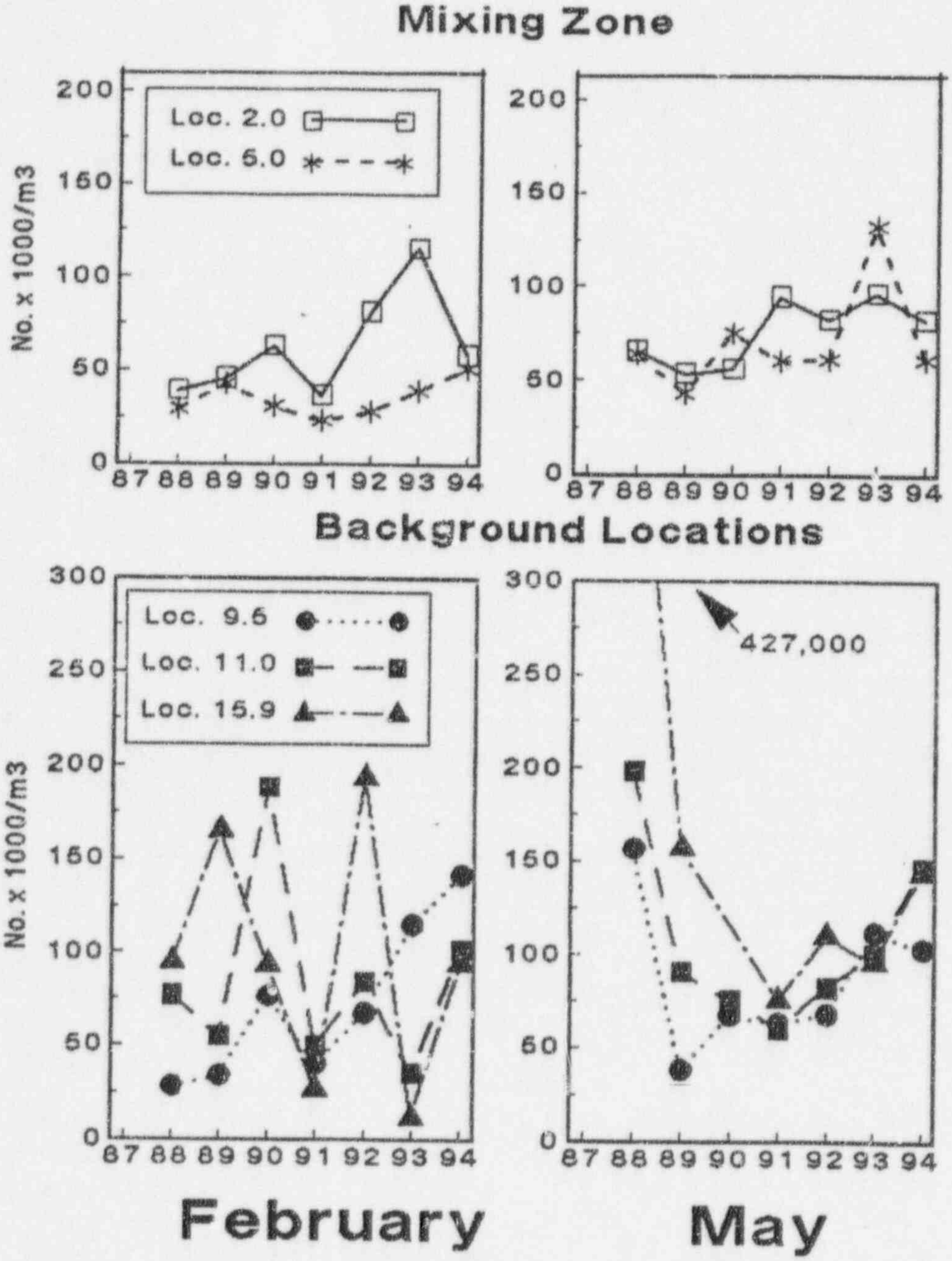

Figure 4-2. Total zooplankton density (units x1000/m^3) by location for samples collected during 1994 in Lake Norman, North Carolina.

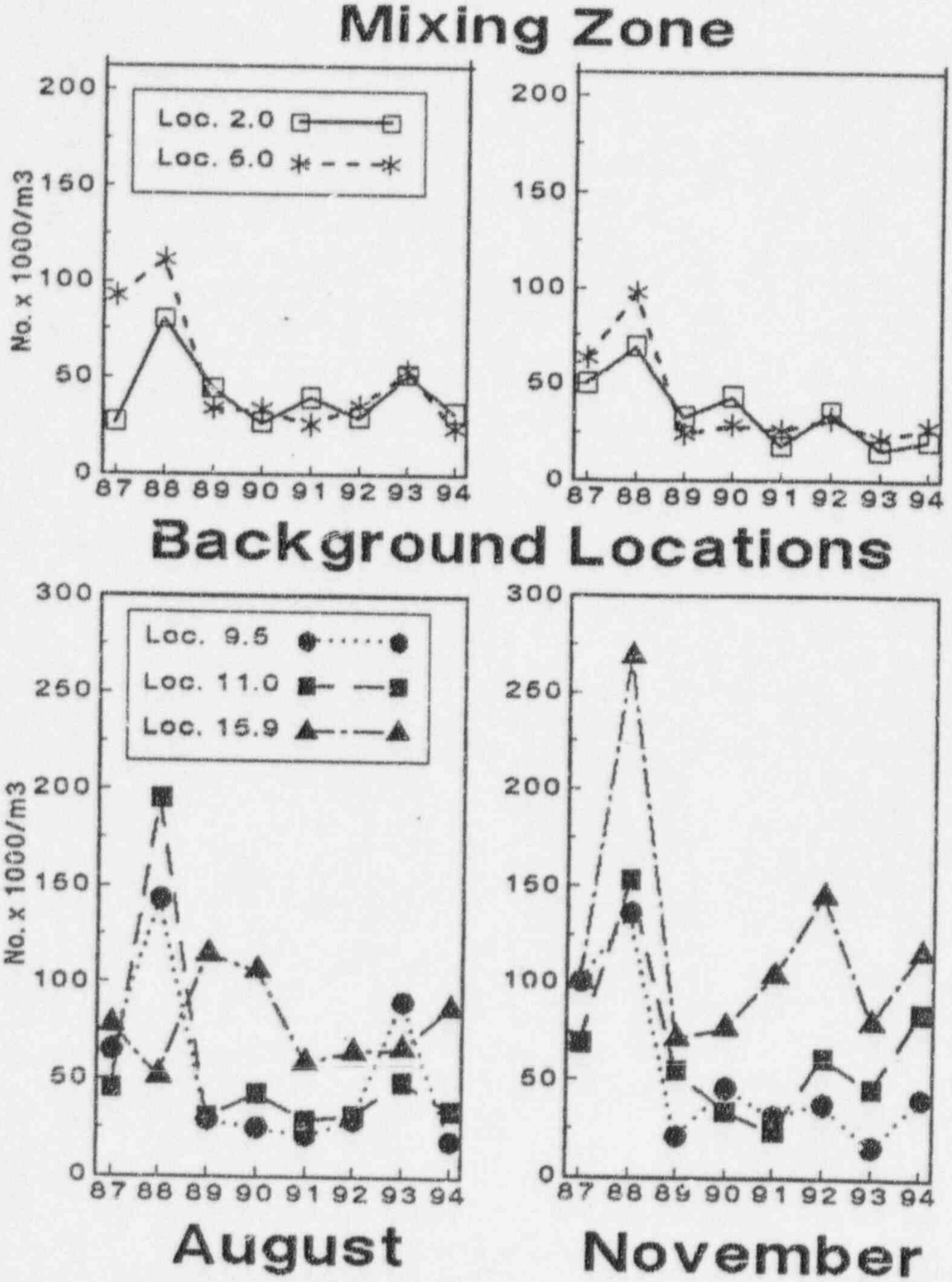

Figure 4-2. Continued

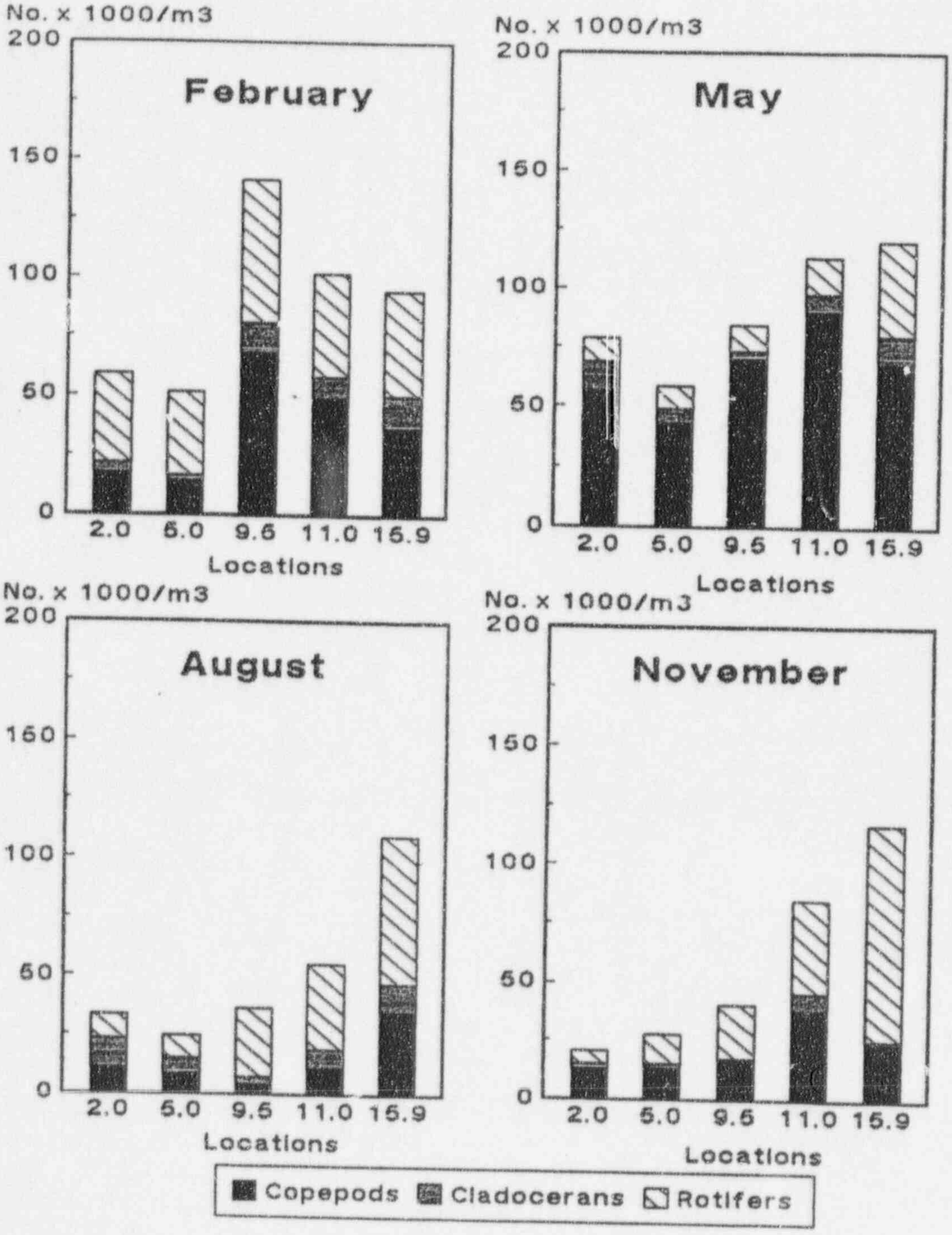

Figure 4-3. Zooplankton composition by month for epiiimnetic samples collected during 1994 in Lake Norman, North Carolina.

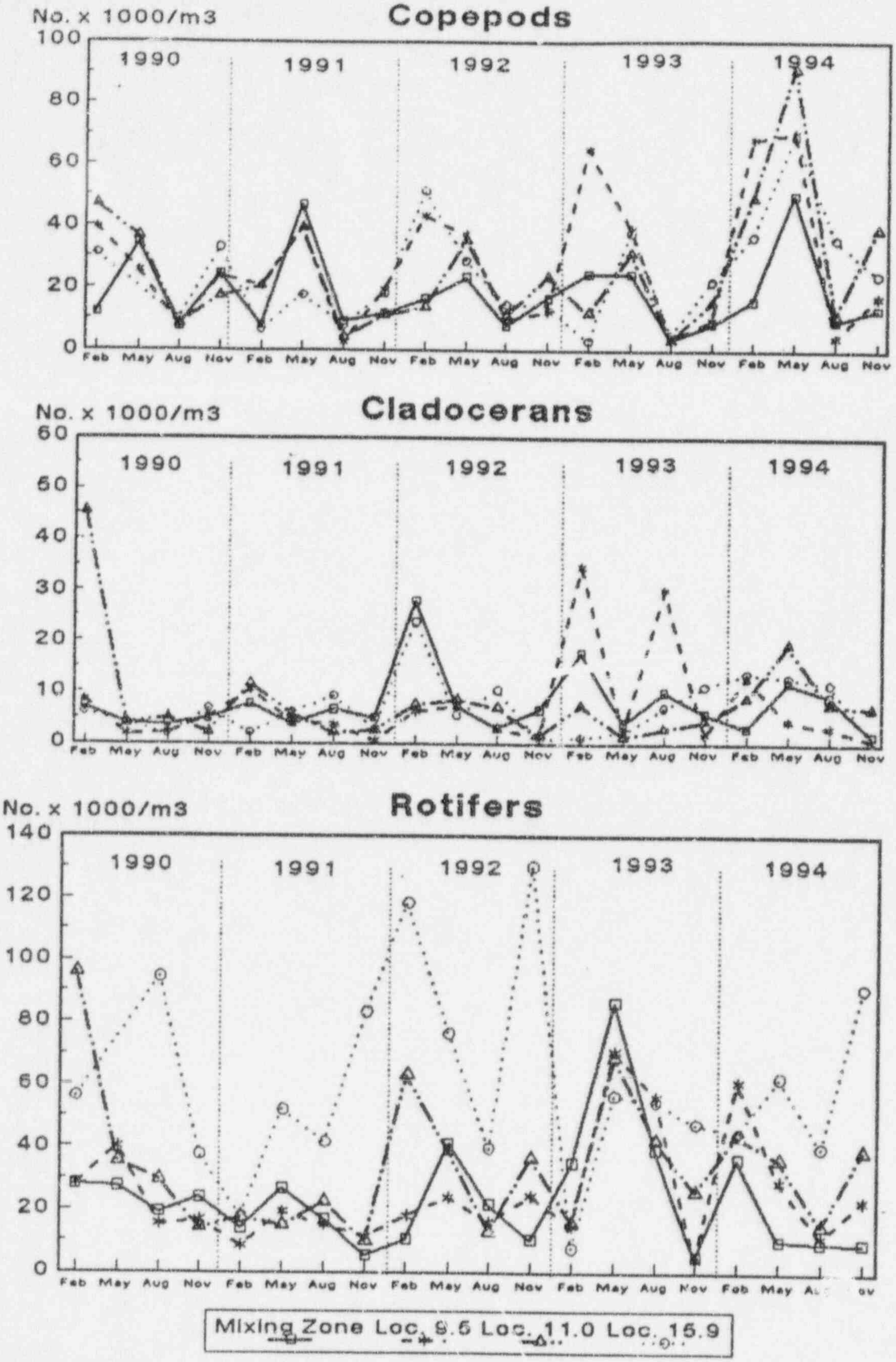

Figure 4-4. Comparison of zooplankton density by group in epilimnetic samples collected from 1989 through 1994 in Lake Norman, North Carolina.

CHAPTER 5

FISHERIES

INTRODUCTION

In accordance with the NPDES permit for McGuire Nuclear Station (MNS), monitoring of specific fish population parameters was continued during 1994. The objectives of the fish monitoring program for Lake Norman during 1994 were to:

*Continue striped bass mortality monitoring throughout the summer.

*Determine fish distribution, and angler harvest, pressure, and success with an angler survey on Lake Norman March 1994 through February 1995.

METHODS AND MATERIALS

We monitored the mixing zone for striped bass mortalities through the summer during sampling trips on the lake, and during the last week of July through August specifically to locate dead or dying fish.

A creel survey was conducted March 1994 through February 1995 on Lake Norman to obtain information about the fishery. Statistical analyses of these data is on-going and a separate report will be forwarded to NCDEHNR for review in 1996.

RESULTS AND DISCUSSION

No dead or dying striped bass were reported in lower Lake Norman during summer 1994. The temporat and spatial of pattern of striped bass habitat expansion and reduction in Lake Norman during 1994 was well within the historic range (Chapter 2).

These results indicate that continuation of the alternative thermal limits to the water quality standard for temperature are warranted.

FUTURE FISH STUDIES

- Continue striped bass mortality monitoring throughout the summer.
- Initiate a cooperative study with NCWRC to determine the feasibility of stocking hybrid striped bass-white bass in Lake Norman.