

DUKE POWER COMPANY  
CATAWBA NUCLEAR STATION  
INTERIM MONITORING STUDY

July 1978-June 1979

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## INTRODUCTION

Lake Wylie, a 5000 ha reservoir, is located in North Carolina and South Carolina. It is one of 11 reservoirs constructed by Duke Power Company along the Catawba River for hydroelectric power generation. The Wylie Hydroelectric Station is rated at 60 MW. Discharge through the station averages 116 cms. Wylie Hydroelectric Station draws water from six to eighteen meters below the surface. In the summer (August) this water is approximately 50% hypolimnetic (Weiss et al. 1975). The lake receives 50% of its water from the Catawba River via Mountain Island Reservoir and 25% from the South Fork River. The remaining 25% is derived from local tributary input and runoff. The reservoir has a theoretical retention time of 32 days.

The southern portion of the lake will serve as the site of Catawba Nuclear Station (CNS), a 2290 MWe nuclear steam generating station. The Station will withdraw 10 cms of water from the main body of Lake Wylie. Cooling water will pass through ten cycles of concentration in mechanical draft cooling towers and blowdown will be discharged at a rate of 0.15 cms to the Allison Creek arm of Lake Wylie. A detailed discussion of the possible impacts of CNS has been prepared by the U.S. Atomic Energy Commission (1973).

In August 1974, Duke Power Company began a sampling program on Lake Wylie. This sampling program constitutes the interim monitoring program for Catawba Nuclear Station. Data for the period 1974 through 1978 have been reported by Duke Power Company (1977, 1978).

The data contained in this report are part of the continuing interim study. These data cover the period July 1978 through June 1979.

Twelve sampling locations on Lake Wylie were monitored and analyses performed in compliance with the approved program.

The objectives of the interim monitoring study for Catawba Nuclear Station are:

- 1) To document any long-term trends in the temporal variability of Lake Wylie water quality and;
- 2) To compare long-term trends in the water quality data immediately above and below the Catawba site.

#### MATERIALS AND METHODS

Field sampling and Laboratory analyses for the 1978-1979 period were the same as for the 1977-1978 period. Sample locations are shown in Figure 1. Laboratory analyses are listed in Table 1.

In April, May and June 1979, Locations 240.0 and 242.0 in the South Fork River were not sampled. Any discussions of water quality in the South Fork River region for the spring 1979 sampling are based totally on data obtained from Location 249.0.

#### SUMMARY AND CONCLUSIONS

Profile data were collected by Duke Power Company monthly on Lake Wylie from July 1978 through June 1979. Water samples for laboratory analyses were collected quarterly during the same period. As noted in previous reports, local hydrology and meteorology exerted the primary influence on the variations of physical and chemical parameters. Peak concentrations in chemical constituents were related to periods of increased precipitation and runoff.

Data indicated that the high inputs observed during 1977-1978 has declined. Concentrations in 1978-1979 had generally returned to levels reported for the period prior to 1977.

Maximum water temperatures occurred in July and August and minimum temperatures occurred in January and February. The thermal regimes of the CNS intake and discharge areas were similar. The stratified period extended from April through September. Water temperatures in the vicinity of CNS remained below the criteria established by North and South Carolina (32.2 C). During the latter part of the stratified period dissolved oxygen in the bottom waters approached anoxic conditions. Surface dissolved oxygen concentrations remained above the North and South Carolina standard of 5.0 mg/l.

Turbidity levels during 1978-1979 indicated that the large inputs of suspended matter reported for 1977-1978 had subsided. This was accompanied by a return to pre-1977 levels for mineral and nutrient concentrations.

## RESULTS AND DISCUSSION

### HYDROLOGY

Precipitation patterns during the 1978-1979 study period are illustrated by Figure 2. Precipitation for the year ending June 30, 1979 was 23.69% above the historical yearly mean (U. S. Dept. of Commerce 1978, 1979). In general, precipitation levels were above normal during winter, spring and summer and below normal during the fall months.

The four quarterly sampling dates for aquatic nutrients, minerals and turbidity are indicated on Figure 2. For the July sampling, rainfall prior to the sampling date was slightly less than normal. (No precipitation was noted for nine sampling days preceeding sampling). The fall sampling

date was preceded by an unusually dry period throughout September and October. The period preceding the winter quarterly sampling was somewhat wetter than normal, although very little precipitation occurred in the days immediately prior to sampling. The spring quarterly sampling was punctuated by a total of 2.76 inches of rainfall occurring within a 24 hour period on April 25-26, however, no significant precipitation had occurred for 11 days prior to that (U. S. Dept. of Commerce 1979).

Daily lake surface elevation and discharge for Lake Wylie are shown on Figures 3 and 4, respectively. Maximum values for both surface elevation and discharge occurred during the late winter and spring of 1979, while minimum values occurred during October and November, 1978. Generally, trends in surface elevation and discharge followed trends in precipitation (Figures 2, 3 and 4).

#### PHYSICAL PARAMETERS (TEMPERATURE, DISSOLVED OXYGEN AND TURBIDITY)

Monthly variations in mean water temperature and mean dissolved oxygen (DO) concentration for each region of Lake Wylie are illustrated in Figures 5(a) - 5(d). Generally the variations for each region on an annual basis have been consistent with previous studies. Maximum mean temperatures for the 1978-1979 period occurred in July and August which was consistent with previous observations (Duke Power Company 1977, 1978). Minimum mean water temperatures were recorded in January and February. Maximum regional DO concentrations for Lake Wylie occurred in either January or February, while minimum concentrations were measured during June, July or September. Generally, 1978-1979 extremes of mean temperature and mean DO concentrations for the four lake regions were less severe than those reported for the previous study period (1977-1978).

Maximum and minimum mean temperatures for Lake Wylie below the CNS discharge during the 1978-1979 study period occurred in August and February, respectively. The maximum mean DO concentration existed in January, while the minimum mean concentration occurred during July (Figure 5(a)). Seasonal transitions of temperature and DO occurred in a smooth pattern during 1978-1979.

Above CNS (Figure 5(b)), mean temperature maxima were measured during July and August, while a minimum mean temperature occurred in February. Mean concentrations of dissolved oxygen reached a maximum value during January and February, and a minimum for the June and July sampling dates. For the region above CNS, smooth seasonal transitions were noted for both temperature and DO means, as has been the case in previous years.

Figure 5(c) illustrates monthly mean temperatures and DO concentrations for the Catawba River (upper lake) region of Lake Wylie. Maximum and minimum mean temperatures occurred during July and February, respectively. Mean DO concentrations in the Catawba River region reached a maximum value during January and February, and a minimum for the September sampling. Cooler ambient air temperatures during June 1979 (U. S. Dept. of Commerce 1979), particularly in the week prior to the monthly sampling, resulted in a decline in the mean water temperature for the Catawba River for that month (Figure 5 (c)). The decline was not reflected at the downlake regions of Lake Wylie, where the seasonal transition from winter to summer is generally less rapidly influenced by variations in air temperature. This is due to the larger heat budget of the downlake regions as compared to the shallower, riverine portions of Lake Wylie (Duke Power Company 1977, 1978). Consistent with the June 1979 decline in temperatures, there

occurred an increase in the mean DO concentration for the Catawba River region (Figure 5(c)) which was not accompanied by an appreciable increase in DO saturation. Increased oxygen solubility was thus primarily a result of lower water temperatures in this region rather than any increase in photosynthetic activity during this month. Mean DO concentrations were consistently higher in the Catawba River region than in the downlake regions throughout the study period, as has been the case in previous years. This difference is the result of more extensive oxygen depletion of the deeper waters of the downlake regions.

For the South Fork region of Lake Wylie, a maximum mean temperature and minimum mean DO concentration occurred during July, whereas January was the month for which a minimum mean temperature and a maximum DO concentration was realized. As was noted for the Catawba River region, cooler June 1979 air temperatures led to a decline in the mean water temperature and an increase in the mean DO concentration for that month (Figure 5(d)). Again, per cent oxygen saturation data supported the conclusion that the increased amount of dissolved oxygen in the water during June was not due to increased photosynthesis in the South Fork region. Also, as noted in the discussion of the Catawba River region, mean DO concentrations remained higher in the South Fork region than in the downlake regions throughout the 1978-1979 study period, as had been the case in previous years (Figure 5(c)).

The CNS intake and discharge (Locations 220.0 and 215.0, respectively) were isothermal from October through February (Figures 6 and 7). Thermal stratification was evident during the summer months in both areas. No appreciable change in the thermal stratification with respect to previous studies was observed during the 1978-79 study.



in November 1978. As noted previously, conductance was generally higher in the South Fork region than in the downlake areas of Lake Wylie.

Seven mineral cations and two mineral anions were determined as in previous studies (Figure 11). Cation concentrations ranged from 0.66 meq/l in spring to 1.14 meq/l in winter. Anions ranged from 0.48 meq/l in spring to 0.66 meq/l in fall. Cations exceeded anions by approximately 0.17 meq/l which was probably due to sulfate as noted in previous reports. In winter of 1979 a difference of 0.66 meq/l was noted. This was probably due to a large increase in particulate associated aluminum and iron, as noted in previous reports (Duke Power Company 1978).

For all samplings except winter sodium remained the major cation accounting for 24-29% of the mineral ions. The major anion, bicarbonate, accounted for 18-28% of the mineral ions. In summer and fall of 1978, bicarbonate equivalents were equal to or less than the chloride concentrations. However in winter and spring of 1979 bicarbonate was about twice the chloride concentration. The 1979 condition was typical of previously presented data.

#### AQUATIC NUTRIENTS (NITROGEN, PHOSPHORUS)

Ammonia concentrations for 1978-1979 (Figure 12) were lower than those observed in 1977-1978 yet higher than those observed in 1975-1977 samplings. Ammonia concentrations in the downlake areas reflected the gradual flushing of the lake of the high nutrient inputs which occurred during 1977 and 1978.

During the 1978-1979 monitoring period, nitrate concentrations (Figure 13) returned to the levels observed prior to the 1977-1978 period. Downlake nitrate concentrations continued to display the temporal pattern previously observed of peak concentrations in the winter and minimal concentrations in the summer and fall.



Monthly depth profiles for the CNS intake and discharge (Figures 8 and 9, respectively) show a depletion of hypolimnetic oxygen occurring during the summer months, as previously observed (Duke Power Company 1977, 1978). The extent of DO depletion from the bottom waters for 1978-1979 was less pronounced than for the 1977-1978 study period.

Mean regional turbidity levels for Lake Wylie are presented in Figure 10. The 1978-79 study period revealed a general decrease in turbidity as compared to the previous study period. Turbidity levels in the South Fork and Catawba River regions varied as a function of precipitation and subsequent runoff (Figures 2 and 10). For all samplings, except the fall sampling, the South Fork River yielded higher turbidity than the Catawba River.

Turbidity levels in the two lake regions (above and below CNS) also reflected precipitation patterns. However, elevated levels in the main lake were detected only when appreciable rainfall had occurred several days prior to the sampling date (i.e., winter sampling of the present study). Hutchinson (1957) has observed that increased turbidity levels due to increased runoff are generally quicker to appear in riverine systems than in lakes.

MINERALS (SPECIFIC CONDUCTANCE, CALCIUM, MAGNESIUM, SODIUM, POTASSIUM, IRON, BICARBONATE, CHLORIDE, SILICA)

Precipitation patterns prior to sampling dates in 1978-1979 were more typical of data observed prior to 1977-1978. Consequently mineral concentrations also displayed patterns similar to historical data. High rainfall immediately before the 1979 winter sampling did produce slightly higher turbidities and an alteration in the lower lake mineral composition as discussed below.

Specific conductance ranged from 42  $\mu\text{mhos/cm}$  in August 1978 to 220  $\mu\text{mhos/cm}$

Concentrations of both ammonia and nitrate continued to be generally higher in the South Fork River than in other areas of Lake Wylie. In isothermal periods nitrate was the dominant form of nitrogen. During stratified periods, ammonia was the dominant nitrogen form.

Figure 14 illustrates temporal trends of total phosphorus in each of the four regions examined. As in the case of nitrogen, phosphorus concentrations during the 1978-1979 period were generally lower than during the 1977-1978 period. The downlake concentrations of total phosphorus continued to exhibit the previously documented trend of peak concentrations occurring in the winter.

## REFERENCES CITED

- American Public Health Association (APHA), American Water Works Association (AWWA), and Water Pollution Control Federation (WPCF). 1976. Standard Methods for the Examination of Water and Wastewater. 14th ed. Amer. Public Health Assn. New York. 874 pp.
- Duke Power Company. 1977. Catawba Nuclear Station. Interim Monitoring Study. 1974-1977. Duke Power Co. Charlotte, NC. np.
- \_\_\_\_\_. 1978. Catawba Nuclear Station Interim Monitoring Study. July 1977-June 1978. Duke Power Co. Charlotte, NC. np.
- Hutchinson, G. E. 1957. Treatise on Limnology. Wiley. New York.
- Hydrolab Corporation. 1973. Instructions for Operating the Hydrolab Surveyor Model 6-D In Situ Water Quality Analyzer. Hydrolab Corp. Austin, TX. 146 pp.
- Monitor Technology. 1973. Monitek Laboratory Turbidimeter Model 150 Operating and Maintenance Instructions. Monitor Technology. Redwood City, CA. 13 pp.
- Perkin-Elmer Corporation. 1976. Analytical Methods for Atomic Absorption Spectroscopy. Perkin-Elmer Corp. Norwalk, CN. np.
- U. S. Atomic Energy Commission. 1973. Final Environmental Statement Related to the Proposed Catawba Nuclear Station Units 1 and 2, Duke Power Company. Docket Nos. 50-413 & 50-414. U. S. AEC. Washington, DC.
- U. S. Department of Commerce. 1978. Meteorological Data for Charlotte, NC. U. S. Dept. of Comm. NOAA. Asheville, NC.
- \_\_\_\_\_. 1979. Meteorological Data for Charlotte, NC. U. S. Dept. of Comm. NOAA. Asheville, NC. (Provisional Data.)
- U. S. Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes. Office of Technol. Transfer. Washington, DC.
- Weiss, C. M., P. H. Campbell, T. P. Anderson, and S. L. Pfauder. 1975. The Lower Catawba Lakes, Characterization of Phyto- and Zooplankton Communities and their Relationships to Environmental Factors. ESE Pub. No. 384. University of North Carolina. Chapel Hill, NC.

Table 1. Methods for analysis of water chemistry variables.

<u>Parameter</u>	<u>Methods</u>	<u>Reference</u>	<u>Preservation Technique</u>	<u>Detection Limit</u>
Alkalinity, total	Method 403	A.P.H.A. et al., 1976	4 C	1 mg/l-CaCO <sub>3</sub>
Aluminum, total	Atomic Absorption-direct aspiration	Perkin-Elmer Corp., 1976	HNO <sub>3</sub>	0.1 mg/l
	Atomic Absorption-graphite furnace	Perkin-Elmer Corp., 1977	HNO <sub>3</sub>	0.1 mg/l
Ammonia	Method 350.1	U.S.E.P.A., 1979	4 C, filtration	0.005 mg/l-N
Cadmium	Atomic Absorption-graphite furnace	Perkin-Elmer Corp., 1976	HNO <sub>3</sub>	0.1 µg/l
Calcium	Atomic Absorption-direct aspiration	Perkin-Elmer Corp., 1977	HNO <sub>3</sub>	0.01 mg/l
Chloride	Method 325.2	U.S.E.P.A., 1979	none	0.3 mg/l
Conductance, specific	Hydrolab Surveyor 6-D	Hydrolab Corp., 1973	in situ	1 µmhos/cm
Copper	Atomic Absorption-graphite furnace	Perkin-Elmer Corp., 1977	HNO <sub>3</sub>	1.0 µg/l
Dissolved oxygen	Hydrolab Surveyor 6-D	Hydrolab Corp., 1973	in situ	0.0 mg/l
Hardness	Method 309 A	A.P.H.A. et al., 1976	none	1 mg/l-CaCO <sub>3</sub>
Iron, total	Atomic Absorption-direct aspiration	Perkin-Elmer Corp., 1976	HNO <sub>3</sub>	0.01 mg/l
Magnesium	Atomic Absorption-direct aspiration	Perkin-Elmer Corp., 1976	HNO <sub>3</sub>	0.01 mg/l
Manganese	Atomic Absorption-direct aspiration	Perkin-Elmer Corp., 1978	HNO <sub>3</sub>	0.01 mg/l
Nitrate-Nitrite	Method 353.2	U.S.E.P.A., 1979	4 C, filtration	0.01 mg/l
Orthophosphate, soluble	Method 365.1	U.S.E.P.A., 1979	4 C, filtration	0.005 mg/l-P
pH	Hydrolab Surveyor 6-D	Hydrolab Corp., 1973	in situ	0.1 pH unit
Phosphorus, total	Method 365.4	U.S.E.P.A., 1974	4 C	0.005 mg/l-P
Potassium	Atomic Absorption-direct aspiration	Perkin-Elmer Corp., 1976	HNO <sub>3</sub>	0.5 mg/l
Silica, soluble	Method 370.1	U.S.E.P.A., 1979	4 C, filtration	0.1 mg/l-SiO <sub>2</sub>
Sodium	Atomic Absorption-direct aspiration	Perkin-Elmer Corp., 1976	HNO <sub>3</sub>	0.2 mg/l
Temperature	Hydrolab Surveyor 6-D	Hydrolab Corp., 1971	in situ	-5.0 C
Turbidity	Monitek Turbidimeter	Monitor Tech. Inc., 1973	4 C	1.0 NTU

Note: Method numbers have been changed to reflect the recent update of the U.S.E.P.A. analytical procedures. The actual analytical methods, however, have remained the same as in previous years.

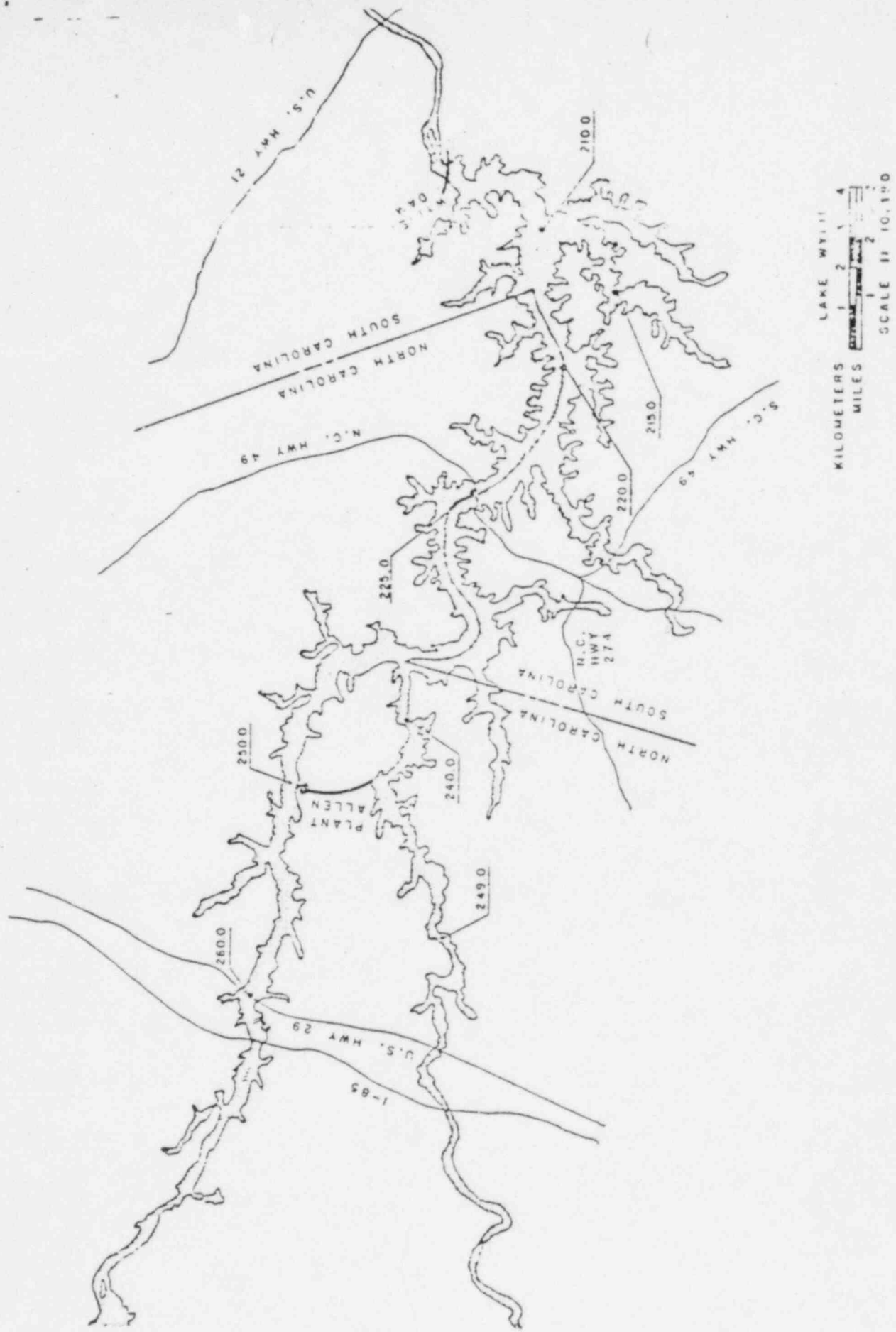


Figure 1. Sampling locations for Catawba Nuclear Station Interim Monitoring.

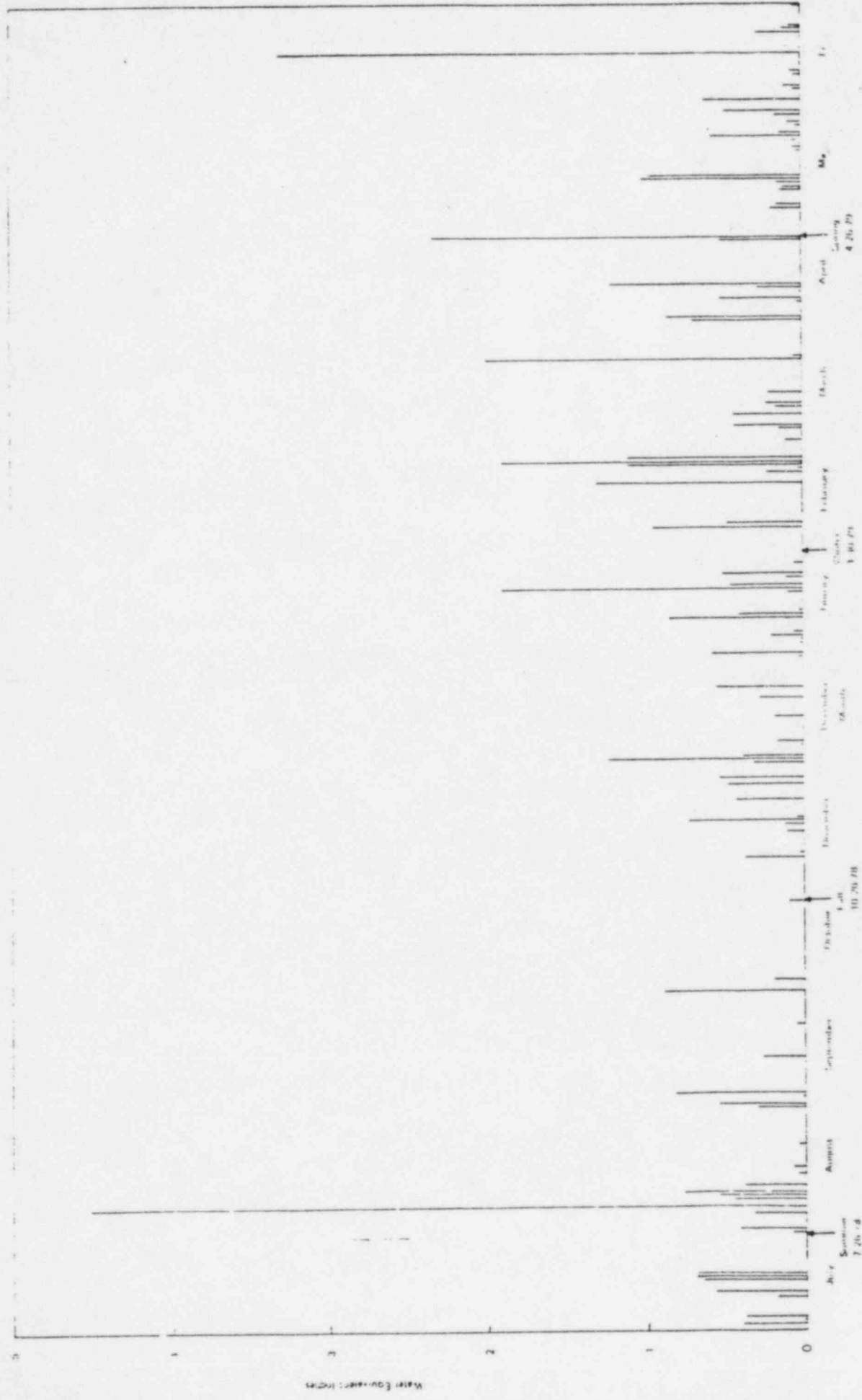


Figure 2. Precipitation at Charlotte Airport (U. S. Dept. of Commerce 1978, 1979).

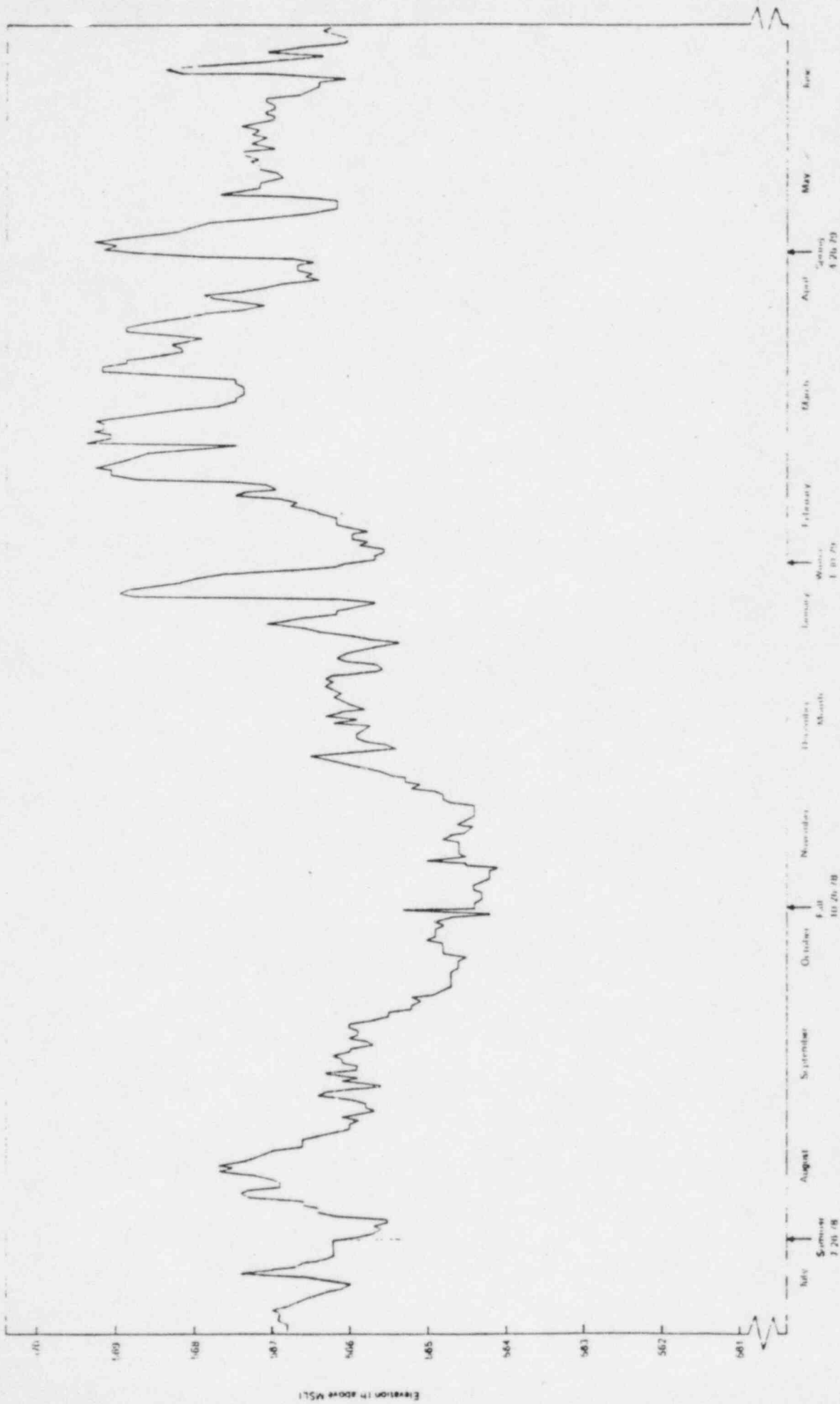


Figure 3. Lake Wylie water surface elevation.



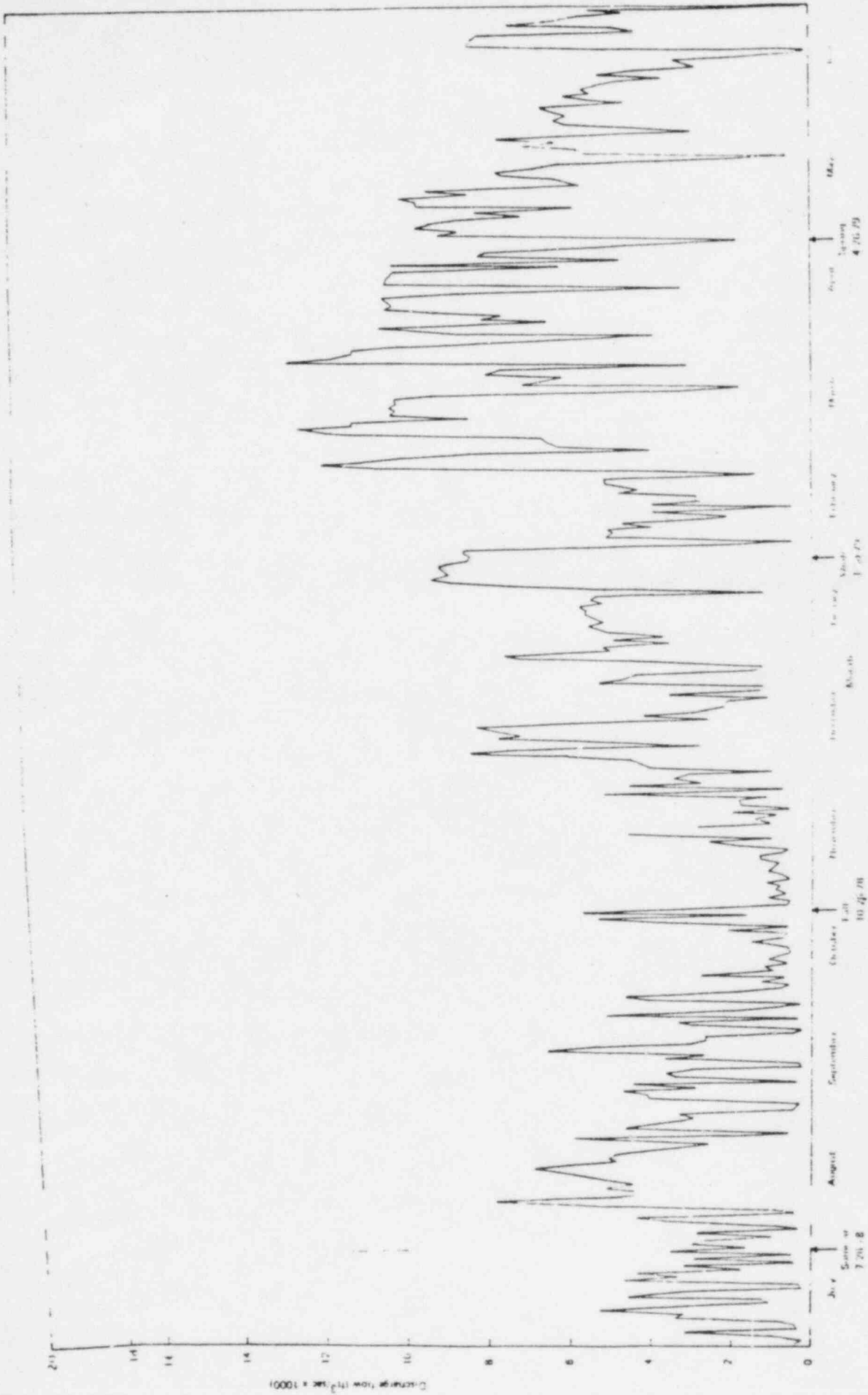
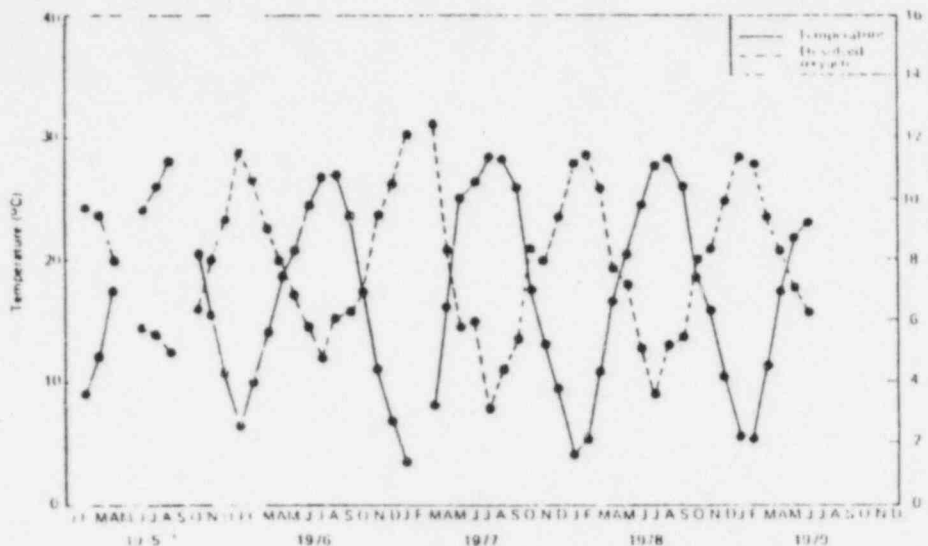
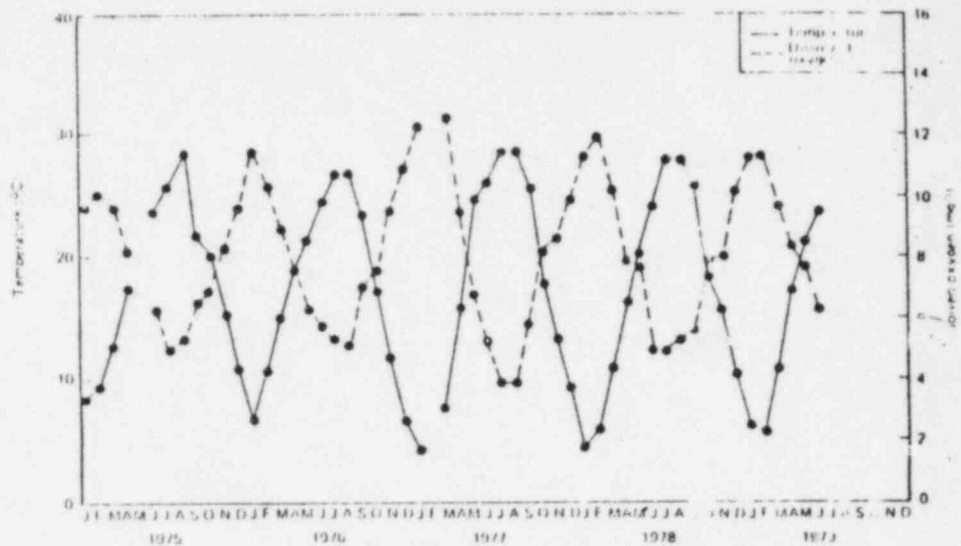


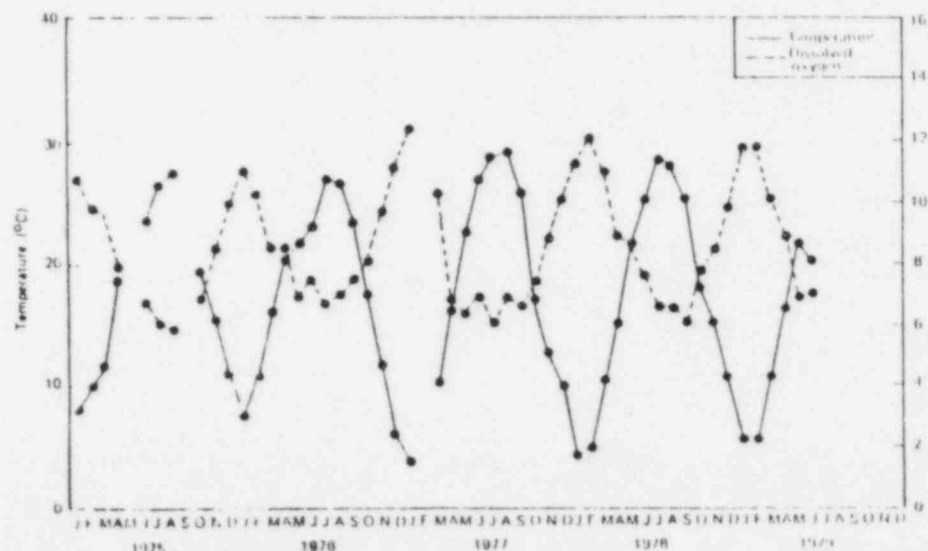
Figure 4. Wylie Hydroelectric Station discharge flow.



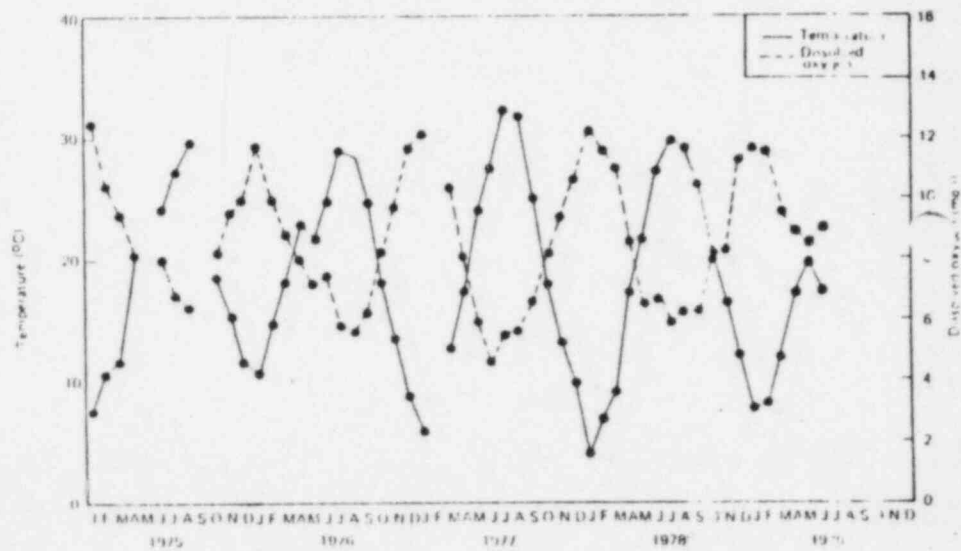
5a. Lake Wylie below CNS



5b. Lake Wylie above CNS



5c. Catawba River



5d. South Fork River

Figure 5. Monthly variations in mean temperature and dissolved oxygen in the four regions of Lake Wylie, 1975-1979.



Figure 6. Thermal regime at the CNS intake (Location 220.0) 1978-1979.

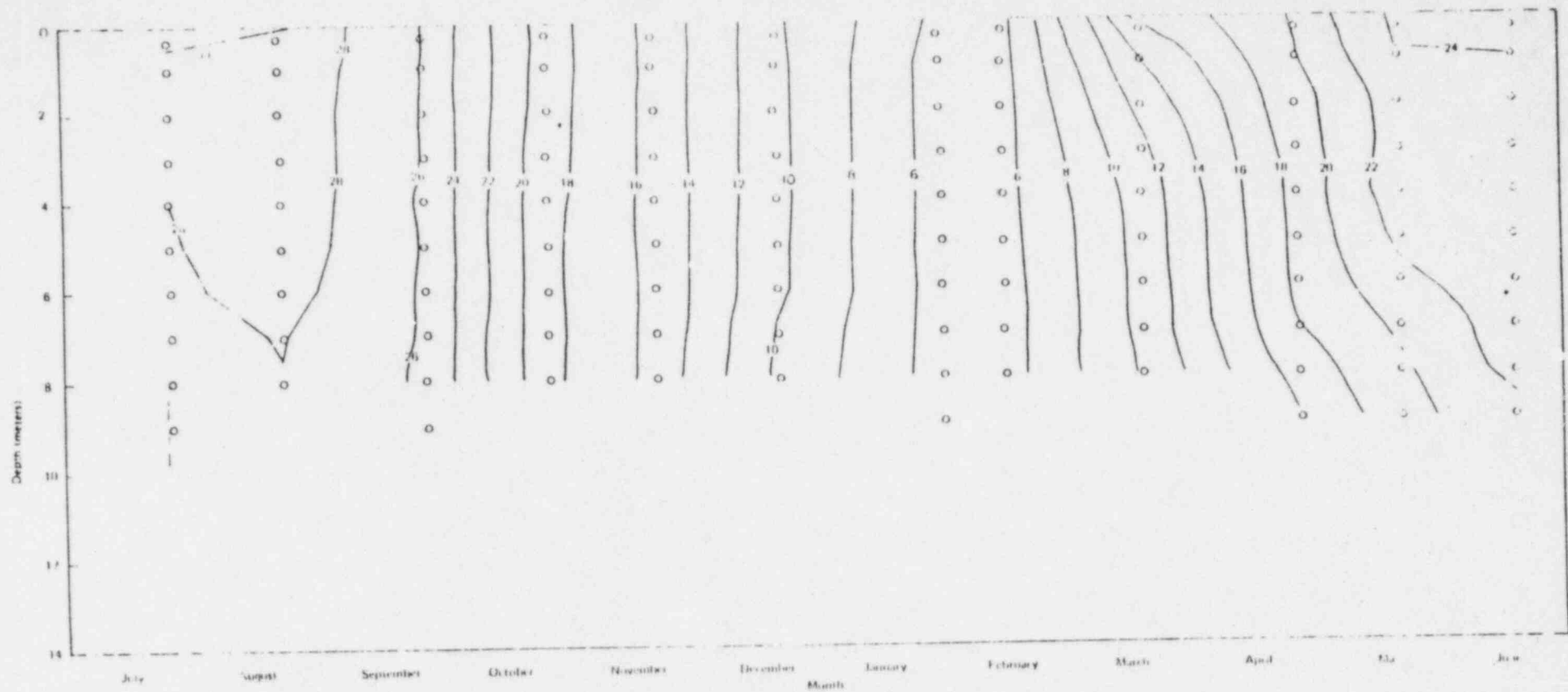


Figure 7. Thermal regime at the CNS discharge (Location 215.0) 1978-1979.

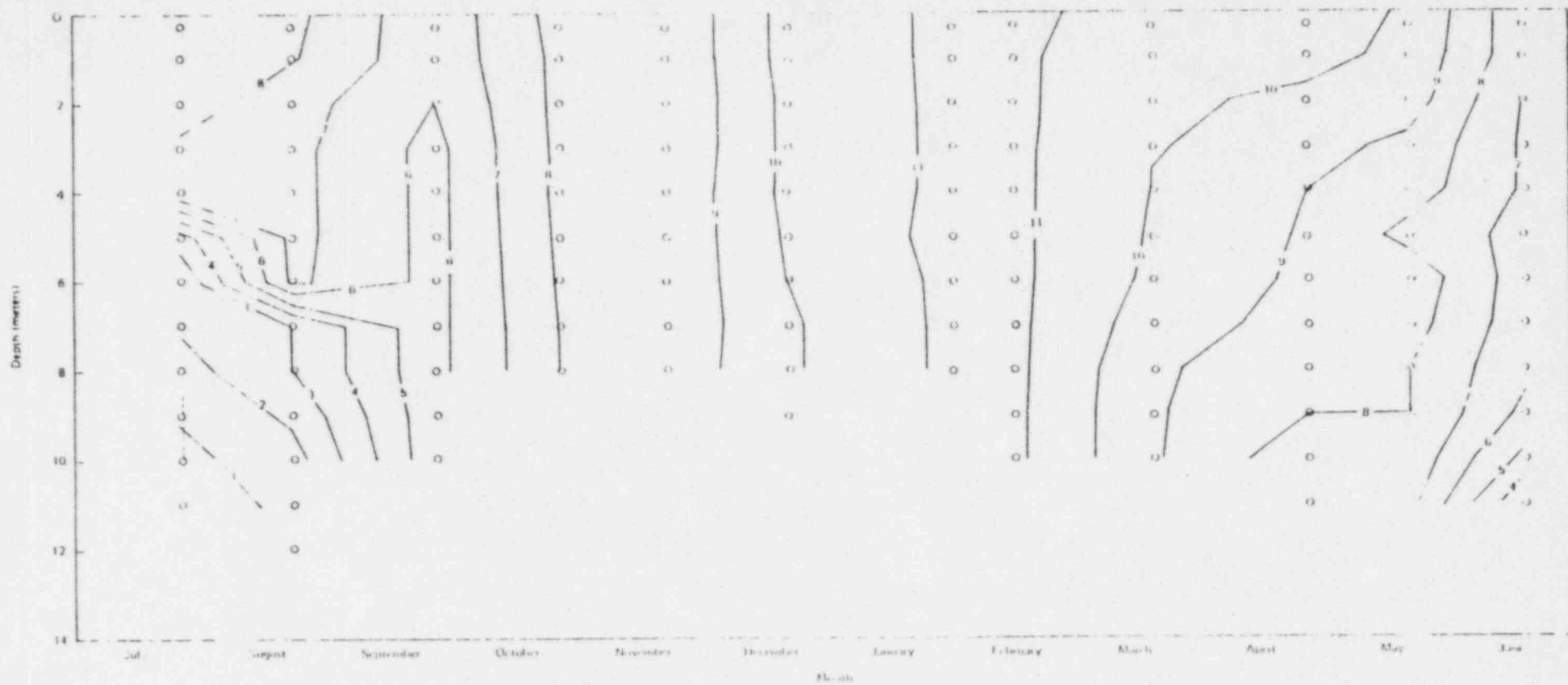


Figure 8. Dissolved oxygen isopleths at CNS intake (Location 220.0) 1978-1979.



Figure 9. Dissolved oxygen isopleths at CNS discharge (Location 215.0) 1978-1979.

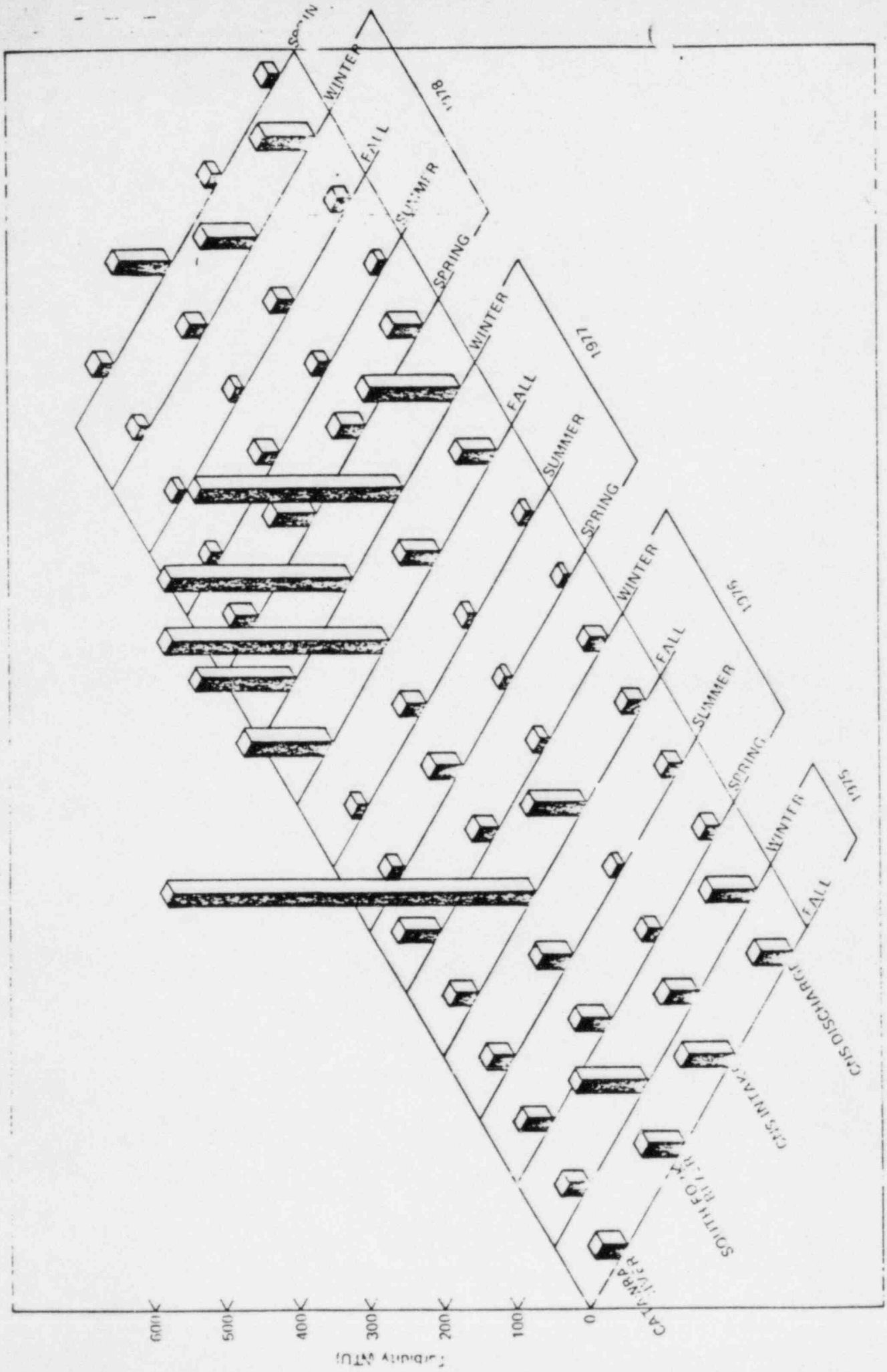


Figure 10. Variations in mean turbidity on Lake Wylie, 1974-1979.



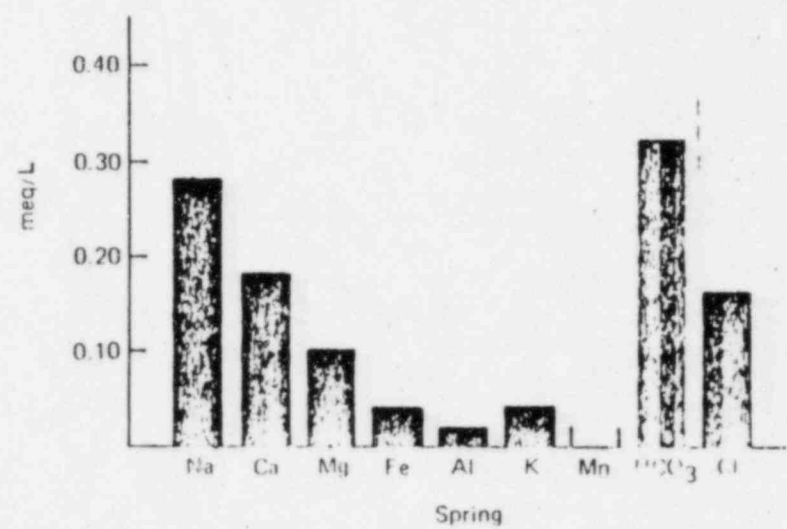
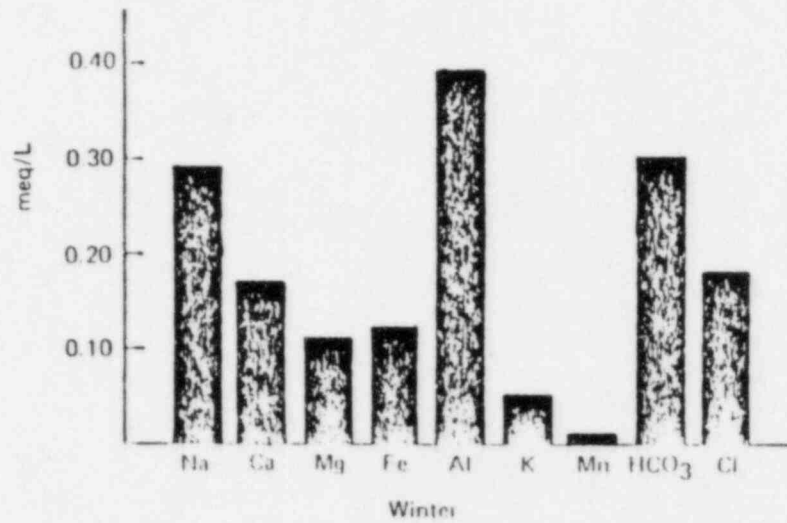
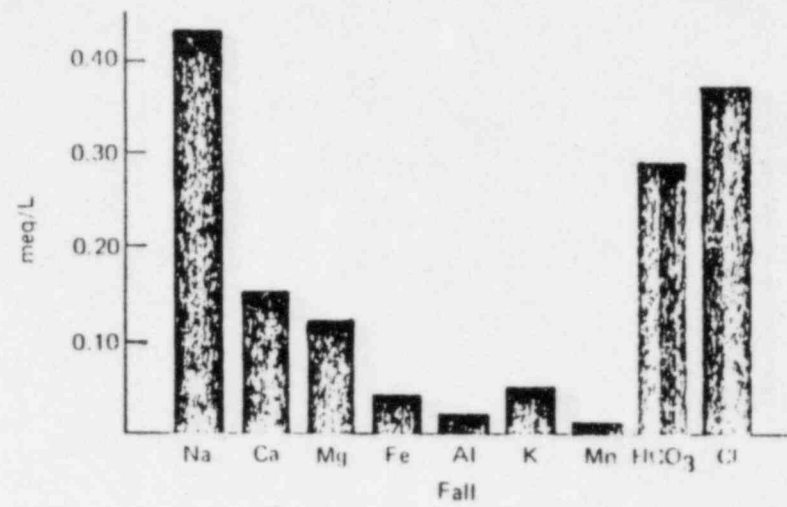
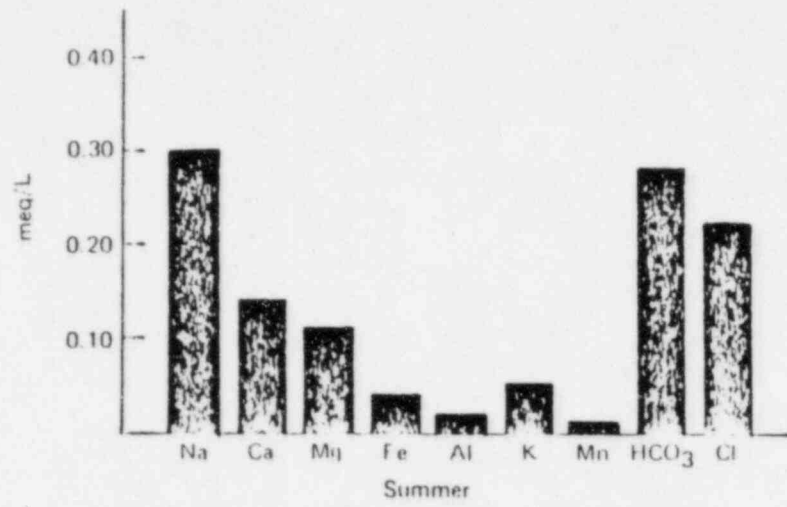


Figure 11. Variations in mineral compositions during 1978-1979.

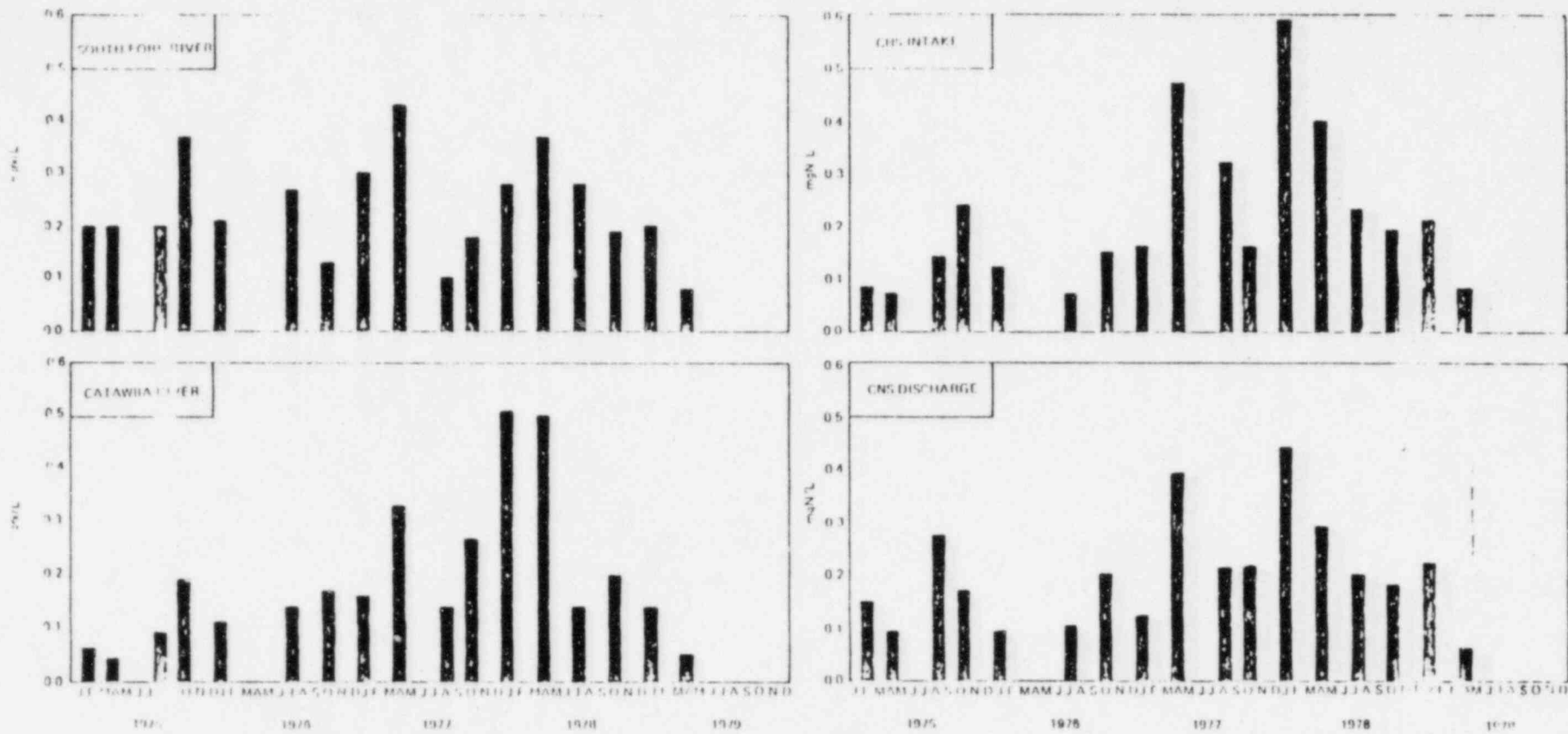


Figure 12. Variations in ammonia concentrations on Lake Wylie

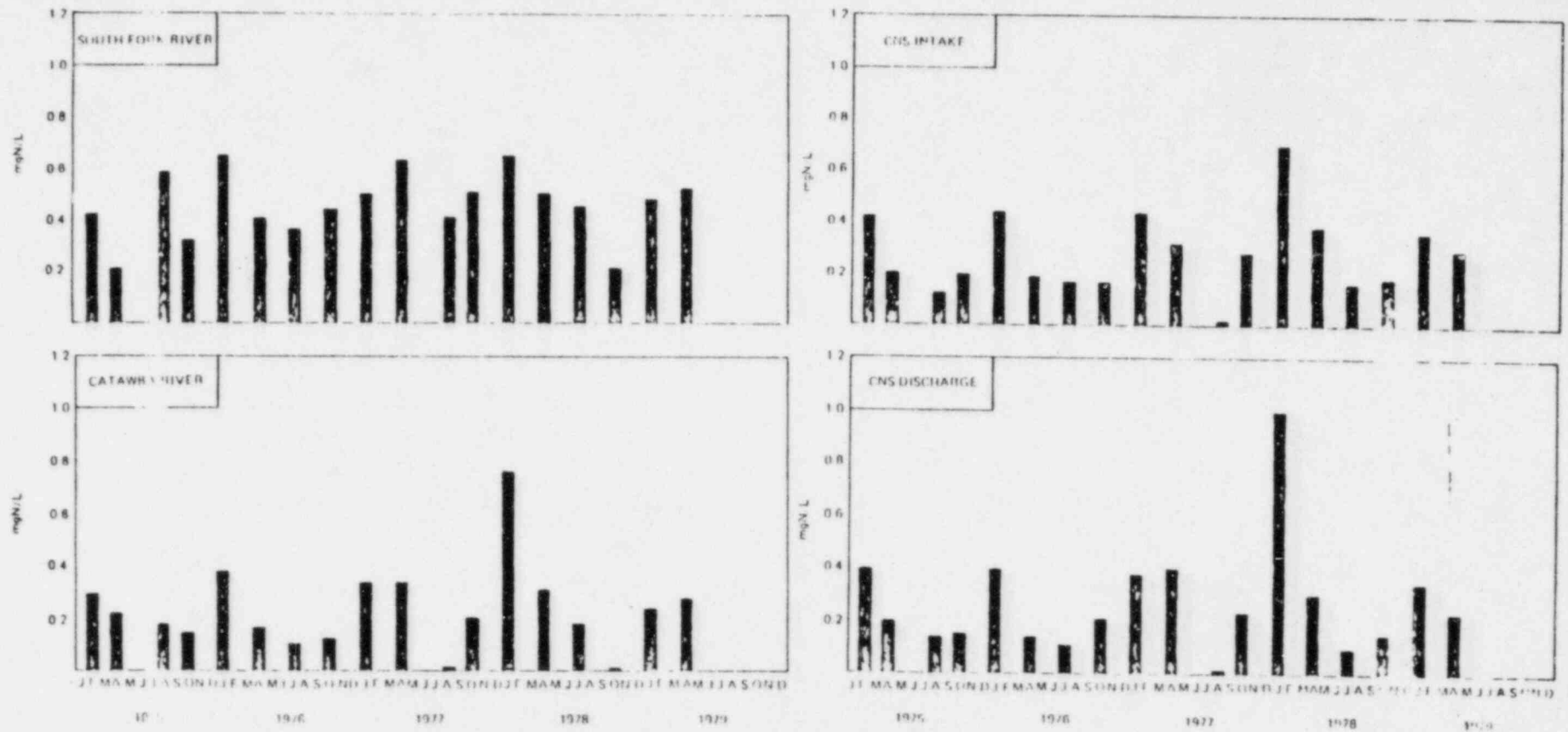


Figure 13. Variations in nitrate concentrations on Lake Wylie

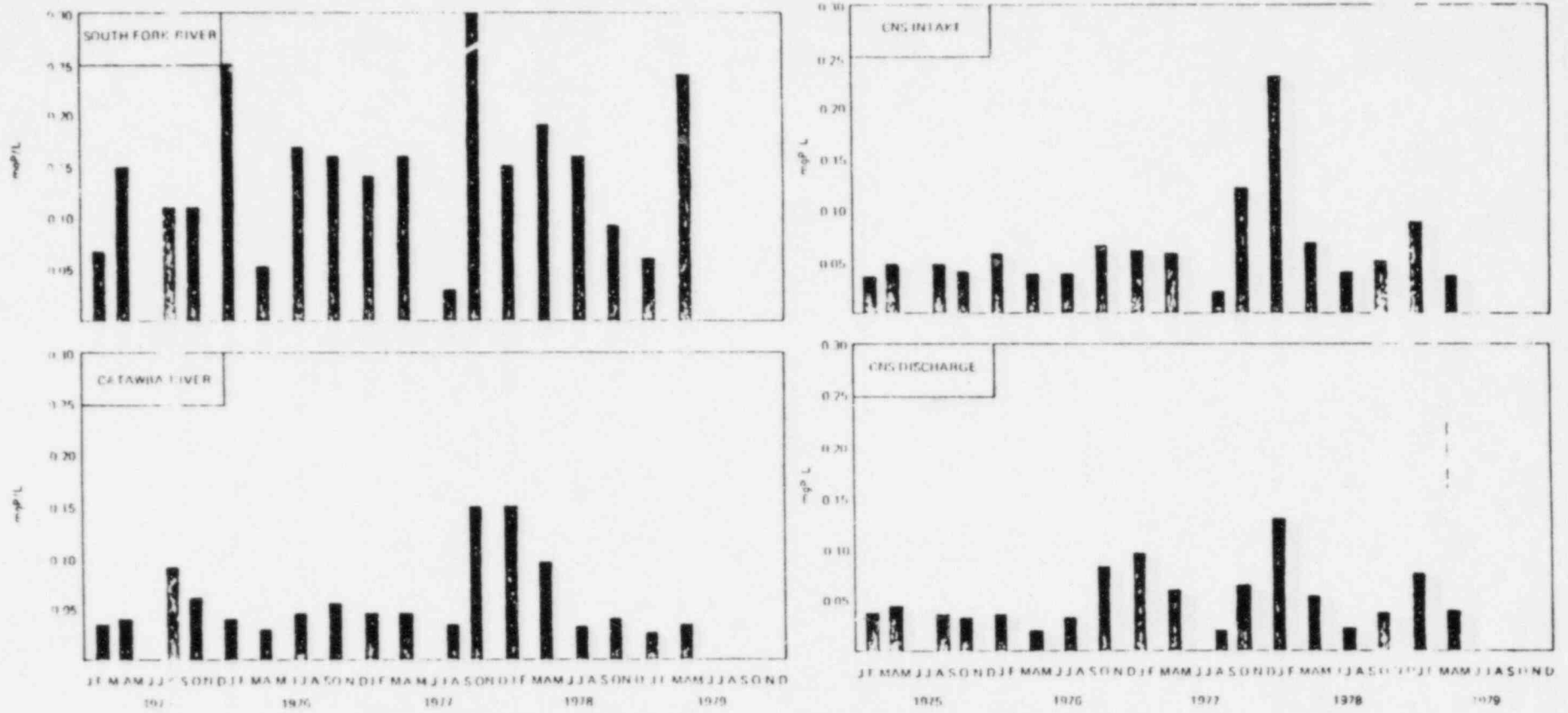


Figure 14. Variations in total phosphorus concentrations on Lake Wylie