WATER QUALITY ASSESSMENT

OF

ARKANSAS' SIGNIFICANT PUBLICLY-OWNED LAKES

SUMMER 1994

ARKANSAS DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY

WATER DIVISION

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During the summer of 1989, the Arkansas Department of Pollution Control and Ecology, Water Quality Management Planning Section, Water Division, completed an assessment of Arkansas' significant publicly-owned lakes. In this assessment, seventy-seven (77) lakes were identified as significant publicly-owned lakes and were divided into five basic types (A,B,C,D, & E, to be discussed later) based on the morphology of each of the lakes. Water quality grab samples were collected from sixty-two (62) of these lakes and analyzed in the Department's water quality laboratory. In-situ measurements for pH, secchi disk transparency, and dissolved oxygen (DO) and temperature profiles were taken. Existing data, including data from other agencies, were used for thirteen of the remaining fifteen lakes. The two large Arkansas River impoundments, Lakes Dardanelle and Ozark, were not included in this study, since they are run-of-the-river reservoirs and the ambient stream and river monitoring program provides data at the dam of each reservoir on a monthly basis. Trophic state indices were calculated and the lakes were tabulated by trophic state index ranking.

During the summer of 1994, the Department reassessed Arkansas' significant publicly-owned lakes. Three new lakes were added to the list of seventy-seven, bringing the total of significant publicly-owned lakes to eighty (SEE TABLE 1). Sixty-five of these lakes were sampled by the Planning Section, ten lakes were sampled by the Ecology Section of the Technical Services Division, and current water quality data from other State or Federal agencies were used to assess the remaining three lakes. The two large Arkansas River impoundments, Lakes Dardanelle and Ozark, were not considered in this study. Water quality parameters were analyzed in the Departments water quality laboratory, temperature profiles, DO profiles, pH and secchi disk transparency were measured in-situ. Trophic state indices were also calculated. Figure 1 is a map depicting the locations of Arkansas' significant publicly-owned lakes.

Water quality standards of the Water Quality Act of 1987, relating to Section (314), the Clean Lakes Section, and Section 305(b), reporting, mandates the development of a public lakes assessment program. The primary objectives of the Lakes assessments were to: (1) identify lakes which were not currently meeting water quality standards; (2) identify degraded, impaired, or threatened lakes, and (3) identify the trophic status of each of these lakes.

TABLE 1. Arkansas' Significant Publicly-Owned Lakes

NO	NAME	COUNTY	ACRES	AVERAGE DEPTH	WATER-SHED[1]	W/A[2]	ECO-REGION[3]	PURPOSE[4]	TYPE
1	WINONA	SALINE	1240	30.0	44.4	22.9	OM	W	A
2	DIERKS	HOWARD	1360	22.0	114.0	53.6	OM	F	A
3	GILLHAM	HOWARD	1370	21.0	271.0	126.6	OM	F	A
4	DEQUEEN	SEVIER	1680	21.0	169.0	64.4	OM	F	A
5	CATHERINE	HOT SPRING	1940	18.0	1516.0	500.1	OM	H	A
6	GREESON	PIKE	7200	38.7	237.0	21.1	OM	H	A
7	HAMILTON	GARLAND	7300	26.0	1441.0	126.3	OM	H	A
8	MAUMELLE	PULASKI	8900	23.0	137.0	9.9	OM	W	A
9	DEGRAY	CLARK	13200	48.8	453.0	22.0	OM	H	A
10	NORFORK	BAXTER	22200	57.0	1806.0	52.5	OH	H	A
11	BEAVER	BENTON	28200	58.0	1186.0	26.9	OH	H	A
12	GREERS FERRY	CLEBURNE	31500	60.0	1153.0	23.4	BM	H	A
13	OUACHITA	GARLAND	40100	51.0	1106.0	17.6	OM	H	A
14	BULL SHOALS	MARION	45440	67.0	6036.0	85.0	OH	H	A
15	CRYSTAL	BENTON	60	12.0	4.5	48.0	OH	A	B
16	SHORES	FRANKLIN	82	10.0	26.0	202.9	BM	R	B
17	SPRING	YELL	82	23.0	10.5	82.0	AV	R	B
18	HORSEHEAD	JOHNSON	100	16.0	17.3	110.7	BM	R	B
19	WEDDINGTON	WASHINGTON	102	16.0	3.0	18.8	OH	R	B
20	COVE	LOGAN	160	10.0	8.5	34.0	AV	R	B
21	ELMDALE	WASHINGTON	180	8.0	6.0	21.3	OH	A	B
22	FAYETTEVILLE	WASHINGTON	196	15.0	6.0	19.6	OH	R	B
23	BOBB KIDD	WASHINGTON	200	13.3	4.0	12.8	OH	A	B
24	WILHELMINA	POLK	200	10.0	13.5	43.2	OM	A	B
25	BARNETT	WHITE	245	27.0	37.5	98.0	AV	A	B
26	SUGARLOAF	SEBASTIAN	250	12.0	5.0	12.8	AV	A	B
27	NOLAN	SEBASTIAN	350	9.0	3.1	5.7	AV	A	B
28	FORT SMITH	CRAWFORD	416	28.0	73.0	112.3	BM	W	B
29	SEQUOYAH	WASHINGTON	500	8.0	275.0	352.0	OH	R	B
30	SWEPCO	BENTON	531	17.0	14.0	16.9	OH	W	B
31	SHEPHERD SPGS.	CRAWFORD	552	31.0	68.0	78.8	BM	W	B
32	CHARLES	LAWRENCE	562	8.0	18.0	20.5	OH	A	B
33	LEE CREEK	CRAWFORD	634	11.0	465.0	469.4	BM	W	B
34	BEAVER FORK	FAULKNER	900	10.0	11.5	8.2	AV	R	B
35	HINKLE	SCOTT	965	15.0	27.5	18.2	AV	A	B
36	BREWER	CONWAY	1165	20.0	36.4	20.0	AV	W	B
37	JUNE	LAFAYETTE	60	5.0	4.0	42.7	GC	A	C
38	BAILEY	CONWAY	124	8.0	7.5	38.7	AV	R	C
39	TRICOUNTY	CALHOUN	280	7.0	11.5	26.3	GC	A	C
40	COX CREEK	GRANT	300	6.0	17.0	36.3	GC	A	C
	TOTAL ACREAGE	356254							

NO	NAME	COUNTY	ACRES	AVERAGE DEPTH	WATER-SHED[1]	W/A[2]	ECO-REGION[3]	PURPOSE[4]	TYPE
41	HURRICANE	SALINE	300	8.0	24.9	53.1	OM	W	C
42	FRIERSON	GREENE	335	7.5	7.3	13.9	DL	A	C
43	STORM CREEK	PHILLIPS	420	7.0	8.0	12.2	DL	D	C
44	CALION	UNION	510	6.0	6.7	8.4	GC	A	C
45	POINSETT	POINSETT	550	7.0	4.5	5.2	DL	A	C
46	BEAR CREEK	LEE	625	10.0	6.0	6.1	DL	R	C
47	UP. WHITE OAK	OUACHITA	630	8.0	20.7	21.0	GC	A	C
48	ATKINS	POPE	750	5.5	10.2	8.7	AV	A	C
49	OVERCUP	CONWAY	1025	4.0	17.2	10.7	AV	A	C
50	LO. WHITE OAK	OUACHITA	1080	8.0	42.5	25.2	GC	A	C
51	HARRIS BRAKE	PERRY	1300	6.0	11.2	5.5	AV	A	C
52	CANE CREEK	LINCOLN	1620	6.0	24.0	9.5	GC	A	C
53	WILSON	ASHLEY	150	5.0	1.0	4.3	DL	A	D
54	ENTERPRISE	ASHLEY	200	5.0	2.0	6.4	DL	A	D
55	1ST OLD RIVER	MILLER	200	4.0	2.0	6.4	GC	A	D
56	PICKTHORNE	LONOKE	207	5.0	0.5	1.5	DL	A	D
57	HOGUE	POINSETT	280	4.4	2.0	4.6	DL	A	D
58	GREENLEE	MONROE	300	6.0	0.5	1.1	DL	A	D
59	MALLARD	MISSISSIPPI	300	6.0	0.5	1.1	DL	A	D
60	GRAMPUS	ASHLEY	334	6.0	2.0	3.8	DL	A	D
61	DESARC	PRAIRIE	350	6.0	1.0	1.8	DL	A	D
62	WALLACE	DREW	362	5.2	1.0	1.8	DL	A	D
63	PINE BLUFF	JEFFERSON	500	6.0	4.0	5.1	DL	A	D
64	ASHBAUGH	GREENE	500	5.0	1.0	1.3	DL	A	D
65	BOIS D'ARC	HEMPSTEAD	750	4.0	4.0	3.4	GC	A	D
66	OLD TOWN	PHILLIPS	900	3.5	23.0	16.4	DL	R	D
67	HORSESHOE	CRITTENDEN	1200	10.0	13.6	7.2	DL	R	E
68	UPPER CHICOT	CHICOT	1270	15.0	14.0	7.1	DL	R	E
69	GRAND	CHICOT	1400	7.0	5.5	2.5	DL	A	E
70	GA. PACIFIC	ASHLEY	1700	4.0	4.0	1.5	GC	W	E
71	BLUE MT.	LOGAN	2900	8.6	488.0	107.7	AV	F	E
72	COLUMBIA	COLUMBIA	2950	11.0	48.0	10.4	GC	W	E
73	NIMROD	YELL	3600	8.2	680.0	120.9	AV	F	E
74	LOWER CHICOT	CHICOT	4030	15.4	350.0	55.6	DL	R	E
75	CONWAY	FAULKNER	6700	5.0	136.0	13.0	AV	A	E
76	ERLING	LAFAYETTE	7000	7.0	400.0	36.6	GC	W	E
77	OZARK	FRANKLIN	10600	14.0	151801.0	9165.3	AV	N	E
78	FELSENTHAL	BRADLEY	14000	7.0	10852.0	496.1	GC	R	E
79	MILLWOOD	LITTLE RIVER	29500	5.2	41444.0	89.9	GC	F	E
80	DARDANELLE	POPE	34300	14.2	153666.0	2867.2	AV	N	E

1 -- Watershed: square miles
2 -- W/A: Watershed (acres)/Area of Lake
3 -- Ecoregion: OM-Ouachita Mountains; BM-Boston Mountains; OH-Ozark Highlands; AV-Arkansas River Valley; GC-Gulf Coastal; DL-Delta
4 -- Purpose: W-Water Supply; F-Flood Control; H-Hydropower; A-Angling (public fishing); N-Navigation; R-Recreation

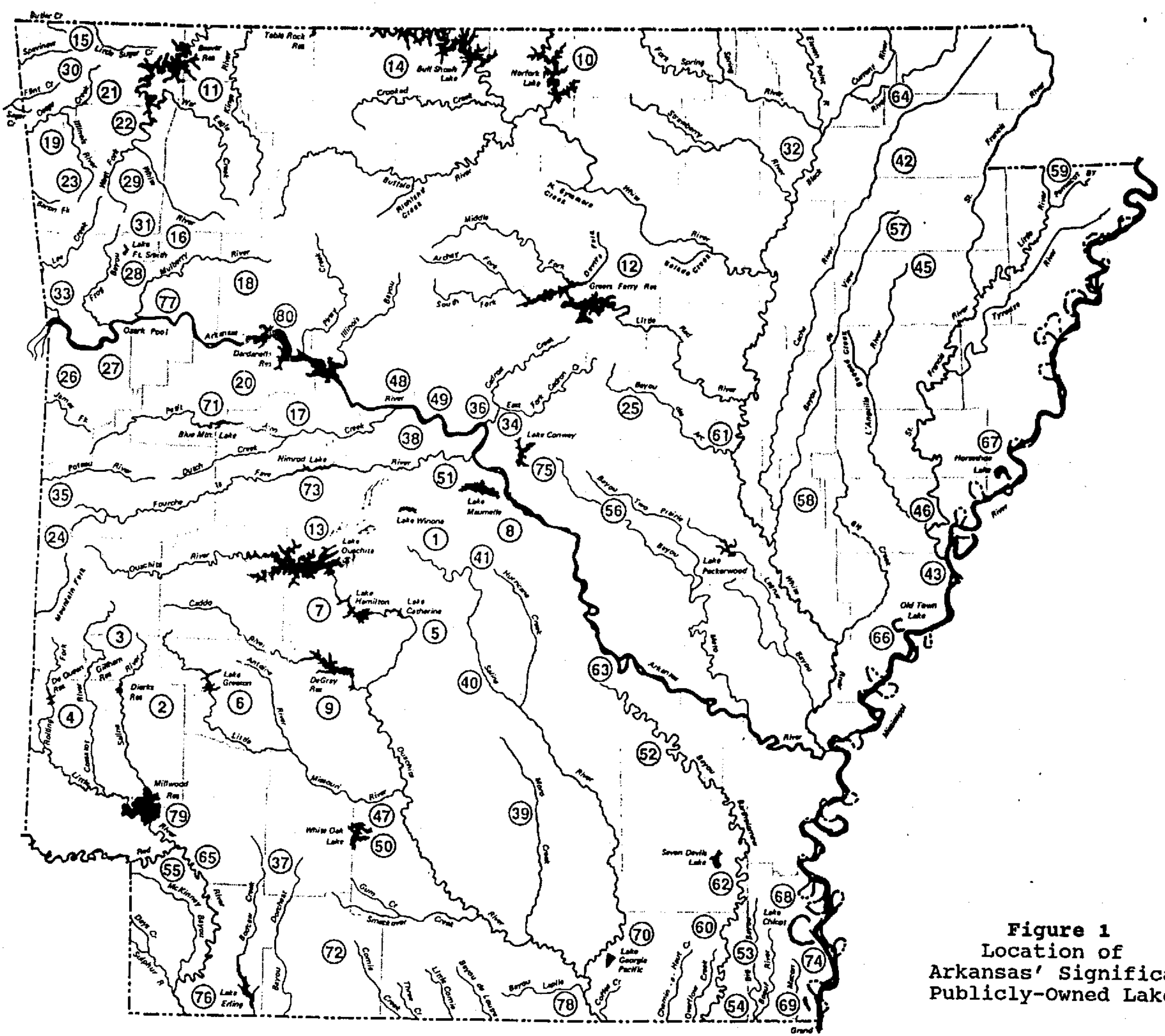


Figure 1
Location of
Arkansas' Significant
Publicly-Owned Lakes

METHODOLOGY

All water quality sampling was completed between July 11, 1994 and August 19, 1994. Two, 2-day sampling trips were made each week and two to four sample sites were sampled each day. Each trip was restricted to no more than two days so the samples could be analyzed within the 48-hour maximum holding time.

A shore to shore transect in the lower portion of each man-made lake (near the dam) was made, depths along the transect were determined and a sample point was established. Lakes of approximately 2000 surface acres or larger had more than one sample transect, including one in the lower one-third and one in the upper one-third of the lake, and if necessary, one near mid-lake. Naturally occurring lakes and oxbow lakes were sampled at their deepest points, normally the middle of the lake.

Field Observations

The following observations were noted at each transect site:

1) Climatical conditions
2) Air temperature
3) Lake surface condition
4) Unusual occurrences
5) Quality Assurance/Quality Control issues

In-Situ Measurements

The following measurements were taken at each sample site:

1) Secchi disc transparency
2) Water temperature profile
3) Dissolved oxygen profile
4) pH - epilimnion, hypolimnion, just above the thermocline

Water temperature and dissolved oxygen concentrations were measured at 1 to 5 meter intervals within the epilimnion; at 1 to 2 meter intervals in the thermocline; and 1 to 5 meter intervals in the hypolimnion. The pH profile was determined by taking pH readings of the epilimnion and hypolimnion water quality grab samples, and the thermocline Chlorophyll ^{a} grab sample.

Water Quality Sampling

Water quality grab samples were collected with an Alpha Water sampler bottle at one meter depth (epilimnion) and at 0.8 (80%) maximum depth (hypolimnion) over the main channel. The grab samples were labeled using the given STORET station identifier at each station and by using either an "E" or an "H" to depict between the epilimnion and hypolimnion samples. Example: LARK001A-H = Lake Conway near the dam, hypolimnion water quality grab sample. The water quality samples were analyzed for the following parameters:

NH_3-N	total phosphorus	chlorides
NO_2+NO_3-N	ortho-phosphorus	sulfates
turbidity	alkalinity	conductivity
total suspended solids	total dissolved solids	
total organic carbon	total hardness	

Bacteria Sampling

Bacteria samples were collected one-half (½) meter below the surface at five locations along the transect. One sample was collected approximately fifty (50) feet from each shore, at each quarter point, and at the mid-point of the transect. One duplicate sample per every two sample transects was collected. Two dilutions of each sample were plated. The dilutions used were determined by the analyst/collector of the sample. The samples were labeled by using the given lake STORET number, using an "L", "C", or "R" to identify the position on the transect - left, right or center while facing the dam, and "S" or "¼" was used to depict either shore or quarter point sample. Example: LARK001A-L¼ = Lake Conway near the dam, left quarter point bacteria sample. Geometric means of the bacteria samples were calculated for each lake.

Metals Sampling

A sample for total dissolved metals analyses was collected from the hypolimnion and the epilimnion at each of the water quality grab sample stations. The samples were collected and preserved in accordance with the 17^{th} Edition of Standard Methods for the Examination of Water and Wastewater, 1989, Parts 300, 301, and 301A. The samples were labeled by using the water quality grab sample labelling scheme mentioned above. The following metals were analyzed:

Cadmium	Chromium	Copper
Lead	Zinc	

Toxic effect ratios were calculated where metals concentrations were abnormally elevated and were compared to acute and chronic metals toxicity criteria.

Chlorophyll a

Chlorophyll a samples were collected from the same sites as the bacteria samples and composited; plus a grab sample just above the thermocline at the mid-channel sample site was collected. The samples were preserved and analyzed according to the methods described in "Standard Methods For the Examination of Water and Wastewater, 17th Edition, 1989, Spectrophotometric Determination of Chlorophyll". Samples were labeled using the lake STORET number and using a "C" or a "T" to depict between the composited or thermocline sample. Example: LARK001A-T = Lake Conway near the dam chlorophyll a sample just above the thermocline.

All other parameter analyses were completed under the Departments existing "Quality Assurance Plan For Ambient Water Quality and Compliance Sampling", 1993.

RESULTS

As with the 1989 survey, data for Dardanelle Reservoir and Ozark Reservoir were not included since these two impoundments are primary flow through systems on the main stem of the Arkansas River. These reservoirs are included as part of the routine ambient monitoring network on the Arkansas River.

The spring and summer of 1994 were unusually wet and cool. Rainfall amounts remained approximately two inches above normal monthly averages and air temperatures remained four to six degrees Fahrenheit below monthly averages. Also, extensive cloud cover prevailed over most of the state during the spring and summer, reducing the intensity of sunlight reaching the surface of the lakes. All of these factors may have slowed the stratification processes in the lakes and reduced the normal production capacity of the lakes throughout the state.

Lake Classification

The 1989 survey classified Arkansas' significant publicly-owned lakes into five general types based on size, average depth and ecoregion. This classification system was used for the 1994 survey.

Type A Lakes

These lakes are located in the montane areas of the state - the Ozark, Ouachita and Boston Mountains - and are usually several thousands acres in size with average depths between 30 to 60 feet. Most are operated by the U.S. Army Corps of Engineers and were constructed mainly as flood control and/or hydropower lakes. The watersheds of most of these lakes are forest dominated; however, this land is continually being cleared for agricultural uses such as pasture and confined animal operations. The watershed to lake area ratios (W/A) are generally between 20 to 100 with the median value being 39.7. The smallest ratio is 9.9 and the largest is 500. The hydraulic residence time in many of these reservoirs is about one year, except those two lakes below Lake Ouachita (Catherine and Hamilton) which have hydraulic residence times of two and four weeks, respectively.

Water quality data for these lakes can be found in Appendix A, Table A-1. Lakes of this type are usually weakly buffered with low alkalinities, except those Ozark Highlands' lakes. Alkalinities in Lakes Bull Shoals and Norfork, which have limestone dominated watersheds, generally range between 100 mg/L and 150 mg/L. Beaver Lake, which receives drainage from both the Ozark Highlands and Boston Mountains, has an alkalinity around 50 mg/L. Alkalinities were not measured on these lakes during this survey. The remainder of these lakes have alkalinities around 20 mg/L or less, reflecting their Ouachita Mountain watersheds. Total dissolved solids and conductivities produce a wide range of values which is also reflective of the drainage basin. Values for pH in Lakes Beaver, Norfork, and Bull Shoals are higher than other Type A lakes, once again reflecting the buffering capacity differences of the lakes in different ecoregions.

Secchi disk transparency ranged from just over three feet in Lake Maumelle to over 21 feet in lower Lake Ouachita. Also, most lakes had transparencies exceeding ten feet deep. Epilimnion turbidity values were generally very low, except for upper Lake Degray. Hypolimnetic values were noticeably higher than the epilimnion values, however none were above 8 NTU. Chlorophyll a concentrations were generally low, except for those values supplied by the Corps of Engineers on Lakes Dierks, Gillham and Dequeen.

Hypolimnetic NO_2+NO_3 nitrogen was higher in Lakes Norfork, Greeson, Greers Ferry and Bull Shoals as compared to the other lakes of this type. This trend reflects the NO_2+NO_3 nitrogen concentrations in the surface and ground waters in the region these lakes are located. Ortho-phosphorus in these lakes generally was below the detection limit and total phosphorus concentrations were only slightly higher, perhaps partly due to the increases in turbidity values.

Six of these lakes had a detectable lead and/or zinc concentration, mostly in the hypolimnion; but only three had levels above the chronic toxicity criteria (Figure D-1). Only upper Lake Ouachita had an elevated epilimnetic zinc concentration, but levels were below the toxic threshold.

Fecal coliform concentrations do not appear to be a problem in this group of lakes (Figure B-5). However, the first set of samples collected form Lakes Catherine and Hamilton were all "to numerous to count" (TNTC) for the dilutions used. The presence of an unknown bacteria covered the plate altering the color structure of the test. A second set of samples was taken fourteen days later with better results.

Type B Lakes

This group of lakes includes the smaller lakes, usually about 500 acres in size, located in the uplands or steeper terrain of the Ozark, Ouachita and Boston Mountains and the mountainous areas of the Arkansas River Valley. Two new lakes were added to this category for the 1994 survey, Lake Nolan and Lee Creek Reservoir. Type B Lakes are generally primary-purpose to multi-purpose recreational lakes, however three lakes are used as a public water supply and one lake is used as a cooling water supply for an electric power plant. Average depths range between 10 to 25 feet and the watershed to lake area ratios range between 5.7 to 352 with a median of about 28. Hydraulic residence time is very short in most of these lakes. Watersheds are predominately forested.

Water quality data for Type B lakes is listed in Appendix A, Table A-2. Turbidity values in the epilimnion of these lakes were generally less than 6 NTU, but the hypolimnion turbidity values were slightly elevated. Chlorophyll a concentrations were between <0.1 μg/L to over 25 μg/L. Secchi disk transparencies ranged from less than two feet to almost ten feet. Most of these lakes have low productivities, however, the Arkansas Game and Fish Commission periodically fertilizes some of these lakes for fisheries enhancement.

Those Type B lakes located in the Ozark Highlands ecoregion have noticeably higher conductivities, pH values, total dissolved solids, and alkalinities than the weaker buffered Type B lakes located in the Ouachita Mountains or Arkansas River Valley ecoregions. Chloride and sulfate values were low in all of these lakes, except that of Lake Swepco, which had a sulfate concentration exceeding the water quality standard for that parameter.

All of the NO_2+NO_3 nitrogen concentrations were less than 0.06 mg/L, except for the hypolimnion sample of Lake Barnett which was almost ten times that of the other Type B lakes. However, hypolimnetic ammonia nitrogen (NH_3-N) concentrations of many of the Type B lakes was atypically high. This is especially noticeable in Lakes Fayetteville and Nolan. Also, Lake Fayetteville had a high total phosphorus concentration in the hypolimnion as compared to the other Type B lakes. Total and ortho-phosphorus concentrations were elevated in several of these lakes. Type B lakes tend to be strongly stratified with a deep anoxic zone which may be contributing to these high nutrient concentrations. Watershed uses range from confined animal operations to urban development, and in-lake management activities could also be contributing factors. Lake Nolan is a recently constructed lake with an abundance of decaying leaf matter and timber on the bottom of the lake adding to the nutrients within the lake. This is also evident by the elevated total organic carbon concentration found in the hypolimnion of the lake.

Zinc and lead were the only metals that illustrated significant concentrations in the Type B lakes. None of the zinc concentrations were above either the acute or chronic toxic criteria. However, lead concentrations in the epilimnion of Lake Barnett was above both toxic criteria, and the lead concentration in the epilimnion of Lake Sugarloaf was above the chronic toxicity criteria (Figure D-1). Both lakes also had elevated concentrations of copper, but neither exceeded toxic criteria.

Fecal coliform concentrations in these lakes was generally below 10 col/100 ml at all sample locations along the transect. However, Lakes Wilhelmina, Sugarloaf, and Charles had elevated counts (Figure B-5). Lake Wilhelmina is used as a fish production facility and Lakes Sugarloaf and Charles increases were probably due to the proximity of homesites along the shorelines.

Type C Lakes

These lakes are mainly found in the flatter, lowland areas of the Delta, Crowley's Ridge region, Gulf Coastal Plains, and the Arkansas River Valley. They generally range in size from 300 to 1000 acres with watershed to lake area ratios between 5 to 50 with a median value of 13. Those lakes with high W/A ratios and shallow average depths generally have high flushing rates. The average depth of Type C lakes is less than 10 feet. Watersheds of these lakes are mostly comprised of lowland hardwoods with some pines, however there are small farms scattered throughout most of these watersheds. These lakes were mainly constructed for public fishing and other types of secondary contact recreation uses, however a few have expanded to multiple recreation use designations. Water quality data for these lakes can be found in Appendix A, Table A-3.

Chloride concentrations, total dissolved solids, conductivity and alkalinities in Lakes June and Calion were seven to ten times higher than that of the other lakes of this group. Oil and gas extraction dominates the watershed activities of these two lakes. Lake Poinsett had a sulfate concentration twice that of any other Type C lake. Lakes Hurricane, Storm Creek, and Bear Creek had elevated conductivities but low chloride, sulfate, total dissolved solids, and turbidity values. Lake Frierson also had an elevated conductivity value, most likely due to the high total suspended solids and turbidity values which were more than five times greater than the next Type C lake value. Most turbidity and total suspended solids values were less than 10 NTU and 10 mg/L, except for those lakes draining the Crowley's Ridge area.

Storm Creek, Bear Creek, Frierson and Upper White Oak lakes all had high chlorophyll a concentrations. Many of these lakes are routinely fertilized for fisheries enhancement. Storm Creek and Bear Creek also had high pH values, possibly due to the high phytoplankton production in these lakes. Also, these two lakes had high hypolimnetic nutrient concentrations but lower epilimnion concentrations. This is perhaps the result of assimilation by the phytoplankton. However, other lakes in this group with elevated chlorophyll a concentrations did not show this same nutrient pattern. Most of these lakes had elevated total phosphorus concentrations, but ortho-phosphorus and NO_2+NO_3 nitrogen concentration were at or below the detection limits.

Five lakes in the group had elevated zinc concentrations and Bear Creek lake had an elevated lead concentration. None of the calculated toxicity values exceeded the acute toxicity criteria, but the Bear Creek lead concentrations exceeded the chronic toxicity criteria (Figure D-1).

Four lakes in this group, June, Frierson, Storm Creek, and Cane Creek, exceeded either the primary and/or secondary contact recreation standard for fecal coliform bacteria concentrations at one or more points on the transect (Figure B-5). Two other lakes had elevated values and the remainder of this group generally had values of less than 10 col/100 ml. The lake stations with elevated levels were generally near one of the shores where houses or fishing camps are located. Also, the elevated turbidity and total suspended solids concentrations, possibly from non-point source contributions, may be increasing the fecal coliform bacteria concentrations.

Type D Lakes

These lakes are the smaller Delta ecoregion impoundments, generally between 200 to 500 acres; however, two similar lakes of 750 and 900 acres in the Gulf Coastal Ecoregion are also included. A new lake, Pickthorne, was added for the 1994 survey. Some of these lakes are naturally occurring oxbows or cut-off lakes from main streams of larger rivers. Some of the oxbow lakes have been altered through the construction of water control structures and have been cut off from their parent stream and/or watershed by levees. Average depth of these lakes is generally less than 5 feet and watershed to lake area ratios are between 0.5 to 23 with a median of 3.6. Watershed uses consist primarily of row crop agriculture; however very little discharge from these activities enters directly to any of these lakes. The primary use of Type D lakes is public fishing. Water quality data for these lakes can be found in Appendix A, Table A-4.

Turbidity values for this group were generally less than 15 NTU. Lake Greenlee had an abnormally high turbidity, 180 NTU, in both the epilimnion and hypolimnion, but it had total suspended solids concentration of less than 5 mg/L. This high turbidity with low total suspended solids was probably caused by very fine colloidal clays. Lake Greenlee's total dissolved solids concentrations were above 600 mg/L, and sulfate values were also elevated. However, the conductivity, alkalinity, total hardness and chloride concentrations were similar to the other lakes of this type. First Old River, Mallard, Ashbaugh, and Old Town had elevated total hardness and conductivities. Chloride and sulfate values in this group were generally less than 5 mg/L, alkalinities were below 50 mg/L and total dissolved solids were less than 100 mg/L.

Nutrient concentrations were all approximately ten times higher in Lake Greenlee as compared to the other Type D lakes, but the chlorophyll a concentration in Greenlee was relatively low. Also, Lake Greenlee had a secchi disk transparency of 4 inches. These factors are indicating that the productivity in Lake Greenlee was temporarily reduced because of a limited light penetration from sources other than phytoplankton production. Ortho-phosphorus and NO_2-NO_3 nitrogen concentrations of the other lakes in this group were generally at or below the detection limit and total phosphorus and ammonia nitrogen concentrations were between 0.1 mg/L to 0.4 mg/L. Chlorophyll a concentrations were generally between 10 μg/L and 40 μg/L, with trophic rankings usually in the top one-third of all lakes sampled. Eight Type D lakes had detectable levels of zinc, none of which were toxic. The Lake Hogue copper hypolimnion concentration exceeded the chronic toxicity criteria (Figure B-12).

Lakes Mallard and Pine Bluff geometric means of fecal coliform bacteria concentrations exceeded the primary contact recreation standard (Figure B-5). Lake Mallard had two samples above the 400 col/100 ml primary contact recreation standard and all five samples on Lake Pine Bluff exceeded this standard. All other lakes in this group had fecal coliform bacteria concentrations well below water quality standards.

Type E Lakes

These are the large lowland lakes, generally from 1000 to 30,000 acres located in the Delta, Gulf Coastal Plains, and Arkansas River Valley ecoregions. Average depth in these lakes is usually less than 10 feet and watershed to lake area ratios range from 1.5 to over 9000. Flushing rates are also quite variable within this group because of the large variations in watershed to lake area ratio. The watersheds of these lakes contain a mixture of row crop agriculture, confined animal operations, pasture land, and some forest land. Primary uses of these lakes include three main stem reservoirs for flood control and navigation, one of which has substantial recreation and fish and wildlife enhancement features; several for water supply; two for industrial water supply; one for municipal uses; and one primarily for public fishing. The water quality data for these lakes can be found in Appendix A, Table A-5.

Lakes Grand and Upper and Lower Chicot had total dissolved solids above 130 mg/L and conductivities of 200 µmhos or greater. These lakes are Mississippi River oxbows which have been cut off from the main stem of the Mississippi River. Chlorides were also higher in these two lakes than other Type E lakes except for Lakes Columbia and Erling. The later two lakes have active oil fields within their watersheds. Typical dissolved solids concentrations of Type E lakes are approximately 50 mg/L with conductivities around 75 µmhos. Chloride and sulfate concentrations were generally below 10 mg/L and total hardness was typically below 25 mg/L. Turbidity values remained below 10 NTU for these lakes, except Lakes Horseshoe and Felsenthal values were just above 20 NTU. Total suspended solids were below 25 mg/L for this group of lakes.

Chlorophyll a concentrations in most of these lakes was low; however lower Lake Conway and Grand Lake values were elevated, and Horseshoe Lake had the highest chlorophyll a concentrations of all lakes sampled. This includes 170 µg/L, composite sample, and 325 µg/L, thermocline sample, in Horseshoe Lake. Its trophic ranking was 3rd highest of all lakes sampled. The Type E lakes ranked in the upper one-third for trophic index of all lakes sampled. Secchi disk transparencies ranged from about one foot deep to almost four feet deep. Ammonia nitrogen concentrations remained relatively low in most of these lakes except the lower Lake Erling hypolimnion sample which was 1.31 mg/L. However, in Lake Erling, the NO_2+NO_3 nitrogen concentration was below the detection level through out the water column. This is similar to the other lakes of this type. Total and ortho-phosphorus concentrations were also relatively low. However, this was the only group of lakes that did not have at least one total phosphorus reading below the detection limit. Also, lower Lake Erling had a ortho-phosphorus concentration of 0.21 mg/L which was approximately four times greater than any other Type E lake.

Seven Type E lakes had measurable quantities of zinc, however none of them had calculated toxicity values above either of the acute or chronic toxicity criteria. Lower Lake Conway had detectable levels of chromium and Upper Lake Chicot had a detectable level of copper in its hypolimnion. Neither of these levels were above either of the toxic criteria. Also, the upper Lake Felsenthal epilimnion sample had a copper concentration of 19 µg/L. The acute toxicity value for copper, based on 25 mg/L hardness, is 4.8 µg/L, and the chronic toxicity value based on the same hardness is 3.6 µg/L. The upper lake Felsenthal epilimnetic copper concentration was the most toxic value measured for all metals in all lakes during this survey (Figure D-1).

Four Type E lake stations exceeded the primary contact recreation standard for fecal coliform concentrations based on the geometric mean (Figure B-5). These lakes were Lake Grand, upper Lake Erling and both the upper and lower stations on Lake Felsenthal. All but the lower Lake Felsenthal station exceeded the secondary contact recreation criteria.

WATER QUALITY STANDARDS

Arkansas' water quality standards for lakes have been adapted from the surface water quality standards for streams. Although the designated uses that are assigned to Arkansas' lakes may be appropriate, the criteria set forth to protect them individually may require some additional considerations. Arkansas' lakes are highly variable in water quality, morphology, watershed characteristics, operation and management activities and naturally occurring influences. Thus, setting specific lake standards for Arkansas' lakes presents many problems. Adopting criteria to protect a specific designated use may interfere with other designated uses for the same waterbody. For example, chlorophyll *a*, phosphorus or water clarity criteria may be designed to protect the drinking water use or certain recreational uses of a lake, but they may be counterproductive for lakes created for the primary purpose of public fishing. Arkansas' current water quality criteria for lakes is, therefore, limited in parameters and designed with great flexibility to help resolve some of the problems mentioned above.

Appendix B compares the lakes water quality criteria in existing standards to the recent data collected from the significant publicly-owned lakes. Figure B-1 displays the temperature data relative to the maximum temperature criteria. The data is from one meter depth and is grouped into Type A and B lakes and Type C, D, and E lakes. The maximum allowable water temperature is 32 degrees Celsius. Only Lake Swepco exceeded this standard. Lake Swepco is a cooling water lake for a fossil fuel power generation facility.

Turbidity values are plotted in Figure B-2 and are grouped into Type A and B, and Type C, D, and E lakes once again. Both the epilimnion and hypolimnion samples for all lakes and lake stations are plotted. The epilimnion values for Type A and B lakes were generally below 5 NTU, except the upper Lake DeGray site (11.0 NTU). Most hypolimnion values for the Type A lakes were usually below 10 NTU, and the Type B lakes were usually below 20 NTU. Only Lake Swepco's hypolimnion turbidity value of 33 NTU exceeded the 25 NTU maximum criteria. Type C, D, and E lakes had slightly higher turbidity values in both the epilimnion and hypolimnion. These exceedances include: 26 NTU in lower Lake Felsenthal, hypolimnion; 30 NTU in Lake Poinsette, hypolimnion; 180 NTU in Lake Greenlee, epilimnion and hypolimnion; 76 NTU in Lake Frierson epilimnion and 93 NTU in its hypolimnion.

Epilimnion and hypolimnion pH values for all lakes and lake stations are plotted in Figure B-3 and are grouped into Type A and B lakes and Type C, D, E lakes. In general, most pH values for the Type A and B lakes were slightly above 7.0 standard units (SU). Epilimnion values were almost always higher than hypolimnion values. Lake Winona's hypolimnion pH was 5.9. Type C, D, and E lakes pH values varied somewhat from lake to lake, but were usually between 6 and 8. Cox Creek lake had a value of 5.84 and Lake Millwood had a value of 5.91 in their hypolimnions. Storm Creek, Bear Creek and Horseshoe Lake had epilimnion pH values slightly above the 9.0 pH criteria. Also, elevated hypolimnion pH values were measured in Storm Creek, Horseshoe, Grand, and lower Chicot lakes. Each of these lakes had high chlorophyll ^{a} concentrations indicating elevated phytoplankton activity. However, several other lakes with chlorophyll ^{a} concentrations comparable to those of Horseshoe, lower Chicot and Grand did not exhibit increased pH values. Many of the lakes exhibiting elevated hypolimnion pH values were either slightly stratified or non-stratified.

The minimum dissolved oxygen criteria for lakes is 5.0 mg/L, but does not specify depth or take into account any adjustment for seasonal variations, lake morphology, etc. Figure B-4 is a plot of the dissolved oxygen concentrations grouped into Type A and B lakes and Type C, D, and E lakes and measured at one meter depth. Type A and B lakes dissolved oxygen concentrations ranged between 5.8 mg/L to 11.0 mg/L. Seven Type C, D, and E lakes were below the dissolved oxygen minimum criteria and five of these lakes were either weakly stratified or not stratified and all but Lake Pickthorne had high chlorophyll ^{a} concentrations.

The geometric means of the five fecal coliform samples collected along a shore-to-shore transect of each lake sampled is plotted in Figure B-5 and is grouped into Type A and B lakes and Type C, D, and E lakes. The majority of Type A and B lakes fecal coliform concentrations were well below the primary and secondary contact recreation criteria. Typically, the highest concentrations were located near the shores where domestic development occurred. Only Lake Wilhelmina exceeded both criteria. It had a geometric mean value of 2320 col/100 ml. The transect on this lake was near a once used caged fish production facility. Type C, D, and E lakes generally had higher concentrations of bacteria than the Type A and B lakes. Six lakes exceeded the primary contact recreation criteria, but none of them exceeded the secondary contact recreation criteria. However, five Type C, D, and E lakes had one or more transect values exceeding 2000 col/100 ml.

The State's water quality standards for chlorides, sulfates and total dissolved solids were developed from naturally occurring background levels from each of the ecoregions within the State. Figures B-6 through B-11 compare the mineral levels found in this survey with the mineral standards. In these figures, the lakes were grouped into the ecoregion containing their watersheds.

The data plotted in these figures is the average of the epilimnion values and hypolimnion values for each lake station. The mineral values for most of the lakes in this survey were usually well below the established standards. Lake Swepco exceeded the Ozark Highlands sulfate standard. Lakes June and Calion exceeded the Gulf Coastal Plains chloride standard and Lake Greenlee exceeded the Delta total dissolved solids standard.

Figure D-1 is plots of the trace metal values that exceeded toxicity criteria. Acute and chronic toxicity criteria were calculated for the respective lakes which had elevated metals concentrations. Only eight lake stations showed potential toxicity problems. Lakes Barnett, Sugarloaf, Hogue, and upper Felsenthal exceeded the chronic toxicity criteria for copper; Lake Hogue and upper Lake Felsenthal exceeded the acute copper toxicity criteria. Lower Greeson, upper DeGray, middle Ouachita, and Bear Creek lakes exceeded the chronic toxicity value for lead. None exceeded the acute lead toxicity criteria. Acute and chronic toxicity criteria are calculated based on the total hardness values at the sample location. These calculated criteria often were below the detection limit capabilities of the laboratory equipment used for analysis. It is important to remember this when examining this data and determining possible toxicity problems.

Trophic Status

A ranking of all lakes sampled relative to their trophic status was accomplished by this survey. The three principal parameters normally considered in trophic state determination are total phosphorus ($\mu g/L$), chlorophyll ^{a} ($\mu g/L$), and secchi disk transparency (inches). Trophic Index (TI) is calculated using the following formula:

$$TI = \frac{\text{T-Phos } (\mu g/L) + \text{Chlorophyll } ^a \ (\mu g/L)}{\text{Secchi Disk Transparency (inches)}}$$

One-half of the detection level was used in calculating the TI for those parameter values that were measured to be at or less than the detection limit. Example: T-Phos 30.0 $\mu g/L$, then 15 $\mu g/l$ was used to calculate the trophic index. Table 2 list all the lake stations sampled, total phosphorus and chlorophyll ^{a} concentrations, secchi disk readings and the calculated trophic index for each listed in descending trophic index ranking order. Highest index values indicate the richest trophic status.

Trophic indices ranged from 288.79 (Lake Greenlee) to 0.08 (Devils Fork arm of Greers Ferry Lake). Lake Greenlee's trophic index was more than ten times greater than the next highest index, Lake Frierson, 24.34. This high index was possibly due to the high turbidity in the lake at the time of sampling (see water quality discussion). This condition limited the secchi disk transparency to 4 inches and possibly contributed to the ten fold increase in total phosphorus concentrations as compared to the next highest lake concentration. Because of this, the trophic index for Lake Greenlee is perhaps not a valid ranking of its trophic status.

Lake Frierson had the next highest trophic ranking of 24.34. It also had an elevated turbidity value and elevated total suspended solids concentration limiting secchi transparency to eight inches. Its chlorophyll a and total phosphorus values in this lake ranked among the highest of all lakes sampled. Even though this trophic ranking may be characteristic of Lake Frierson's trophic status, the excessive turbidity in the lake may be the most significant influence on its trophic ranking.

Horseshoe and Old Town lakes had the next highest rankings, followed by lakes Mallard, Grand, Upper and Lower Chicot, Bear Creek and First Old River. There is not a definite separation between consecutive trophic indices below this point. This makes further grouping difficult.

The lower one-third of all lakes ranked was comprised of Type A and Type B lake stations only. Upper Lake DeGray has the highest Type A lake station trophic index. This was followed by upper Lake Catherine and upper Lake Maumelle. Seventy-two percent (72%) of the Type A lakes ranked in the lower one-third and they also comprised the ten lowest trophic levels. The mean Type A trophic index is about one-half that of Type B Lakes, 0.45 as compared to 0.94. Lake Charles had the highest Type B trophic index of 4.99 and Lake Shepherd Springs had the lowest at 0.15. Forty-five percent (45%) of the Type B lakes ranked in the lower one-third, and seventy-three percent (73%) in the lower one-half of the trophic ranking.

The mean trophic index of Type C lakes was 4.50. Lake Frierson had the highest ranking of 24.34, followed by Bear Creek at 9.28 and Lake June at 6.20. Lake Hurricane had the lowest trophic index of Type C Lakes. Fifty-six percent (56%) of the Type C lake stations ranked in the upper one-third of the list.

Ninety-three percent (93%) of Type D lake stations ranked in the top one-third trophic status. Lake Greenlee had the highest Type D lake ranking value of 288.79, but this value was strongly skewed by high levels of colloidally suspended silt particles. The next highest value was 16.81 in Old Town Lake. The mean Type D lake trophic ranking, including Lake Greenlee, was 26.12; however, the mean value excluding Lake Greenlee was only 5.91. Lake Pickthorne had the lowest Type D lake station trophic index of 1.73.

TABLE 2. Trophic Rankings of Arkansas' Significant Publicly-Owned Lakes

NO	NAME	STN	TL-P (mg/L)	CHLOR * (µg/L)	SECCHI (in)	INDEX	TYPE
58	GREENLEE	L	1.140	15.16	4.0	288.79	D
42	FRIERSON	L	0.169	25.71	8.0	24.34	C
67	HORSESHOE	L	0.149	170.00	18.0	17.72	E
66	OLD TOWN	L	0.209	110.36	19.0	16.81	D
59	MALLARD	L	0.199	45.42	21.0	11.64	D
69	GRAND	L	0.187	40.00	20.0	11.35	E
74	CHICOT	L	0.197	0.89	18.5	10.70	E
68	CHICOT	U	0.187	13.70	20.0	10.04	E
46	BEAR CREEK	L	0.119	38.81	17.0	9.28	C
55	1ST OLD RIVER	L	0.148	13.35	18.0	8.96	D
57	HOGUE	L	0.119	14.68	18.5	7.26	D
75	CONWAY	L	0.076	28.70	15.8	6.52	E
63	PINE BLUFF	L	0.138	26.00	25.5	6.43	D
37	JUNE	L	0.158	0.05	25.5	6.20	C
62	WALLACE	L	0.167	4.81	29.0	5.92	D
43	STORM CREEK	L	0.069	60.74	23.0	5.64	C
61	DESARC	L	0.099	36.12	24.0	5.63	D
78	FELSENTHAL	U	0.086	2.67	16.0	5.54	E
32	CHARLES	L	0.069	25.63	19.0	4.99	B
39	TRICOUNTY	L	0.106	3.85	23.0	4.78	C
71	BLUE MT.	L	0.077	3.20	17.5	4.57	E
75	CONWAY	U	0.076	0.89	18.0	4.27	E
78	FELSENTHAL	L	0.086	3.10	22.5	3.96	E
53	WILSON	L	0.126	3.20	33.0	3.92	D
54	ENTERPRISE	L	0.106	43.80	42.0	3.57	D
47	UP. WHITE OAK	L	0.088	27.70	34.0	3.40	C
76	ERLING	U	0.108	7.48	34.0	3.40	E
49	OVERCUP	L	0.087	14.14	31.0	3.27	C
64	ASHBAUGH	L	0.079	10.32	34.0	2.63	D
48	ATKINS	L	0.087	12.82	39.0	2.57	C
38	BAILEY	L	0.087	13.62	40.0	2.52	C
40	COX CREEK	L	0.076	1.42	31.0	2.50	C
60	GRAMPUS	L	0.096	0.53	41.0	2.36	D
79	MILLWOOD	L	0.051	8.40	27.3	2.19	E
9	DEGRAY	U	0.158	3.20	74.0	2.18	A
76	ERLING	L	0.078	9.61	42.0	2.09	E
24	WILHELMINA	L	0.077	<0.10	37.5	2.06	B
72	COLUMBIA	U	0.078	1.34	44.0	1.80	E
22	FAYETTEVILLE	L	0.086	8.81	53.0	1.80	B
29	SEQUOYAH	L	0.055	7.38	35.0	1.79	B
56	PICKTHORNE	L	0.035	2.20	21.5	1.73	D
27	NOLAN	L	0.067	6.87	44.0	1.68	B
70	GA. PACIFIC	L	0.066	0.53	40.0	1.66	E
45	POINSETT	L	0.059	1.57	38.0	1.60	C
50	LO. WHITE OAK	L	0.068	6.94	48.0	1.56	C
73	NIMROD	L	0.049	7.20	37.0	1.52	E
44	CALION	L	0.056	4.76	41.0	1.48	C
5	CATHERINE	U	0.056	3.00	42.0	1.40	A
23	BOBB KIDD	L	0.055	6.46	46.0	1.34	B
34	BEAVER FORK	L	0.077	3.20	81.0	1.27	B

NO	NAME	STN	TL-P (mg/L)	CHLOR * (µg/L)	SECCHI (in)	INDEX	TYPE
8	MAUMELLE	U	0.035	2.10	35.0	1.06	A
51	HARRIS BRAKE	L	0.035	2.70	37.0	1.02	C
72	COLUMBIA	L	0.058	14.38	72.0	1.00	E
52	CANE CREEK	L	0.045	<0.01	46.0	0.98	C
7	HAMILTON	U	<0.030	2.13	54.0	0.97	A
36	BREWER	L	0.077	0.53	80.0	0.86	B
41	HURRICANE	L	<0.030	10.30	31.0	0.82	C
3	GILLHAM	L	<0.030	14.00	55.0	0.74	A
21	ELMDALE	L	0.045	1.46	86.0	0.70	B
5	CATHERINE	L	0.045	<0.10	64.0	0.70	A
15	CRYSTAL	L	0.045	5.07	74.0	0.68	B
3	GILLHAM	M	<0.03	14.00	43.0	0.67	A
6	GREESON	U	0.048	<0.01	74.0	0.65	A
2	DIERKS	M	0.050	15.00	47.0	0.64	A
26	SUGARLOAF	L	0.047	1.34	77.0	0.63	B
35	HINKLE	L	0.047	1.34	81.0	0.60	B
6	GREESON	L	0.038	2.40	68.0	0.59	A
2	DIERKS	L	<0.030	13.00	55.0	0.51	A
11	BEAVER-HB	U	0.048	0.80	107.0	0.46	A
11	BEAVER-PC	M	0.048	<0.10	111.0	0.43	A
4	DEQUEEN	M	<0.030	9.60	59.0	0.42	A
4	DEQUEEN	L	<0.030	7.80	59.0	0.39	A
30	SWEPCO	L	<0.030	4.20	61.0	0.31	B
9	DEGRAY	L	0.036	1.07	146.0	0.27	A
20	COVE	L	<0.030	2.84	68.0	0.26	B
13	OUACHITA	U	0.047	0.27	183.0	0.26	A
25	BARNETT	L	<0.030	0.33	62.0	0.25	B
12	GREERS FERRY	L	0.059	1.07	245.0	0.25	A
17	SPRING	L	<0.030	2.14	72.0	0.24	B
16	SHORES	L	<0.030	2.40	77.0	0.23	B
33	LEE CREEK	L	<0.030	1.07	72.0	0.22	B
11	BEAVER-LB	L	0.048	0.53	219.0	0.22	A
13	OUACHITA	M	0.037	<0.10	176.0	0.21	A
18	HORSEHEAD	L	<0.030	2.80	89.0	0.20	B
7	HAMILTON	L	<0.030	4.64	108.0	0.18	A
19	WEDDINGTON	L	<0.030	2.67	109.0	0.16	B
8	MAUMELLE	L	<0.030	3.40	122.0	0.16	A
28	FT. SMITH	L	<0.030	1.34	112.0	0.16	B
31	SHEPHERD SPGS.	L	<0.030	1.34	112.0[3]	0.16	B
13	OUACHITA	L	0.037	1.07	261.0	0.16	A
10	NORFORK	L	<0.030	1.87	142.0	0.12	A
1	WINONA	L	<0.030	<0.10	134.0	0.11	A
14	BULL SHOALS	OA	<0.030	1.34	146.0	0.11	A
14	BULL SHOALS	L	<0.030	1.18	146.0	0.11	A
10	NORFORK	BB	<0.030	0.58	144.0	0.11	A
14	BULL SHOALS	U	<0.030	1.34	152.0	0.11	A
12	GREERS FERRY	U	<0.030	<0.10	157.0	0.10	A
10	NORFORK	U	<0.030	<.010	151.0	0.10	A
12	GREERS FERRY	DF	<0.030	0.63	185.0	0.08	A

[3] Secchi transparency was not taken at Lake Shepherd Springs; the secchi transparency from Lake Ft. Smith was used to calculate the trophic index.

OA - Oakland Arm BB - Bennett's Bayou Arm DF - Devil's Fork Arm

Two-thirds of the Type E lake stations ranked in the top one-third of all lakes ranked and the mean trophic index was 5.89, similar to Type D lakes. Horseshoe Lake had the highest Type E trophic index of 17.72, and lower Lake Columbia had the lowest at 1.0.

The mean trophic indices of Type C, D, and E lakes was four to six times greater than that of Type A and B lakes. This demonstrated that Type C, D, and E lakes were generally more eutrophic than Type A and B lakes.

Nine of the ten lakes with the highest trophic index rankings are located in the Delta ecoregion, while First Old River Lake is located in the Gulf Coastal Plains. Seven of the lakes are oxbows which have been cut off from their parent stream. Lakes Mallard and Greenlee are Game and Fish lakes which have levees on all four sides. Some of these ten lakes receive agricultural runoff and a few are routinely fertilized to enhance fisheries production.

Lakes Stratification

Dissolved oxygen and temperature profiles measured for each of the lake stations can be found in Appendix C. Arkansas' lakes can be best categorized as warm monomictic lakes; however, several lakes diverge from the above categorization. Most lakes in Arkansas do form a distinctive summertime stratification with a definable anoxic zone and eventually turnover in late fall to winter or early spring. However, other lakes within the State may experience several turnovers and repeated stratifications while others may not ever stratify and are continually mixed.

A few of the larger lakes demonstrated an unique stratification pattern. The thermocline of most of these lakes was located at approximately 10 meters in depth. Just above the thermocline and at the down-lake station, the dissolved oxygen concentration usually increased slightly, probably from increased phytoplankton activity, but the dissolved oxygen would decrease sharply to near zero milligrams per liter through the thermocline. A recovery of the dissolved oxygen concentration to approximately 5 mg/L would then occur in much of the hypolimnion. In the smaller Ozark Highlands lakes, the dissolved oxygen profiles and the temperature profiles mirror one another throughout the water column (Figures C-8 through C-13) and unlike the larger Ozark Highlands lakes, a very distinctive anoxic hypolimnion exist in each of these lakes and the dissolved oxygen concentration does not recover. Only Lake Wilhelmina and Lake Fort Smith exhibited an increase in the dissolved oxygen concentration just above the thermocline, indicating increased photosynthetic activity. This phenomenon was not present in lakes outside the mountainous ecoregions.

Dissolved oxygen and temperature profiles in the small lakes of the flatter terrain areas of the State, mainly Type C lakes, displayed several differences (Figures C-14 through C-17). Several of the lakes had a very sharp decline in dissolved oxygen at approximately two meters in depth and a well defined thermocline. Others in the group displayed a more gradual decline in dissolved oxygen and temperature concentrations. Most all of these lakes had an anoxic hypolimnion. There were a couple of lakes in this group that had either no or very little decline in dissolved oxygen and temperature throughout their water columns or displayed a remnant of a thermocline near their maximum depth while possessing an overall lower dissolved oxygen concentration. This perhaps was indicating that turnover had occurred and that the lake was beginning to re-stratify. Also, the small, more open waterbodies in this group tend to be less stratified, perhaps due to the continual mixing of the lake waters because of wind actions. The abnormal cooler and wetter weather conditions throughout the spring and summer may have also had an effect on lake stratification of these smaller impoundments.

Type D lakes are primarily located in the flat terrain of the delta. Several of these lakes are either horseshoe-shaped or a were constructed with a levee on three or four sides. These lakes are usually very shallow and tend to be well mixed by wind action. This is evident when examining their dissolved oxygen and temperature profiles (Figures C-18 through C-21). These profiles change very little from surface to bottom with only a small anoxic zone usually located just above the bottom of the lake. The majority of these lakes had surface dissolved oxygen concentrations between 5 mg/L and 10 mg/L with the upper two meters of the water column remaining well oxygenated.

The larger lakes within the State, classified as Type E lakes, displayed very different dissolved oxygen and temperature profiles (Figures C-21 through C-25). This is to be expected because of the different lake morphologies within this group. The lakes located in the flatter terrain areas of the State and even a couple of the larger Corps lakes had straight line profiles with a very small anoxic zone. A couple of the smaller lakes displayed a distinctive thermocline and anoxic zone. The lake's depth, the effects of wind actions and the fetch (the distance over the water surface the wind can travel uninterrupted by a physical barrier) all characterize the dissolved oxygen and temperature profiles of these lakes.

Degraded, Threatened, or Impaired Lakes

This "single point in time" survey is insufficient to positively identify those lakes which may be degraded, threatened or impaired due to point or nonpoint sources of pollution. However, some generalities can be made.

All designated uses for Arkansas' significant publicly-owned lakes were being maintained during this survey. Some water quality violations did occur, but they were most likely short term, naturally occurring, occasional events. Only Lake Swepco seems to be continually violating temperature and sulfate standards, however the designated uses of that waterbody are still being maintained. This is the only lake which has a point source discharge effecting the designated uses.

Nonpoint sources of pollution are much more difficult to identify and detect. However, there may be some indication of impairment from nonpoint sources of pollution in some delta lakes. Excessive turbidity and/or nutrients displayed in the water quality are most likely due to agricultural activities within their watersheds. Also, elevated chlorophyll a and total phosphorus concentrations may also be indicating nonpoint source pollutant impacts. Old Town lake and Horseshoe are perhaps two examples of a lake being impacted by nutrient-enriched agricultural run-off. Lake Frierson is perhaps being impacted by silt laden agricultural run-off.

Chlorophyll a

Two chlorophyll a samples were collected from each of the lakes sampled. A five sample composite was collected from just below the surface along the lake transect and one grab sample was collected just above the thermocline. Figure E-1 displays the chlorophyll a data collected during this survey.

There was very little difference between the chlorophyll a samples from the surface and thermocline in the Type A lakes. These lakes were generally deeply stratified with deep secchi disk transparencies. These lakes have well defined riverine zones and lentic zones. Large impoundments are generally more productive in the riverine zones of the lake than in the main body or near the dam. Therefore, the main body of Type A lakes are generally less productive than the riverine areas and is perhaps one explanation for the similarity between the surface and thermocline chlorophyll a concentrations collected during this survey.

The thermocline chlorophyll a concentrations of the Type B lakes were usually higher than the surface concentrations. These lakes were generally well stratified with fairly deep secchi disk transparencies. In comparison to Type A lakes, Type B lakes are smaller with little to no riverine zones. Incoming nutrients are generally flushed into the main body of these lakes and settle to the top of the more dense, colder waters at the thermocline. There is an increase in the chlorophyll a concentration through increased photosynthesis above the thermocline because of this.

The more productive lakes of the Type C, D, and E groups had similar surface and thermocline chlorophyll a concentrations. These generally shallow lakes remain well mixed resulting in fairly weak stratification and low secchi disk transparencies. This limits light penetration and does not allow for the mid-depth settling of phytoplankton and nutrients. Thus, there is a more uniform chlorophyll a concentration throughout the water column.

Type A and B lakes surface chlorophyll a concentration was approximately 16 times less than that of the Type C, D, and E, lakes. The average thermocline chlorophyll a concentration of Type A and B lakes was approximately five times less than that of the Type C, D, and E lakes. This indicates that Type C, D, and E lakes are more productive systems than Type A and B lakes, perhaps mainly due to their watershed characteristics and land uses.

1994 LAKES DATA COMPARED TO 1989 LAKES DATA

Water Quality Standards

There were some similarities in water quality standards exceedances between the 1989 survey and the 1994 survey. Lake Swepco was the only lake in both surveys to exceed the water temperature standard of 32 degrees Celsius. Lake Swepco also exceeded the turbidity standard of 25 NTU in its hypolimnion sample during both surveys. Also, Lake Frierson's hypolimnion sample exceeded the turbidity standard in both surveys.

Unlike the 1989 survey which identified eight Ouachita Mountains Type A and B lakes hypolimnetic pH values below the 6.0 pH standard, the 1994 survey identified only one Type A and B lake slightly below this standard. Also, the 1989 survey identified eight Type C, D, and E lakes with epilimnetic values above the 9.0 standard with three of these lakes hypolimnetic values exceeding this standard. No Type C, D, and E lakes pH values were below 6.0. However, the 1994 survey identified two lakes with hypolimnion pH values below 6.0 and three lakes with epilimnion values exceeding the 9.0 standard.

The dissolved oxygen standard of 5.0 mg/L was not maintained in nine type C, D, and E lakes during the 1989 survey and in seven Type C, D, and E lakes in 1994. Most of these occurrences were only slightly below the standard and were probably short term effects from climatical events. Neither survey identified any dissolved oxygen standard violations in Type A and B lakes.

The fecal coliform standard is based on different criteria for primary and secondary contact recreation activities. The 1989 survey indicated that the fecal coliform values for all lakes was substantially below the criteria established for swimmable waters.

However, the 1989 survey did identify that lakes Hinkle's and Wilhelmina's bacteria samples collected along a shore-to-shore transect were all to numerous to count. Lake Wilhelmina exceeded both the primary and secondary contact recreation standards during the 1994 survey. Six additional Type A and B lakes exceeded the primary contact recreation standard and five Type C, D, and E lakes exceeded the secondary contact recreation standard during the 1994 survey. Most of these exceedances occurred at the near-shore sample point near homesites.

The 1989 survey identified only one mineral standard exceedance; Lake Swepco exceeded the Ozark Highlands sulfate standard. This same standard was exceeded in the 1994 survey. Also in the 1994 survey, Lakes June and Calion exceeded the Gulf Coastal Plains chloride standard and Lake Greenlee exceeded the Delta total dissolved solids standard.

Trophic Status

Trophic state indices were calculated using the same formula in both surveys enabling a direct comparison of the results between both surveys. Six of the top ten highest ranking lakes in 1989 ranked in the top ten in 1994. Four of the top five lakes in both surveys are the same. Table 3 is a list the lakes comparing their trophic rankings between the two surveys.

The lower one-third of all lakes ranked in both list was comprised of Type A and B lakes and approximately seventy percent (70%) of all Type A lakes in both surveys ranked were in the lower one-third of the list. Eight of the lowest ten ranked lakes stations were similar in both surveys. These stations are from lakes Ouachita, Bull Shoals, Norfork and Greers Ferry. Also, the upper lake station of the larger Type A lakes generally ranked higher than their middle and lower lake stations. This demonstrates that the more riverine zones of the larger lakes are more productive than their more lentic zones.

Sixty-three percent (63%) of Type C lakes ranked in the upper one-third of the 1989 trophic ranking as compared to fifty-six percent (56%) in 1994. Lake June had the highest Type C lake ranking in 1989, ranking third in 1994, and Lake Frierson had the highest Type C ranking in 1994. However, Lake Frierson's 1994 trophic ranking may have been adversely affected by the low secchi disk reading caused by excessive lake turbidity at the time of sampling.

TABLE 3. Comparison of Trophic Rankings Between 1989 and 1994 of Arkansas' Significant Publicly-Owned Lakes

NO	NAME	STN	1994 INDEX	1994 RANK	1989 INDEX	1989 RANK
68	GREENLEE	L	288.79	1	15.64	4
42	FRIERSON	L	24.34	2	4.09	21
67	HORSESHOE	L	17.72	3	14.44	5
66	OLD TOWN	L	16.81	4	41.19	1
59	MALLARD	L	11.64	5	22.56	3
69	GRAND	L	11.36	6	26.32	2
74	CHICOT	L	10.70	7	4.38	20
68	CHICOT	U	10.04	8	13.70	6
46	BEAR CREEK	L	9.28	9	10.81	9
55	1st OLD RIVER	L	8.96	10	7.24	15
57	HOGUE	L	7.29	11	2.02	38
75	CONWAY	L	6.52	12	8.89	11
63	PINE BLUFF	L	6.43	13		
37	JUNE	L	6.20	14	12.81	7
62	WALLACE	L	5.92	15	11.08	8
43	STORM CREEK	L	5.64	16	7.84	13
61	DESARC	L	5.63	17	2.94	28
78	FELSENTHAL	U	5.54	18	2.32	34
32	CHARLES	L	4.89	19	2.90	29
39	TRICOUNTY	L	4.78	20	6.39	16
71	BLUE MT.	L	4.57	21	1.11	49
75	CONWAY	U	4.27	22	7.86	12
78	FELSENTHAL	L	3.96	23	1.96	39
53	WILSON	L	3.92	24	3.14	25
54	ENTERPRISE	L	3.57	25	3.06	26
47	UP. WHITE OAK	L	3.40	26	3.00	27
76	ERLING	U	3.40	27	7.46	14
49	OVERCUP	L	3.27	28	4.63	19
64	ASHBAUGH	L	2.63	29	3.15	24
48	ATKINS	L	2.57	30	1.78	41
38	BAILEY	L	2.52	31	4.80	17
40	COX CREEK	L	2.50	32		
60	GRAMPUS	L	2.35	33	3.53	23
79	MILLWOOD	L	2.19	34	1.54	42
9	DEGRAY	U	2.18	35	0.49	59
76	ERLING	L	2.09	36	4.64	18
24	WILHELMINA	L	2.06	37	1.30	46
72	COLUMBIA	U	1.80	38	2.62	31
22	FAYETTEVILLE	L	1.80	39	0.65	54
29	SEQUOYAH	L	1.79	40		
58	PICKTHORNE	L	1.73	41		
27	NOLAN	L	1.68	42		
70	GA. PACIFIC	L	1.66	43	2.25	36
45	POINSETT	L	1.60	44	0.47	62
50	LO. WHITE OAK	L	1.56	45	1.41	44
73	NIMROD	L	1.52	46	0.88	50
44	CALION	L	1.48	47	2.57	33
6	CATHERINE	U	1.40	48	1.48	43
23	BOBB KIDD	L	1.34	49	1.19	47
34	BEAVER FORK	L	1.27	50	0.45	64
8	MAUMELLE	U	1.06	51	0.38	71
51	HARRIS BRAKE	L	1.02	52	2.89	30
72	COLUMBIA	L	1.00	53	2.59	32
52	CANE CREEK	L	0.98	54	3.66	22
7	HAMILTON	U	0.97	55	0.60	55
36	BREWER	L	0.86	56	0.76	53
41	HURRICANE	L	0.82	57	1.85	40
3	GILLHAM	L	0.74	58	0.41	68
21	ELMDALE	L	0.70	59	2.03	37
5	CATHERINE	L	0.70	60	1.33	45
15	CRYSTAL	L	0.68	61	0.25	75
3	GILLHAM	M	0.67	62	0.47	61
6	GREESON	U	0.65	63	0.50	57
2	DIERKS	M	0.64	64	0.78	52
26	SUGARLOAF	L	0.63	65	0.49	58
35	HINKLE	L	0.60	66	0.45	63
6	GREESON	L	0.59	67	0.13	83
2	DIERKS	L	0.51	68	0.43	66
11	BEAVER-HB	U	0.46	69	0.80	51
11	BEAVER-PC	M	0.46	70	0.17	81
4	DEQUEEN	M	0.42	71	0.39	69
4	DEQUEEN	L	0.39	72	0.32	72
30	SWEPCO	L	0.31	73	0.22	78
9	DEGRAY	L	0.27	74	0.11	86
20	COVE	L	0.26	75	0.27	74
13	OUACHITA	U	0.26	76	0.22	79
25	BARNETT	L	0.26	77	2.29	35
12	GREERS FERRY	L	0.25	78	0.13	84
17	SPRING	L	0.24	79	0.38	70
16	SHORES	L	0.23	80	0.41	67
33	LEE CREEK	L	0.22	81		
11	BEAVER-LB	L	0.22	82	0.09	90
13	OUACHITA	M	0.21	83	0.15	82
18	HORSEHEAD	L	0.20	84	0.48	60
7	HAMILTON	L	0.18	85	0.57	56
19	WEDDINGTON	L	0.16	86	0.22	77
8	MAUMELLE	L	0.15	87	0.29	73
28	FT. SMITH	L	0.16	88	0.23	76
31	SHEPHERD SPGS.	L	0.15	89	0.44	65
13	OUACHITA	L	0.15	90	0.08	92
10	NORFORK	L	0.12	91	0.09	89
1	WINONA	L	0.11	92	0.20	80
14	BULL SHOALS	OA	0.11	93		
14	BULL SHOALS	L	0.11	94	0.08	93
10	NORFORK	BB	0.11	95		
14	BULL SHOALS	U	0.11	96	0.11	87
12	GREERS FERRY	U	0.10	97	0.11	88
10	NORFORK	U	0.10	98	0.11	85
12	GREERS FERRY	DF	0.08	99		

[3] Secchi transparency was not taken at Lake Shepherd Springs; the secchi transparency from Lake Ft. Smith was used to calculate the trophic index.

OA - Oakland Arm BB - Bennett's Bayou Arm DF - Devil's Fork Arm

Type D lakes comprised eighty-five percent (85%) of the upper one-third of the trophic rankings in 1989 and ninety-three (93%) of the upper one-third of the ranking list in 1994. Old Town Lake had the highest trophic ranking in 1989, ranking fourth in 1994, and Lake Greenlee had the highest ranking in 1994. However, Lake Greenlee's 1994 trophic ranking may have been adversely affected by the low secchi disk transparency caused be excessive turbidity in the lake.

Fifty percent (50%) of Type E lake stations ranked in the upper one-third of all lakes ranked in 1989 as compared to sixty-six percent (66%) of Type E lake stations in 1994. Grand Lake had the highest Type E lake station trophic index in 1989, ranking second of Type E lakes in 1994. Horseshoe Lake had the highest 1994 Type E lake ranking, ranking second in 1989.

Nine of the top ten trophic ranked lakes in 1994 were Delta lakes. Six of these lakes ranked in the top ten during the 1989 survey. Five of the 1989 lakes and six of the 1994 lakes were oxbows which have been primarily cut-off from their parent streams by levees. Many of these lakes receive runoff from agriculture activities and of few are routinely fertilized for fisheries enhancement.

<u>Lakes Stratification</u>

The larger lakes in the montane regions of the State displayed a unique stratification and dissolved oxygen (DO) pattern during the 1989 survey. The DO would decrease to near anoxic conditions in the metalimnion but recover somewhat in the hypolimnion. During the 1994 survey this pattern was observed in only a few of the larger lakes. There was a slight DO stratification pattern difference in the smaller Ozark Highlands lakes between the two surveys. The 1989 survey indicated that DO concentrations in several of these lakes displayed a slight to substantial increase just above the thermocline, and then declined to almost zero in the hypolimnion. This DO concentration increase just above the thermocline was not as apparent in the 1994 survey, however, the presence of a deep anoxic zone was still prevalent in most of the Ozark Highlands lakes.

The larger, more shallow lakes of the Delta ecoregion displayed similar stratification characteristics between the two surveys. These lakes tend to remain well mixed from unabated wind action causing straight-line DO and temperature profiles with perhaps only the bottom one to two meters being anoxic.

The smaller lakes in the States flatter terrain areas displayed similar stratification trends among surveys. Many had only remnant thermoclines, suggesting a turnover event had recently occurred, and others displayed only little stratification, indicating a continuous mixing trait. Both surveys indicated that some of these lakes had a gradual decline in DO and temperature through out the water column, and that many possessed an anoxic hypolimnion.

As discussed in the 1989 survey, Lake Felsenthal exhibited very unique dissolved oxygen and temperature profiles. Profiles were taken in the upper and lower ends of the lake with additional profiles being collected in the western and eastern portions of the flood pool. The 1989 survey indicated that the profiles at all four lake station were virtually straight-line through out the water column and that the maximum dissolved oxygen concentration at any depth was 2.1 mg/L. The 1994 survey indicated similar conditions at three of the lake stations, the upper, lower, and eastern, but the maximum dissolved oxygen concentration was 5 mg/L. The profile taken from the western lake station indicated a gradual decrease in dissolved oxygen to near anoxic conditions with a surface dissolved oxygen of approximately 4 mg/L.

SUMMARY

Eighty (80) impoundments were identified as significant publicly-owned lakes and were selected because of size, public significance and accessibility. Water quality data was collected from many of these lakes during the 1994 summer. Supplemental data from the larger Corps of Engineers reservoirs, collected about the same time, was also incorporated. Water quality parameters such as nutrients, minerals, dissolved oxygen and temperature profiles, fecal coliform bacteria and dissolved metals were collected from both the epilimnion and hypolimnion of these lakes. Usually more than one sample site was located on many of the larger lakes.

The classification system used in the 1989 survey was once again used for this survey. The lakes were categorized into five basic lake types based on watershed characteristics and morphologies. The watershed characteristics undoubtedly influenced the water quality of each of the lakes within the individual lake types. Dissolved oxygen and temperature profiles and chlorophyll ^{a} concentrations were all greatly influenced by the physical properties of these lakes. However, the chemical parameters were more greatly influenced by the lake watershed chemical properties.

A ranking of all the lakes based on trophic status was made. Lake Greenlee's trophic ranking was over ten times greater than the next highest. This trophic ranking was probably abnormally high due to the very low secchi disk transparency caused mainly by turbidity from suspended clay particles. Lake Frierson's second highest trophic ranking was probably influenced by silt-caused turbidity resulting in a low secchi disk transparency. Horseshoe Lake had the highest chlorophyll ^{a} concentration of 170.00 μg/L and ranked third in trophic status. Old Town Lake had the second highest chlorophyll ^{a} concentration of 110.36 μg/L, ranking it fourth in trophic status. Both of these lakes can probably be classified as eutrophic. The lowest one-third of all of the trophic indices of all lakes ranked were comprised of Type A and B lakes.

Ninety-three percent (93%) of the Type D lake stations and two-thirds of the Type E lake stations were in the upper one-third of all lake station trophic indices. Nine of the ten lakes with the highest trophic rankings are located in the Delta ecoregion; the other is a Gulf Coastal Plains ecoregion lake.

A comparison of the in-lake water quality data to water quality standards must be made with some qualifications. The State's in-lake water quality standards have been adopted from the State's stream standards. Therefore, the standards must remain flexible to address the inherent variability of the many lake water quality parameters. Even though every lake is a unique system, the vast majority of the water quality data collected from all the State's lakes as a whole fell within these water quality standards.

Only Lake Swepco violated the temperature standard. It also violated the Boston Mountains ecoregion turbidity and sulfate standards. This lake is a cooling water lake for a fossil fuel power generation plant. Three additional lakes, all located in the Delta, had turbidity concentrations above the standard, probably because of recent storm or turnover events causing a re-suspension of in-lake silt particles. There were only slight violations of the pH standard, mostly in the lakes with excessive photosynthetic activity. Dissolved oxygen concentrations of seven lakes fell below the 5 mg/L standard, Lake Mallard was below 4 mg/L. Lake Wilhelmina's fecal coliform geometric mean exceeded both the primary and secondary contact recreation criteria and lakes Mallard, Pine Bluff, Grand, upper Erling, and upper and lower Felsenthal's fecal coliform values exceeded the primary contact recreation standard. These exceedances are perhaps due to runoff from storm waters during the abnormally wet and cool spring and summer. The only mineral standards exceeded during the survey were Lake Swepco's sulfate concentration, lakes June and Calion's chloride concentrations, and Lake Greenlee's total dissolved solids concentration. Lakes June and Calion receive runoff from active oil fields and Lake Greenlee's excessive turbidity perhaps caused the excessive total dissolved solids value.

Acute and chronic lead and copper toxicity criteria were exceeded in some lakes; however, only a few incidences may be of concern. In some of the lakes, the calculated toxic values, based on total hardness values, was below the detection limit of the laboratory equipment. There were three stations that had toxic levels of metals that might be of some concern. The upper Lake Felsenthal epilimnion copper concentration was approximately five times above the acute and chronic criteria and the Bear Creek epilimnion and the lower Lake Greeson hypolimnion lead concentrations were three to five times higher than the criteria. These concentrations may have been temporarily elevated by either recent turnover events or excessive runoff from storm events.

APPENDIX A

WATER QUALITY DATA BY LAKE TYPE

Appendix A lists the water quality data by lake type collected during the summer of 1994. Most of the data was collected by personnel from the Water Quality Management Planning Section, Water Division, of the Department. Additional data was collected by Department personnel from the Ecology Section, Technical Services Division. All of the water quality samples collected by Department personnel were analyzed in the Department's Water Quality Laboratory under the existing Quality Assurance/Quality Control project plan. Also, supplemental data from the larger Corps of Engineers Lakes, Dierks, Gillham, DeQueen, Norfork, Beaver, Bull Shoals, Greers Ferry, Blue Mountain and Nimrod, and the City of Little Rock's water supply lakes survey from the USGS survey, were provided by the Little Rock District Corps of Engineers. Lakes Ouachita, DeGray, Catherine, Hamilton and Greeson were sampled by Department personnel. Data from Beaver Reservoir's and Lake Millwood's recently completed Phase I, Diagnostic/Feasibility Clean Lakes Studies were also used.

The unit of measure for the parameters listed are as follows: fecal coliform in numbers of colonies per 100 ml (col/100 ml); chlorophyll *a* in μg/L; secchi disk transparencies in inches; turbidity in NTU; conductivity in micro-mhos per centimeter; alkalinity, chlorides, sulfates, ammonia-nitrogen, nitrite-nitrate nitrogen, total phosphorus, ortho-phosphorus, total organic carbon, total dissolved solids, total suspended solids and total hardness in mg/L; metals in μg/L. The laboratory detection limits were: NH_3-N=0.05 mg/L; NO_2-NO_3-N=0.02 mg/L; total phosphorus and ortho-phosphorus=0.03 mg/L; total dissolved solids, total suspended solids, turbidity, and sulfates=1.0 mg/L; chlorides=1.2 mg/L; total hardness and total organic carbon=2.0 mg/L; Cadmium=0.5 μg/L; Chromium=1.0 μg/L; Copper=4.0 μg/L, Lead=2.0 μg/L; Zinc=8.0 μg/L. Data under the "E" column was collected from the epilimnion and data under the "H" column was collected from the hypolimnion. Chlorophyll *a* data under the "com" column is from the composite samples across the transect, and data under the "thcl" column is from the sample collected just above the thermocline. Fecal coliform columns are: ls=left shore, l¼=left quarter point, c=center, r¼=right quarter point, rs=right shore, and mean is the geometric mean of the five samples. Station designations (STN) are as follows: l=lower portion of the lake, normally near the dam; m=mid lake station; u=upper portion of the lake.

TABLE A-1. Water Quality Data from Type A Lakes

No.	Lake Name	STN	Chlor * com	Chlor * thcl	Schi in	TSS E	TSS H	Turb E	Turb H	TDS E	TDS H	Cond E	Cond H	T-Hard E	T-Hard H	Alk E	Alk H	Cl E	Cl H	SO_4 E	SO_4 H	NH_3-N E	NH_3-N H	NO_3-N E	NO_3-N H	TL-P E	TL-P H	O-PO_4 E	O-PO_4 H	TOC E	TOC H
1	WINONA	L	<0.10	0.53	134	1.0	<1.0	1.3	3.0	21	25	na	na	6.0	<5.0	8	8	1.54	1.50	2.80	4.00	<0.05	<0.05	<0.02	0.04	<0.03	<0.03	<0.03	<0.03	5.9	4.8
2	DIERKS	M	na	15.00	47	na	na	2.2	4.1	na	na	na	na	na	na	na	na	na	na	na	na	na	na	<0.02	<0.02	0.05	0.03	<0.03	<0.03	na	na
2	DIERKS	L	na	13.00	55	na	na	2.0	6.1	na	na	na	na	na	na	na	na	na	na	na	na	na	na	<0.02	0.15	<0.03	0.04	<0.03	<0.03	na	na
3	GILLHAM	M	na	14.00	43	na	na	4.4	4.3	na	na	na	na	na	na	na	na	na	na	na	na	na	na	<0.02	<0.02	<0.03	<0.03	<0.03	<0.03	na	na
3	GILLHAM	L	na	14.00	39	na	na	5.0	6.3	na	na	na	na	na	na	na	na	na	na	na	na	na	na	<0.02	<0.02	<0.03	0.07	<0.03	0.05	na	na
4	DEQUEEN	M	na	9.50	59	na	na	2.0	6.9	na	na	na	na	na	na	na	na	na	na	na	na	na	na	<0.02	<0.02	<0.03	0.05	<0.03	0.03	na	na
4	DEQUEEN	L	na	7.80	59	na	na	<1.0	2.5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	<0.02	<0.02	<0.03	<0.03	<0.03	<0.03	na	na
5	CATHERINE	U	3.00	2.67	42	3.5	4.0	3.2	4.0	47	43	66.3	76.0	17.4	17.4	20	21	2.67	2.99	7.00	8.00	<0.05	0.19	0.09	0.20	0.05	0.04	<0.03	<0.03	5.1	4.3
5	CATHERINE	L	<0.10	0.27	64	5.5	10.0	5.5	7.4	48	43	63.2	58.1	15.6	15.6	16	20	2.76	2.27	7.00	2.10	<0.05	<0.05	0.09	0.30	0.06	0.05	<0.03	<0.03	4.7	4.6
6	GREESON	U	<0.01	void	74	2.5	3.5	2.6	7.8	23	31	27.4	35.2	16.5	6.3	na	na	2.16	2.11	1.80	3.00	0.09	0.07	<0.02	<0.02	0.05	0.06	0.04	0.03	void	void
6	GREESON	L	2.40	10.41	68	2.0	<1.0	2.3	4.6	22	31	23.7	28.8	<5.0	<5.0	na	na	1.98	1.68	1.80	3.00	<0.05	<0.05	<0.02	0.26	0.04	0.04	<0.03	<0.03	void	void
7	HAMILTON	U	2.13	0.53	54	3.5	3.5	4.4	3.4	33	37	42.7	51.8	12.3	12.3	18	20	2.31	2.95	2.10	2.10	0.05	0.16	<0.02	0.11	<0.03	<0.03	<0.03	<0.03	4.3	4.0
7	HAMILTON	L	4.54	3.47	108	2.0	1.5	1.6	2.0	37	37	43.8	63.3	10.5	16.6	16	16	2.11	2.76	2.10	7.00	<0.05	<0.05	<0.02	0.09	<0.03	0.06	<0.03	<0.03	3.6	4.7
8	MAUMELLE	U	2.10	1.00	35	3.0	5.5	2.8	6.9	22	28	na	na	6.0	10.8	10	12	1.84	1.80	4.00	4.00	0.09	0.08	0.04	<0.02	0.04	<0.03	<0.03	<0.03	5.6	5.3
8	MAUMELLE	L	na	3.40	122	na	na	na	1.0	na	22	na	na	na	7.0	na	7	na	1.50	na	2.80	na	<0.05	na	<0.02	na	<0.03	na	<0.03	na	4.3
9	DEGRAY	U	3.20	<0.10	74	4.5	2.0	11.0	2.8	56	44	71.4	65.9	16.5	18.0	na	na	2.20	2.03	7.20	3.00	0.29	<0.05	<0.02	<0.02	0.16	0.06	0.14	<0.03	void	void
9	DEGRAY	L	1.07	void	148	<1.0	<1.0	1.0	2.8	32	38	47.2	48.3	11.4	9.6	na	na	2.00	1.90	4.10	4.10	0.11	<0.05	<0.02	0.25	0.04	0.04	<0.03	<0.03	void	void
10	NORFORK	U	<0.10	na	151	<1.0	<1.0	0.9	2.6	160	165	na	na	void	void	na	na	2.86	2.82	4.50	4.50	<0.05	<0.05	<0.02	0.02	<0.03	<0.03	<0.03	<0.03	2.8	2.2
10	NORFORK	BB	0.58	na	144	<1.0	3.5	1.0	4.2	162	178	na	na	void	void	na	na	3.01	2.87	5.60	4.50	<0.05	0.17	<0.02	<0.02	<0.03	<0.03	<0.03	<0.03	2.9	3.0
10	NORFORK	L	1.87	na	142	1.5	<1.0	0.7	0.9	155	174	na	na	174	193	na	na	3.18	3.01	5.60	5.60	0.07	0.06	<0.02	0.47	<0.03	<0.03	<0.03	<0.03	3.6	3.2
11	BEAVER-hb	U	0.80	2.40	107	<1.0	1.5	3.4	3.5	80	85	na	na	59.4	63.0	na	na	2.78	2.68	6.20	5.10	<0.05	0.07	0.10	0.22	0.05	0.05	<0.03	<0.03	void	void
11	BEAVER-pc	M	<0.10	6.84	111	1.0	2.5	1.6	3.4	81	85	na	na	60.6	61.8	na	na	2.84	2.80	6.20	6.20	<0.05	0.11	0.13	0.50	0.05	0.07	<0.03	<0.03	void	void
11	BEAVER-lb	L	0.53	<0.10	219	<1.0	<1.0	0.8	1.0	83	88	na	na	63.0	65.4	na	na	2.61	2.67	6.20	6.20	<0.05	<0.05	0.11	0.23	0.05	0.05	<0.03	<0.03	void	void
12	GREERS FY3	U	<0.10	0.68	157	<1.0	<1.0	0.9	1.9	30	31	43.0	37.0	12.0	9.9	15	12	1.95	1.72	3.20	3.20	0.08	0.08	0.02	0.16	<0.03	0.04	<0.03	<0.03	3.6	3.0
12	GREERS FY2	DF	0.53	0.53	185	<1.0	<1.0	0.8	2.0	31	38	46.0	62.0	12.0	15.9	18	18	2.04	1.90	3.20	4.10	0.09	0.09	0.03	0.18	<0.03	0.04	<0.03	<0.03	4.2	3.4
12	GREERS FY1	L	1.07	0.53	245	<1.0	<1.0	0.7	0.9	27	27	41.0	42.0	<5.0	8.9	16	16	2.00	2.10	4.10	4.10	0.08	0.12	0.02	0.04	0.06	<0.03	<0.03	<0.03	4.0	3.6
13	OUACHITA	U	0.27	1.07	183	<1.0	<1.0	0.8	5.2	35	38	52.6	49.9	14.1	17.1	21	20	2.19	2.13	3.80	4.80	<0.05	<0.05	<0.02	0.30	0.05	0.05	<0.03	<0.03	5.0	5.8
13	OUACHITA	M	<0.10	<0.10	176	<1.0	<1.0	0.5	0.7	33	27	52.8	50.8	17.1	17.1	22	18	1.88	1.94	3.80	3.80	<0.05	<0.05	<0.02	0.21	0.04	0.04	<0.03	<0.03	4.8	5.4
13	OUACHITA	L	1.07	0.80	261	<1.0	<1.0	0.7	0.8	35	38	52.8	54.9	18.6	20.1	21	20	1.84	1.77	3.80	3.80	<0.05	<0.05	<0.02	0.16	0.04	0.04	<0.03	<0.03	5.2	5.0
14	BULL SH-1	U	1.34	2.67	152	1.0	3.6	1.1	3.4	133	144	na	na	131	147	na	na	4.97	5.10	7.50	7.60	0.08	0.12	<0.02	0.56	<0.03	<0.03	0.04	<0.03	3.8	3.1
14	BULL SH-2	OA	1.34	2.67	146	1.0	<1.0	0.7	2.2	141	178	na	na	void	void	na	na	4.44	3.81	5.60	5.60	<0.05	<0.05	<0.02	0.23	<0.03	<0.03	<0.03	<0.03	3.3	2.8
14	BULL SH-3	L	1.18	1.60	146	1.0	<1.0	0.8	0.8	142	153	na	na	130	155	na	na	5.18	4.61	7.50	7.60	0.10	0.07	<0.02	0.56	<0.03	<0.03	0.04	<0.03	4.4	2.8

BB -- Bennett's Bayou Arm
hb -- Horseshoe Bend
FY1 -- Choctaw Arm
SH-1 -- Lead Hill Arm

pc -- Prairie Creek Arm
FY2 -- Devil's Fork Arm
SH-2 -- Oakland Arm

lb -- Lost Bridge
FY3 -- Near Dam
SH-3 -- Near Dam

TABLE A-1. Water Quality Data from Type A Lakes (cont)

No.	Lake Name	STN	Fecal coliform ls	l¼	c	r¼	rs	Gm[1] mean	Cd E	Cd H	Cr E	Cr H	Cu E	Cu H	Pb E	Pb H	Zn E	Zn H
1	WINONA	L	-[3]	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	DIERKS	L							-	-	-	-	-	-	-	-	-	-
3	GILLHAM	U							-	-	-	-	-	-	-	-	-	-
3	GILLHAM	L							-	-	-	-	-	-	-	-	-	-
4	DEQUEEN	U							-	-	-	-	-	-	-	-	-	-
4	DEQUEEN	L							-	-	-	-	-	-	-	-	-	-
5	CATHERINE[2]	U	689	-	17	-	7	43.4	<0.05	<0.05	<1	<1	<4	<4	<2	<2	<8	<8
5	CATHERINE[2]	L	3	-	6	-	6	4.8	<0.05	<0.05	<1	<1	<4	<4	<2	<2	<8	<8
6	GREESON	U	10	3	5	3	8	5.1	<0.05	<0.05	<1	<1	<4	<4	<2	<2	<8	<8
6	GREESON	L	13	37	40	32	40	30.1	<0.05	<0.05	<1	<1	<4	<4	<2	4.8	<8	<8
7	HAMILTON[2]	U	58	-	28	-	69	48.2	<0.05	<0.05	<1	<1	<4	<4	<2	<2	<8	<8
7	HAMILTON[2]	L	0[4]	-	3	-	3	3.0	<0.05	<0.05	<1	<1	<4	<4	<2	<2	<8	23.0
8	MAUMELLE	U							-	-	-	-	-	-	-	-	-	-
8	MAUMELLE	L	-	-	<1	-	-		-	-	-	-	-	-	-	-	-	-
9	DEGRAY	U	7	10	8	5	7	7.2	<0.05	<0.05	<1	<1	<4	<4	<2	2.6	<8	<8
9	DEGRAY	L	7	2	0	13	5	5.5	<0.05	<0.05	<1	<1	<4	<4	<2	<2	<8	9.0
10	NORFORK	U			<4				-	-	-	-	-	-	-	-	-	-
10	NORFORK	L			<4				-	-	-	-	-	-	-	-	-	-
11	BEAVER-hb	U			<4				-	-	-	-	-	-	-	-	-	-
11	BEAVER-lb	M			<4				-	-	-	-	-	-	-	-	-	-
11	BEAVER-pc	L			~8				-	-	-	-	-	-	-	-	-	-
12	GREERS FY3	U			void				-	-	-	-	-	-	-	-	-	-
12	GREERS FY1	L			void				-	-	-	-	-	-	-	-	-	-
13	OUACHITA	U	0	0	0	0	0	0.0	<0.05	<0.05	<1	<1	<4	<4	<2	<2	16.0	<8
13	OUACHITA	M	2	0	0	0	0	2.0	<0.05	<0.05	<1	<1	<4	<4	<2	3.0	<8	<8
13	OUACHITA	L	0	0	1	1	0	1.0	<0.05	<0.05	<1	<1	<4	<4	<2	<2	<8	<8
14	BULL SH-1	U			<4				-	-	-	-	-	-	-	-	-	-
14	BULL SH-2	OA			<4				-	-	-	-	-	-	-	-	-	-
14	BULL SH-3	L			<4				-	-	-	-	-	-	-	-	-	-

[1] Geometric mean
[2] Data represents bacteria samples collected on 7/28/94; bacteria samples collected on 7/14/94 were TNTC.
[3] Sample not taken at that transect location
[4] Actual value, no colonies grown.

BB -- Bennett's Bayou Arm
hb -- Horseshoe Bend
FY1 -- Choctaw Arm
SH-1 -- Lead Hill Arm
pc -- Prairie Creek Arm
FY2 -- Devil's Fork Arm
SH-2 -- Oakland Arm
lb -- Lost Bridge
FY3 -- Near Dam
SH-3 -- Near Dam

TABLE A-2. Water Quality Data from Type B Lakes

No.	Lake Name	STN	Chlor[a] com	Chlor[a] thcl	Schi in	TSS E	TSS H	Turb E	Turb H	TDS E	TDS H	Cond E	Cond H	T-Hard E	T-Hard H	Alk E	Alk H	Cl E	Cl H	SO_4 E	SO_4 H	NH_3-N E	NH_3-N H	NO_3-N E	NO_3-N H	TL-P E	TL-P H	O-PO_4 E	O-PO_4 H	TOC E	TOC H
15	CRYSTAL	L	5.07	11.46	74	2.0	8.5	2.2	10.0	91	139	160.0	223.0	71.1	111.0	69	96	4.24	3.59	3.40	4.40	<0.05	1.50	<0.02	<0.02	0.05	0.22	<0.03	0.04	5.8	10.2
16	SHORES	L	2.40	21.02	77	<1.0	6.5	2.2	14.0	29	59	35.0	58.0	9.3	19.8	na	na	1.58	1.70	2.70	5.00	0.05	0.76	void	void	<0.03	<0.03	<0.03	<0.03	3.1	4.0
17	SPRING	L	2.14	2.49	72	2.5	4.0	3.2	13.0	24	62	28.0	46.0	6.9	14.1	na	na	2.26	1.90	3.80	9.90	0.06	<0.05	<0.02	<0.02	<0.03	<0.03	<0.03	<0.03	3.4	6.3
18	HORSEHEAD	L	2.80	1.07	89	1.5	2.5	2.0	8.8	24	34	31.0	41.0	<5.0	11.7	na	na	1.86	1.89	3.80	6.00	0.05	0.21	<0.02	<0.02	<0.03	<0.03	<0.03	<0.03	3.2	3.1
19	WEDDINGTON	L	2.67	14.15	108	<1.0	3.0	1.2	8.1	74	131	121.0	160.0	57.6	71.1	60	80	3.25	2.78	4.40	3.40	<0.05	0.34	<0.02	<0.02	<0.03	<0.60	<0.03	<0.03	4.4	3.5
20	COVE	L	2.94	5.33	68	3.0	6.0	3.6	17.0	25	48	27.0	40.0	6.9	9.3	10	18	1.79	1.77	3.90	9.00	0.06	0.33	<0.02	<0.02	<0.03	<0.03	<0.03	<0.03	3.8	5.0
21	ELMDALE	L	1.46	11.75	86	3.5	3.5	2.4	9.6	103	119	178.0	205.0	80.7	88.5	86	98	6.58	5.48	2.30	4.40	<0.05	1.03	<0.02	<0.02	0.05	0.33	<0.03	0.17	8.4	11.4
22	FAYETTEVILLE	L	8.81	9.97	63	6.0	13.0	3.4	21.0	93	150	147.0	280.0	62.1	108.0	76	141	6.66	6.31	3.40	4.40	<0.05	4.28	<0.02	<0.02	0.08	1.06	<0.03	0.10	7.2	12.8
23	BOBB KIDD	L	8.45	5.07	46	4.0	7.0	3.8	19.0	91	111	143.0	192.0	56.4	64.5	51	89	6.10	5.94	11.70	9.80	<0.05	2.22	<0.02	<0.02	0.06	0.45	<0.03	0.24	5.9	6.8
24	WILHELMINA	L	<0.10	7.63	37	5.0	22.0	5.2	18.0	24	43	26.0	42.0	11.1	11.1	9	20	1.80	2.20	2.60	10.60	0.09	1.11	<0.02	<0.02	0.08	0.32	<0.03	0.19	6.4	7.7
25	BARNETT	L	0.33	1.80	62	2.5	1.5	2.2	2.1	30	36	37.5	44.8	12.9	12.9	12	12	2.86	3.40	1.50	2.80	<0.05	0.15	0.02	0.45	<0.03	<0.03	<0.03	<0.03	5.6	3.5
26	SUGARLOAF	L	1.34	5.61	77	1.5	1.6	3.1	2.8	38	60	53.6	72.9	17.1	20.1	15	28	2.74	2.62	6.90	7.90	0.07	0.42	<0.02	<0.02	0.05	0.08	<0.03	0.04	6.0	5.6
27	NOLAN	L	6.87	7.78	44	3.0	7.5	3.4	7.4	48	111	71.5	190.0	14.1	66.6	37	83	3.97	4.26	4.80	8.80	0.17	3.06	0.04	0.03	0.07	0.11	<0.03	0.05	8.6	13.3
28	FT. SMITH	L	1.34	2.94	112	1.0	1.5	1.6	6.8	31	38	37.0	41.0	15.9	15.9	na	na	1.82	1.90	3.90	3.90	0.08	0.08	void	void	<0.03	<0.03	<0.03	<0.03	2.5	1.8
29	SEQUOYAH	L	7.38	3.20	35	4.0	7.5	6.5	9.1	74	85	120.0	141.0	52.8	58.8	57	68	2.72	2.70	4.40	3.40	<0.05	0.40	<0.02	<0.02	0.05	0.07	<0.03	<0.03	5.7	7.5
30	SWEPCO	L	4.20	4.81	61	1.0	<1.0	2.0	33.0	190	211	313.0	368.0	99.3	138.0	77	138	11.40	12.80	62.30	45.80	<0.05	1.37	<0.02	<0.02	<0.03	0.03	<0.03	<0.03	6.3	7.2
31	SHEPHERD SPGS	L	1.34	11.21	112[1]	<1.0	<1.0	1.4	4.5	34	34	42.0	44.0	1.4	4.5	na	na	1.75	1.77	3.90	3.90	0.05	0.07	void	void	<0.03	<0.03	<0.03	<0.03	3.1	1.8
32	CHARLES	L	25.63	22.51	18	11.5	10.5	7.2	8.0	149	147	245.0	259.0	133.0	142.0	132	132	5.19	4.35	3.80	2.60	0.23	0.38	<0.02	0.03	0.07	0.09	0.05	0.05	void	void
33	LEE CREEK	L	1.07	3.06	72	1.0	6.5	2.7	15.0	47	84	67.0	120.0	19.8	49.5	na	na	2.85	2.70	5.00	9.00	<0.05	0.62	void	void	<0.03	<0.03	<0.03	<0.03	6.3	8.0
34	BEAVER FORK	L	3.20	9.01	81	1.5	2.0	2.2	3.4	37	39	67.0	73.0	6.9	18.0	12	15	6.29	6.09	5.00	6.00	0.07	0.10	0.03	0.02	0.07	0.08	<0.03	<0.03	5.6	5.8
35	HINKLE	L	1.34	3.20	81	1.5	1.5	2.4	15.0	27	35	36.8	47.6	12.6	14.1	13	18	2.51	2.24	4.80	4.80	<0.05	0.14	<0.02	0.08	0.05	0.05	<0.03	<0.03	5.1	5.9
36	BREWER	L	0.53	8.01	90	<1.0	1.0	2.0	19.0	28	56	49.0	92.0	11.7	19.8	14	38	3.05	3.49	5.00	9.90	0.07	1.20	0.02	0.03	0.08	0.18	<0.03	0.13	4.8	5.8

No	Lake Name	STN	Fecal coliform ls	Fecal coliform l¼	Fecal coliform c	Fecal coliform r¼	Fecal coliform rs	Gm mean	Cd E	Cd H	Cr E	Cr H	Cu E	Cu H	Pb E	Pb H	Zn E	Zn H
15	CRYSTAL	L	10	18	3	3	5	6.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
16	SHORES	L	2	0	0	0	0	2.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
17	SPRING	L	0	0	2	0	0	2.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
18	HORSEHEAD	L	5	2	2	0	2	2.5	<0.5	<0.5	<1	1.1	<4	<4	<2	<2	<8	<8
19	WEDDINGTON	L	0	0	0	3	0	3.0	<0.5	<0.5	1.1	<1	<4	<4	<2	<2	<8	<8
20	COVE	L	2	3	0	0	3	2.6	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
21	ELMDALE	L	2	0	0	0	0	2.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	16.0	9.0
22	FAYETTEVILLE	L	3	0	2	0	0	2.4	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
23	BOBB KIDD	L	0	0	0	0	3	3.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
24	WILHELMINA	L	<1000	<2400	<2300	<2900	<4200	<2320.2	<0.5	<0.5	1.0	<1	4.0	<4	2.3	<2	9.0	<8
25	BARNETT	L	3	3	5	7	3	3.9	<0.5	<0.5	<1	<1	4.6	<4	2.0	<2	<8	<8
26	SUGARLOAF	L	260	5	10	8	10	16.0	<0.5	<0.5	<1	<1	6.5	<4	<2	<2	15.0	13.0
27	NOLAN	L	3	5	8	3	5	4.5	<0.5	<0.5	<1	<1	<4	<4	<2	<2	18.0	10.0
28	FT. SMITH	L	0	0	7	0	3	4.6	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
29	SEQUOYAH	L	0	0	0	0	3	3.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	14.0
30	SWEPCO	L	0	0	0	0	0	0.0	<0.5	<0.5	<1	1.0	<4	<4	<2	<2	<8	<8
31	SHEPHERD SPGS	L	0	0	0	0	0	0.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
32	CHARLES	L	48	40	0	710	<6400	<97.3	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	10.0
33	LEE CREEK	L	13	10	2	7	2	5.2	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	8.0
34	BEAVER FORK	L	0	0	0	3	8	4.9	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
35	HINKLE	L	2	0	2	5	3	2.8	<0.5	<0.5	<1	<1	<4	<4	<2	<2	10.0	<8
36	BREWER	L	0	0	0	0	0	0.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8

TABLE A-3. Water Quality Data from Type C Lakes

No.	Lake Name	STN	Chlor *		Schi	TSS		Turb		TDS		Cond		T-Hard		Alk		Cl		SO_4		NH_3-N		NO_3-N		TL-P		O-PO_4		TOC	
			com	thcl	in	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H
37	JUNE	L	<0.10	24.60	28	7.0	10.0	6.3	8.0	113	119	170.9	180.1	22.8	27.3	na	na	30.40	30.70	6.10	6.20	<0.05	<0.05	<0.02	<0.02	0.16	0.17	<0.03	<0.03	12.0	11.8
38	BAILEY	L	13.62	6.72	40	3.5	6.0	4.6	9.3	32	36	32.9	36.8	14.1	17.1	11	14	2.02	2.22	1.60	1.60	0.07	0.11	0.03	0.03	0.09	0.09	<0.03	<0.03	7.9	8.2
39	TRICOUNTY	L	3.86	18.80	23	7.0	7.6	7.2	7.0	64	60	67.3	67.4	11.4	9.6	15	16	6.72	6.74	3.00	3.00	<0.05	<0.05	<0.02	<0.02	0.11	0.10	<0.03	<0.03	12.4	10.4
40	COX CREEK	L	1.42	void	31	3.0	16.0	6.8	19.0	36	59	19.9	67.7	<6.0	13.2	11	24	2.44	3.37	6.10	9.10	0.06	0.24	<0.02	<0.02	0.08	0.07	<0.03	0.04	8.5	12.8
41	HURRICANE	L	10.30	20.60	31	4.0	6.0	6.4	6.2	68	68	90.4	103.1	32.4	42.3	47	48	3.62	3.79	6.10	7.30	<0.05	0.14	0.04	0.03	<0.03	0.11	<0.03	0.05	7.8	7.8
42	FRIERSON	L	26.71	14.69	8	47.0	76.0	76.0	93.0	111	109	46.0	60.0	24.6	17.1	18	17	2.97	3.73	6.90	6.80	0.22	0.48	0.03	0.04	0.17	0.20	0.21	0.21	void	void
43	STORM CREEK	L	60.74	64.07	23	4.0	6.0	10.0	14.0	100	126	159.0	223.0	76.6	106.0	84	118	1.72	1.76	4.10	8.20	0.10	1.79	0.03	0.03	0.07	0.46	<0.03	0.20	10.6	10.6
44	CALION	L	4.76	9.34	41	3.0	13.0	2.8	8.8	80	80	115.3	116.8	18.0	18.0	15	16	23.10	23.30	1.80	3.00	0.12	<0.06	<0.02	<0.02	0.06	0.08	<0.03	<0.03	9.1	10.1
45	POINSETT	L	1.57	<0.10	38	4.6	24.0	6.0	30.0	61	82	64.0	94.0	17.1	24.6	9	23	2.41	3.43	15.80	18.20	0.13	0.84	<0.02	<0.02	0.06	0.44	<0.03	0.45	void	void
46	BEAR CREEK	L	38.81	146.96	17	6.5	2.6	14.0	10.0	93	108	139.0	182.0	70.2	86.8	76	96	1.90	2.06	3.20	9.90	0.10	1.60	0.03	0.02	0.12	0.46	<0.03	0.37	13.0	11.5
47	UP WHITE OAK	L	27.70	44.80	34	2.6	6.6	3.8	8.6	27	67	26.1	60.2	6.3	16.6	9	27	2.31	2.89	<1.00	14.4	<0.05	0.83	<0.02	<0.02	0.09	0.09	<0.03	<0.03	8.8	12.8
48	ATKINS	L	12.82	9.79	39	2.0	3.0	2.8	3.4	44	49	67.2	36.6	20.1	20.1	22	20	4.40	4.08	3.80	3.80	0.22	0.08	0.03	0.03	0.09	0.08	0.03	<0.03	9.5	8.4
49	OVERCUP	L	14.14	19.22	31	6.6	6.6	6.4	6.2	60	60	89.6	81.2	28.1	24.6	36	28	4.89	4.87	2.60	1.60	0.49	0.08	0.03	0.03	0.09	0.09	<0.03	<0.03	11.9	12.0
50	LO WHITE OAK	L	6.94	7.33	48	1.0	2.6	3.3	14.0	25	33	24.0	42.0	<6.0	8.1	11	16	2.47	2.38	1.80	1.80	0.07	0.41	0.02	0.02	0.07	0.08	<0.03	<0.03	7.6	7.3
51	HARRIS BRAKE	L	2.70	<0.10	37	2.6	3.0	3.0	3.0	31	35	37.2	36.9	17.1	12.9	12	12	3.14	3.14	2.80	2.80	<0.05	<0.05	<0.02	0.03	0.04	<0.03	<0.03	<0.03	6.6	6.3
52	CANE CREEK	L	<0.01	2.90	48	2.6	11.6	3.8	12.0	64	94	na	na	26.1	43.8	19	69	3.34	3.87	9.40	14.20	0.08	1.34	<0.02	<0.02	0.06	0.22	<0.03	0.14	8.2	12.2

No.	Lake Name	STN	Fecal coliform					Gm	Cd		Cr		Cu		Pb		Zn	
			ls	l¼	c	r¼	rs	mean	E	H	E	H	E	H	E	H	E	H
37	JUNE	L	163	850	46	33	104	72.9	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
38	BAILEY	L	5	7	2	10	0	5.1	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
39	TRICOUNTY	L	8	5	0	7	10	7.3	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
40	COX CREEK	L	8	15	10	8	8	9.5	<0.5	<0.5	<1	<1	<4	<4	<2	<2	12.0	<8
41	HURRICANE	L	2	0	3	0	0	2.4	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
42	FRIERSON	L	68	11	400	34	20	45.9	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
43	STORM CREEK	L	850	0	0	2	0	41.2	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
44	CALION	L	7	8	7	7	10	7.7	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	21.0
45	POINSETT	L	240	52	230	44	58	94.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	10.0
46	BEAR CREEK	L	0	0	0	0	0	0.0	<0.5	<0.5	<1	<1	<4	<4	5.9	3.0	<8	<8
47	UP WHITE OAK	L	90	60	32	100	25	53.3	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
48	ATKINS	L	2	0	0	5	0	3.2	----	----	--	--	--	--	--	--	--	--
49	OVERCUP	L	18	0	2	2	17	5.9	<0.5	<0.5	<1	<1	<4	<4	<2	<2	9.0	9.0
50	LO WHITE OAK	L	2	5	8	5	8	5.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
51	HARRIS BRAKE	L	5	5	3	2	16	4.7	<0.5	<0.5	1.1	<1	<4	<4	<2	<2	<8	<8
52	CANE CREEK	L	260	920	31	<6400	168	187.9	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	9.0

TABLE A-4. Water Quality Data from Type D Lakes

No.	Lake Name	STN	Chlor *		Schi	TSS		Turb		TDS		Cond		T-Hard		Alk		Cl		SO_4		NH_3-N		NO_3-N		TL-P		O-PO_4		TOC	
			com	thcl	in	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H	E	H
53	WILSON	L	3.20	2.13	30	8.0	8.5	4.2	4.8	81	58	77.7	82.8	18.9	22.2	29	30	5.22	5.36	<1.00	<1.00	0.09	0.30	0.02	<0.02	0.13	0.14	<0.03	<0.03	10.2	9.4
54	ENTERPRISE	L	43.80	60.10	42	2.0	4.0	2.0	2.8	41	38	47.5	48.6	17.4	10.5	16	16	4.26	4.27	<1.00	<1.00	<0.05	<0.05	<0.02	<0.02	0.11	0.10	<0.03	<0.03	10.2	9.9
55	1ST OLD RIVER	L	13.35	14.69	18	17.5	16.0	12.0	12.0	113	118	176.8	179.7	78.6	72.3	na	na	3.66	3.37	<1.00	<1.00	<0.05	<0.05	<0.02	<0.02	0.15	0.16	<0.03	<0.03	void	void
56	PICKTHORNE	L	2.20	<0.10	21	9.5	16.5	10.0	15.0	61	59	65.4	67.6	17.1	17.1	23	24	4.70	4.57	1.50	1.50	<0.05	0.07	0.03	0.03	0.04	0.04	<0.03	<0.03	10.3	10.2
57	HOGUE	L	14.68	31.07	18	16.5	15.5	10.0	9.7	63	63	74.0	74.0	20.1	17.1	30	28	3.18	3.29	2.60	2.60	0.14	0.13	<0.02	<0.02	0.12	0.06	0.08	<0.03	void	void
58	GREENLEE	L	15.16	7.74	4	4.0	4.5	180.0	180.0	612	615	63.0	63.0	36.3	33.3	63	63	4.87	5.12	13.60	14.30	0.41	0.46	0.31	0.31	1.14	1.09	0.62	0.67	9.4	10.7
59	MALLARD	L	45.42	37.38	21	19.5	20.0	18.0	18.0	126	127	177.0	178.0	70.2	76.5	76	76	5.81	6.66	4.80	3.80	0.39	0.43	<0.02	<0.02	0.20	0.20	0.06	0.04	void	void
60	GRAMPUS	L	0.53	9.34	41	6.0	8.0	2.2	8.3	34	36	31.0	39.9	8.7	10.5	38	19	1.70	1.88	<1.00	<1.00	<0.05	<0.05	<0.02	<0.02	0.10	0.17	<0.03	0.04	9.9	9.9
61	DESARC	L	36.12	42.41	24	6.5	8.5	7.4	7.5	40	41	56.0	55.0	15.9	12.0	56	55	2.38	2.68	3.20	3.20	0.21	0.11	0.03	0.02	0.13	0.10	0.04	0.04	7.8	8.8
62	WALLACE	L	4.81	7.48	29	9.5	9.0	5.9	5.4	79	63	63.9	62.8	26.7	18.9	27	29	3.20	3.03	<1.00	<1.00	0.07	<0.05	<0.02	<0.02	0.17	0.16	0.04	0.04	9.8	9.8
63	PINE BLUFF	L	26.00	20.00	25	11.5	11.5	8.5	8.8	84	83	na	na	39.6	39.6	48	48	3.68	4.12	6.20	6.20	0.10	0.18	<0.02	<0.02	0.14	0.14	0.05	0.05	8.4	7.9
64	ASHBAUGH	L	10.32	13.57	34	8.0	8.0	4.8	4.8	87	94	161.0	278.0	57.3	69.0	72	74	3.32	3.26	6.90	4.80	0.19	0.16	<0.02	<0.02	0.08	0.06	0.04	<0.03	void	void
65	BOIS D'ARC	L	na	na	na	12.5	8.5	10.0	9.7	87	86	na	na	21.3	25.8	na	na	8.78	8.50	1.80	1.80	0.05	<0.05	<0.02	<0.02	0.16	0.17	<0.03	<0.03	9.9	8.8
66	OLD TOWN	L	110.36	99.68	19	17.0	17.5	14.0	15.0	89	88	130.0	132.0	42.0	49.8	68	64	3.17	3.18	3.20	3.20	0.16	0.15	0.04	0.03	0.21	0.25	0.06	0.06	9.9	9.8

No.	Lake Name	STN	Fecal coliform					Gm	Cd		Cr		Cu		Pb		Zn	
			ls	l¼	c	r¼	rs	mean	E	H	E	H	E	H	E	H	E	H
53	WILSON	L	315	62	240	44	56	102.9	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
54	ENTERPRISE	L	13	18	13	15	33	17.2	<0.5	<0.5	<1	<1	<4	<4	<2	<2	12.0	10.0
55	1ST OLD RIVER	L	12	3	3	13	7	6.3	<0.5	<0.5	<1	1.0	<4	<4	<2	<2	<8	<8
56	PICKTHORNE	L	4	4	2	0	4	3.4	<0.5	<0.5	<1	<1	<4	<4	<2	<2	9.0	12.0
57	HOGUE	L	10	10	2	3	6	5.1	<0.5	<0.5	<1	<1	<4	4.3	<2	<2	<8	<8
58	GREENLEE	L	0	9	0	0	9	9.0	<0.5	<0.5	<1	1.0	<4	<4	<2	3.0	<8	<8
59	MALLARD	L	1800	270	96	470	90	287.8	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	10.0
60	GRAMPUS	L	50	27	32	23	25	30.1	<0.5	<0.5	<1	<1	<4	<4	<2	<2	9.0	<8
61	DESARC	L	0	0	2	3	5	3.1	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	8.0
62	WALLACE	L	7	22	22	15	387	28.8	<0.5	<0.5	<1	<1	<4	<4	<2	<2	9.0	9.0
63	PINE BLUFF	L	567	1560	180	1760	<6400	727.6	<0.5	void	<1	<1	<4	<4	<2	void	<8	<8
64	ASHBAUGH	L	33	64	32	7	380	44.8	<0.5	<0.5	<1	<1	<4	<4	<2	<2	13.0	8.0
65	BOIS D'ARC	L	210	7	7	3	0	13.3	----	----	--	--	--	--	--	--	--	--
66	OLD TOWN	L	3	7	10	12	7	7.1	<0.5	<0.5	<1	<1	<4	<4	<2	<2	14.0	<8

TABLE A-5. Water Quality Data from Type E Lakes

No.	Lake Name	STN	Chlor * com	Chlor * thcl	Schi in	TSS E	TSS H	Turb E	Turb H	TDS E	TDS H	Cond E	Cond H	T-Hard E	T-Hard H
67	HORSESHOE	L	170.00	325.29	18	8.5	14.5	20.0	15.0	96	87	134.0	136.0	65.7	65.7
68	UPPER CHICOT	L	13.70	3.33	20	23.5	22.5	9.5	9.2	183	135	238.0	238.0	93.9	96.0
69	GRAND	L	40.00	<0.10	20	18.0	20.5	8.0	7.7	131	124	188.8	198.8	88.8	93.9
70	GA. PACIFIC	L	0.63	1.34	40	<1.0	1.5	4.3	5.2	69	69	84.9	85.0	14.7	11.4
71	BLUE MT.	L	3.20	na	17	11.5	12.5	1.0	18.0	47	47	na	na	<5.0	<5.0
72	COLUMBIA	U	1.34	2.67	44	2.0	2.5	2.9	2.9	57	56	76.8	77.1	14.7	13.2
72	COLUMBIA	L	14.38	2.97	72	<1.0	2.5	1.8	6.3	59	89	77.9	116.1	13.2	30.3
73	NIMROD	L	7.20	1.14	37	4.5	11.0	5.2	12.0	34	38	43.0	47.0	8.9	9.9
74	LOWER CHICOT	L	0.89	34.10	18	18.5	19.0	7.6	7.6	148	146	262.0	263.0	89.7	102.0
75	CONWAY	U	0.89	<0.10	18	10.0	9.5	9.4	9.6	61	62	81.2	84.4	24.3	26.1
75	CONWAY	L	26.70	<0.10	15	7.0	7.0	6.7	6.8	59	58	75.4	75.3	21.0	22.8
76	ERLING	U	7.48	10.40	34	2.0	2.0	3.6	4.0	66	67	76.2	77.4	18.0	14.7
76	ERLING	L	9.61	2.29	42	<1.0	6.5	2.2	8.7	63	114	77.2	124.9	16.5	33.3
77	OZARK	U													
78	FELSENTHAL	U	2.67	0.69	16	20.5	31.0	20.0	23.0	74	73	75.8	75.5	16.5	18.0
78	FELSENTHAL	L	3.10	0.38	22	26.5	36.0	22.0	26.0	77	77	80.1	80.2	18.0	18.0
79	MILLWOOD	U													
79	MILLWOOD	L													
80	DARDANELLE	L													

No.	Lake Name	STN	Alk E	Alk H	Cl E	Cl H	SO_4 E	SO_4 H	NH_3-N E	NH_3-N H	NO_3-N E	NO_3-N H	TL-P E	TL-P H	O-PO_4 E	O-PO_4 H	TOC E	TOC H
67	HORSESHOE	L	67	70	1.31	1.53	4.10	4.10	0.10	0.10	0.02	0.02	0.15	0.13	0.05	<0.03	11.6	8.5
68	UPPER CHICOT	L	96	128	13.40	13.90	5.90	5.90	0.07	0.06	<0.02	<0.02	0.20	0.19	0.05	0.05	9.4	8.9
69	GRAND	L	98	100	3.03	2.64	<1.00	<1.00	<0.05	<0.05	<0.02	<0.02	0.19	0.19	0.06	0.07	9.5	9.2
70	GA. PACIFIC	L	14	14	3.82	3.98	16.90	16.90	<0.05	<0.05	<0.02	<0.02	0.07	0.07	<0.03	<0.03	8.8	11.6
71	BLUE MT.	L	na	na	3.31	3.07	8.20	7.30	<0.05	<0.05	<0.02	0.03	0.08	0.08	<0.03	<0.03	6.0	4.8
72	COLUMBIA	U	12	12	11.80	11.90	3.00	1.80	<0.05	<0.05	<0.02	<0.03	0.08	0.07	<0.03	<0.03	10.2	9.7
72	COLUMBIA	L	13	38	11.80	14.30	1.80	1.80	<0.05	0.35	0.02	0.02	0.06	0.07	<0.03	<0.03	10.2	13.5
73	NIMROD	L	18	9	2.74	2.38	3.20	4.10	0.12	0.28	0.05	0.02	0.05	0.08	<0.03	<0.03	6.8	6.8
74	LOWER CHICOT	L	109	109	10.90	13.2	10.80	4.70	0.11	0.19	0.04	0.05	0.19	0.17	0.03	0.04	9.0	9.1
75	CONWAY	U	31	32	5.09	4.94	2.80	2.80	<0.05	0.08	0.03	0.03	0.08	0.08	<0.03	<0.03	7.4	8.0
75	CONWAY	L	29	29	5.21	4.84	2.80	1.50	0.05	0.06	0.03	0.05	0.08	0.09	<0.03	<0.03	8.2	7.7
76	ERLING	U	na	na	10.20	10.20	1.80	1.80	<0.05	0.05	0.02	<0.02	0.11	0.10	<0.03	<0.03	12.1	12.1
76	ERLING	L	na	na	10.30	11.80	1.80	15.20	<0.05	1.31	<0.02	<0.02	0.08	0.30	<0.03	0.21	12.2	17.3
77	OZARK	U																
78	FELSENTHAL	U	14	15	7.02	6.77	7.20	7.20	0.10	0.07	0.15	0.14	0.09	0.07	0.04	0.06	10.6	11.2
78	FELSENTHAL	L	18	15	7.49	7.72	8.10	7.20	0.07	0.07	0.15	0.18	0.09	0.09	0.05	0.05	10.0	10.0
79	MILLWOOD	U																
79	MILLWOOD	L																
80	DARDANELLE	L																

No.	Lake Name	STN	Fecal coliform ls	Fecal coliform l¼	Fecal coliform c	Fecal coliform r¼	Fecal coliform rs	Gm mean	Cd E	Cd H	Cr E	Cr H	Cu E	Cu H	Pb E	Pb H	Zn E	Zn H
67	HORSESHOE	L	2	0	0	10	10	5.8	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
68	UPPER CHICOT	L	148	15	18	82	100	50.5	<0.5	<0.5	<1	<1	<4	5.0	<2	<2	11.0	9.0
69	GRAND	L	5600	13	18	80	3800	209.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	17.0
70	GA. PACIFIC	L	8	3	0	0	5	4.1	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
71	BLUE MT.	L							----	----	--	--	--	--	--	--	--	--
72	COLUMBIA	U	2	0	2	10	2	3.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
72	COLUMBIA	L	3	2	3	7	7	3.9	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
73	NIMROD	L	-	-	<4	-	-	---	----	----	--	--	--	--	--	--	--	--
74	LOWER CHICOT	L	198	157	220	76	120	144.2	<0.5	<0.5	<1	<1	<4	<4	<2	<2	20.0	14.0
75	CONWAY	U	0	4	3	12	7	5.6	<0.5	<0.5	<1	<1	<4	<4	<2	<2	13.0	13.0
75	CONWAY	L	21	31	24	32	27	27.0	<0.5	<0.5	1.5	1.5	<4	<4	<2	<2	9.0	14.0
76	ERLING	U	225	530	240	980	2380	582.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
76	ERLING	L	15	360	110	0	2	33.0	<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
77	OZARK		--	--	--	--	--	---	----	----	--	--	--	--	--	--	--	--
78	FELSENTHAL	U	2000	600	680	210	1380	749.5	0.9	<0.5	<1	<1	19.0	<4	7.5	<2	13.0	<8
78	FELSENTHAL	L	175	816	270	1700	17	256.7	<0.5	<0.5	<1	<1	<4	<4	<2	<2	9.0	8.0
79	MILLWOOD	U							<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
79	MILLWOOD	L							<0.5	<0.5	<1	<1	<4	<4	<2	<2	<8	<8
80	DARDANELLE		--	--	--	--	--	---	----	----	--	--	--	--	--	--	--	--

APPENDIX B

LAKES DATA COMPARED TO WATER QUALITY CRITERIA AND GUIDELINES

Figure B-1 Temperature data by lake types

Maximum standard is 32 degrees Celsius
Samples taken one meter below the surface

Figure B-2 Turbidity data by lake types

Maximum standard is 25 NTU
Samples taken one meter below the surface (epilimnion) and at eighty percent (80%) of the maximum depth (hypolimnion)

Figure B-3 pH data by lake types

Maximum standard is 9.0 standard units
Minimum standard is 6.0 standard units
Samples taken one meter below the surface (epilimnion) and at eighty percent (80%) of the maximum depth (hypolimnion)

Figure B-4 DO data by lake types

Minimum standard is 5 mg/l
Samples taken one meter below the surface

Figure B-5 Bacteria data by lake types

Primary contact recreation: geometric mean of five samples collected with in a 30-day period shall not exceed 200 col/100 ml; 10% of samples shall not exceed 400 col/100 ml.

Secondary contact recreation: geometric mean of five samples collected with in a 30-day period shall not exceed 1000 col/100 ml; 10% of samples shall not exceed 2000 col/100 ml.

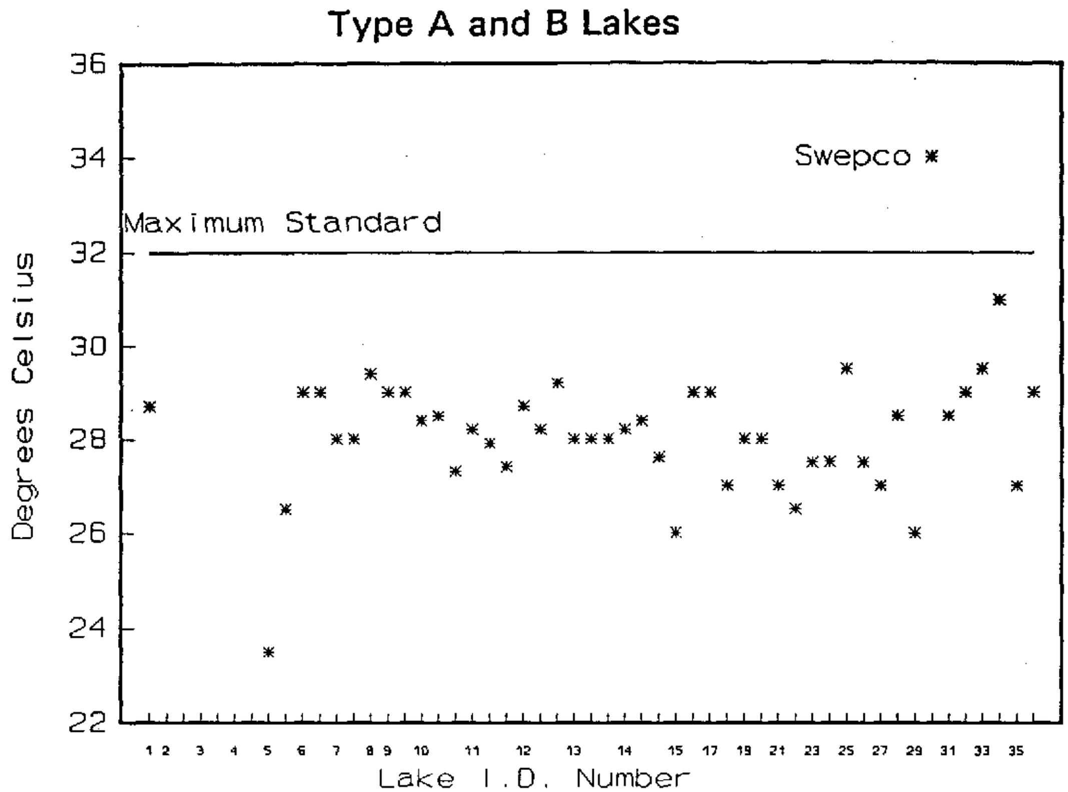
Figures B-6, B-7, B-8, B-9, B-10, B-11

Minerals data - Chlorides, Sulfates, and Total Dissolved Solids

Based on ecoregion standards

Note: Transect identification letters (U,L,M) for those lakes with two or more transects are not depicted on the X axis. Upper lake station data appear first, identified by lake number only, followed by middle and lower lake station transect data with no X axis identifiers.

Figure B-1 - Temperature Data



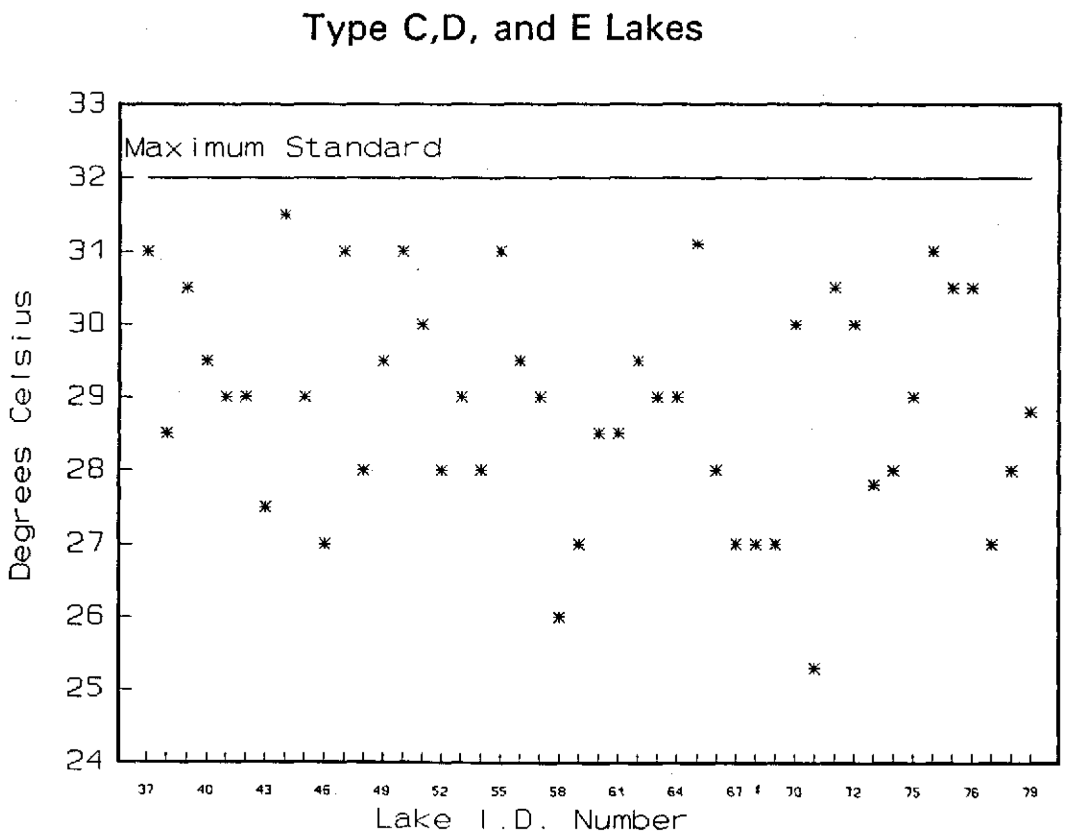
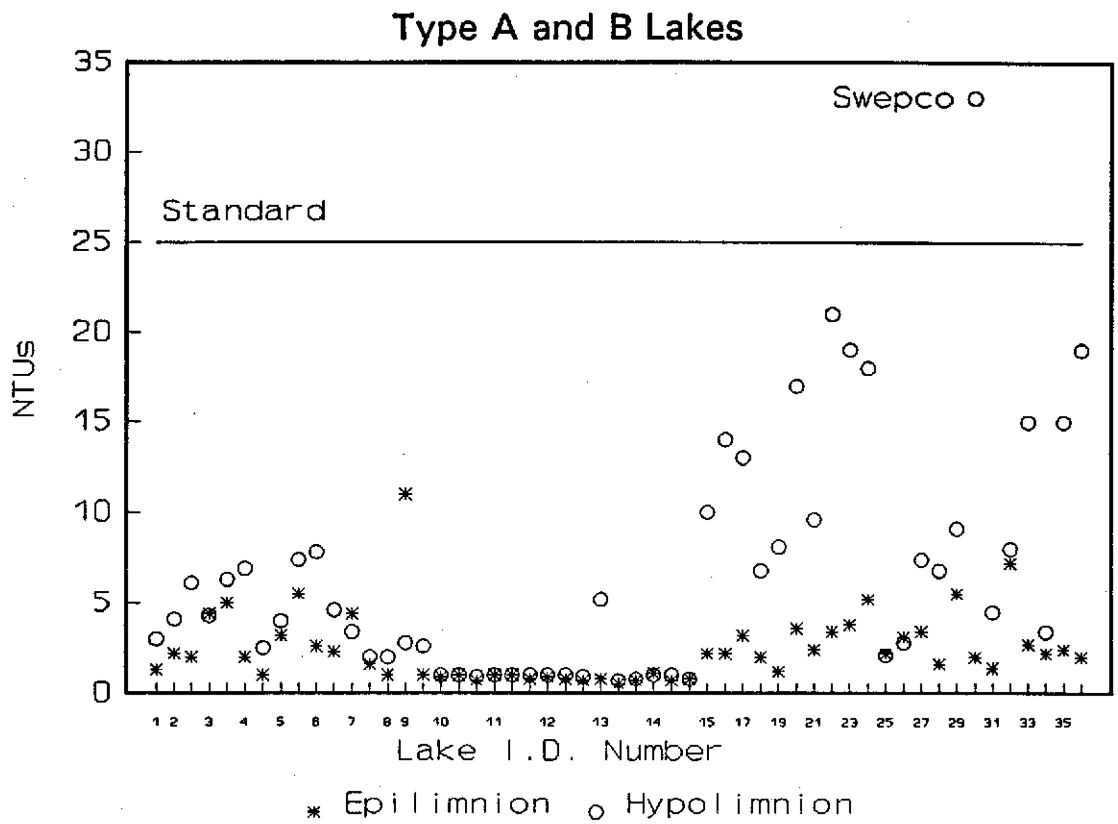


Figure B-2 - Turbidity Data



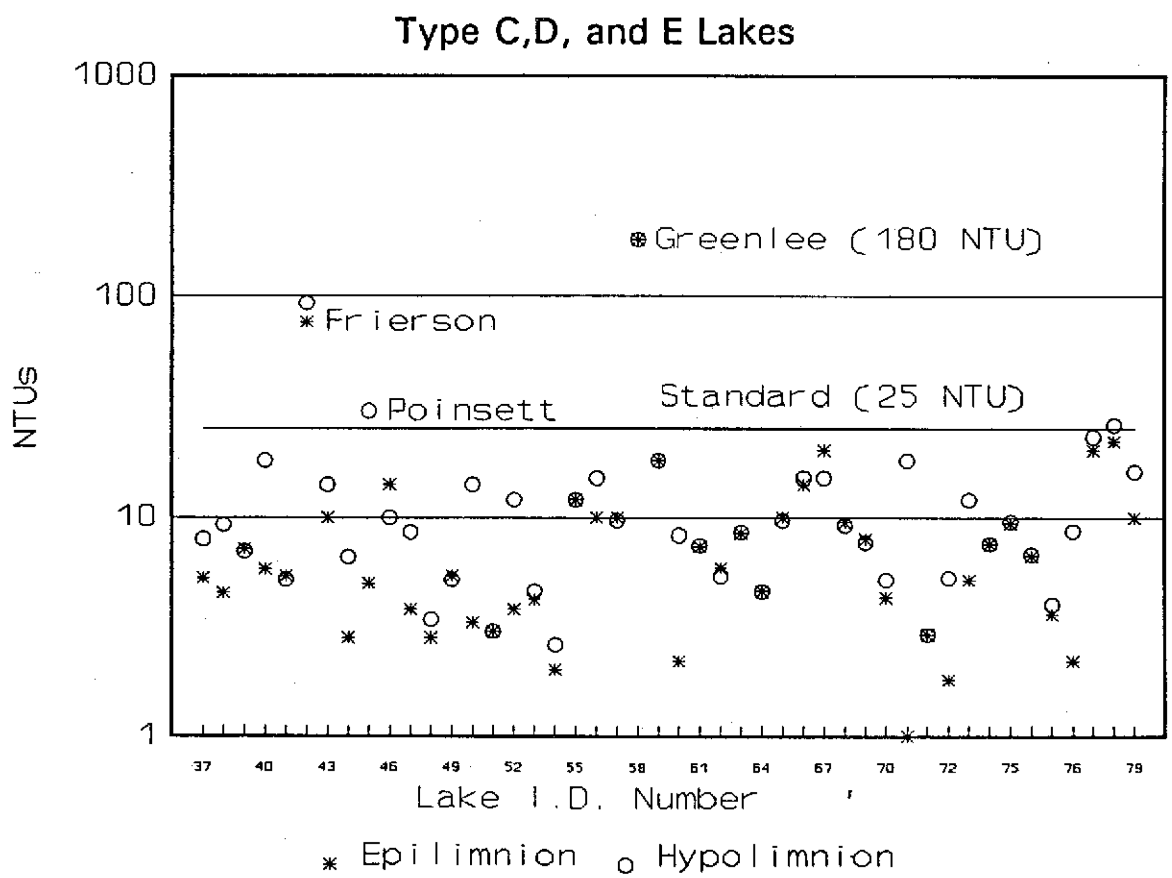
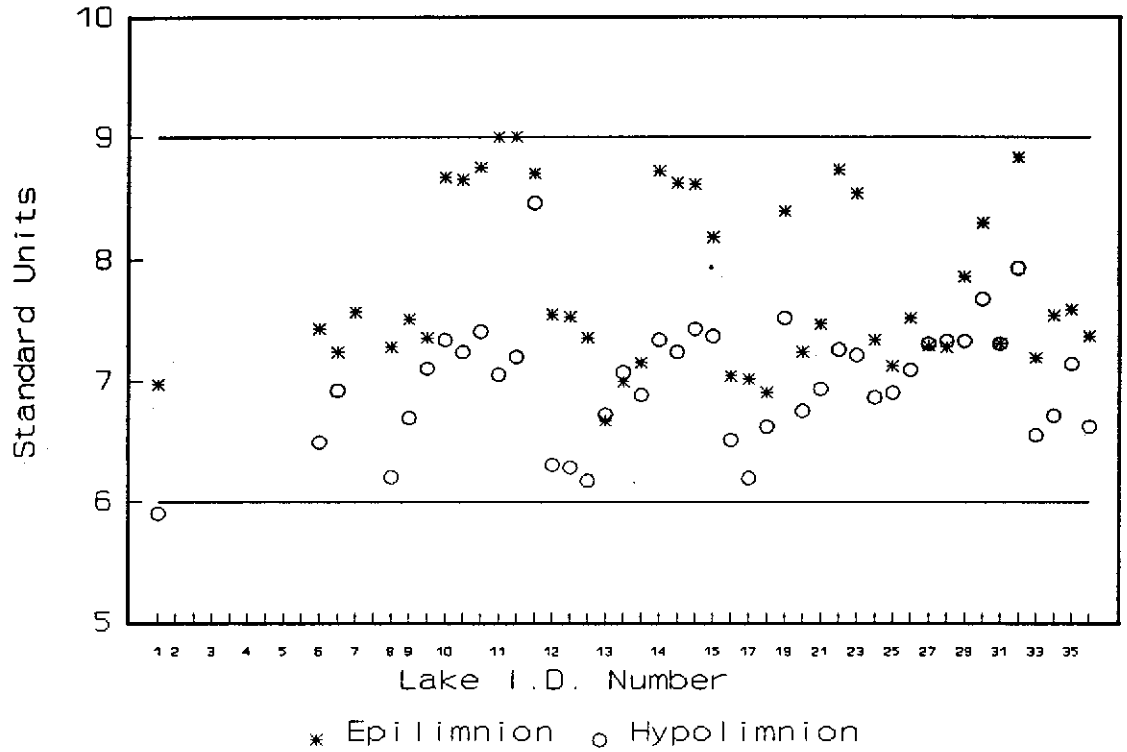


Figure B-3 - pH Data

Type A and B Lakes



Type C,D, and E Lakes

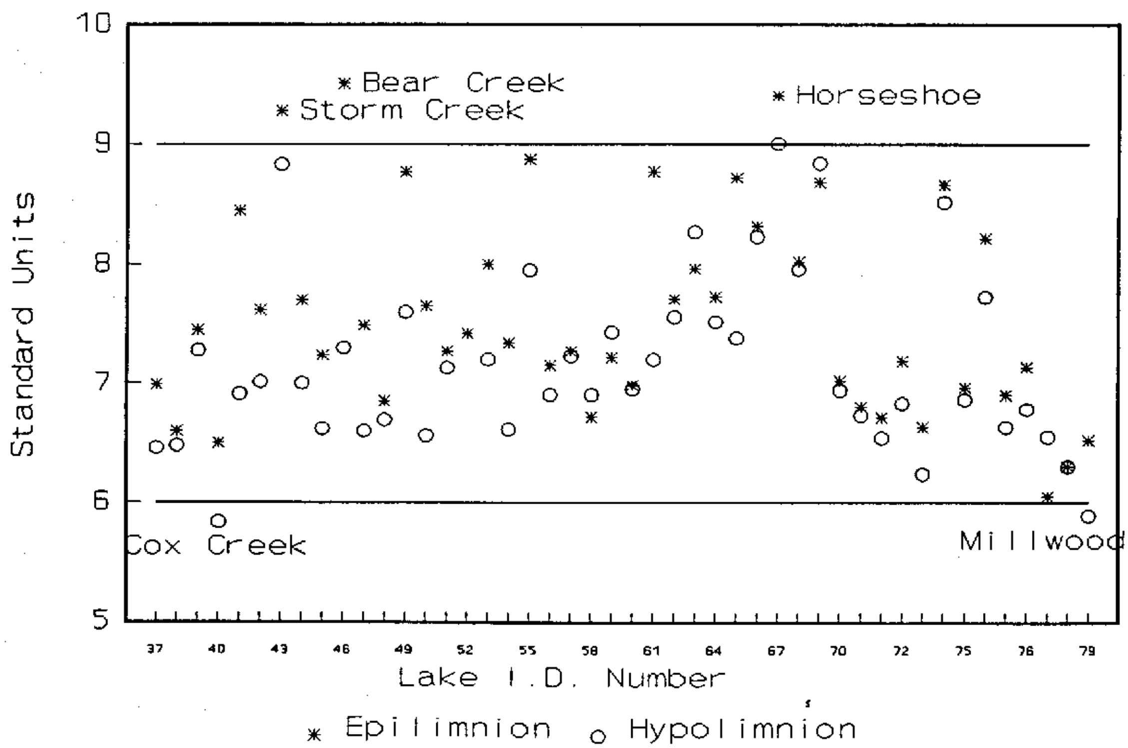
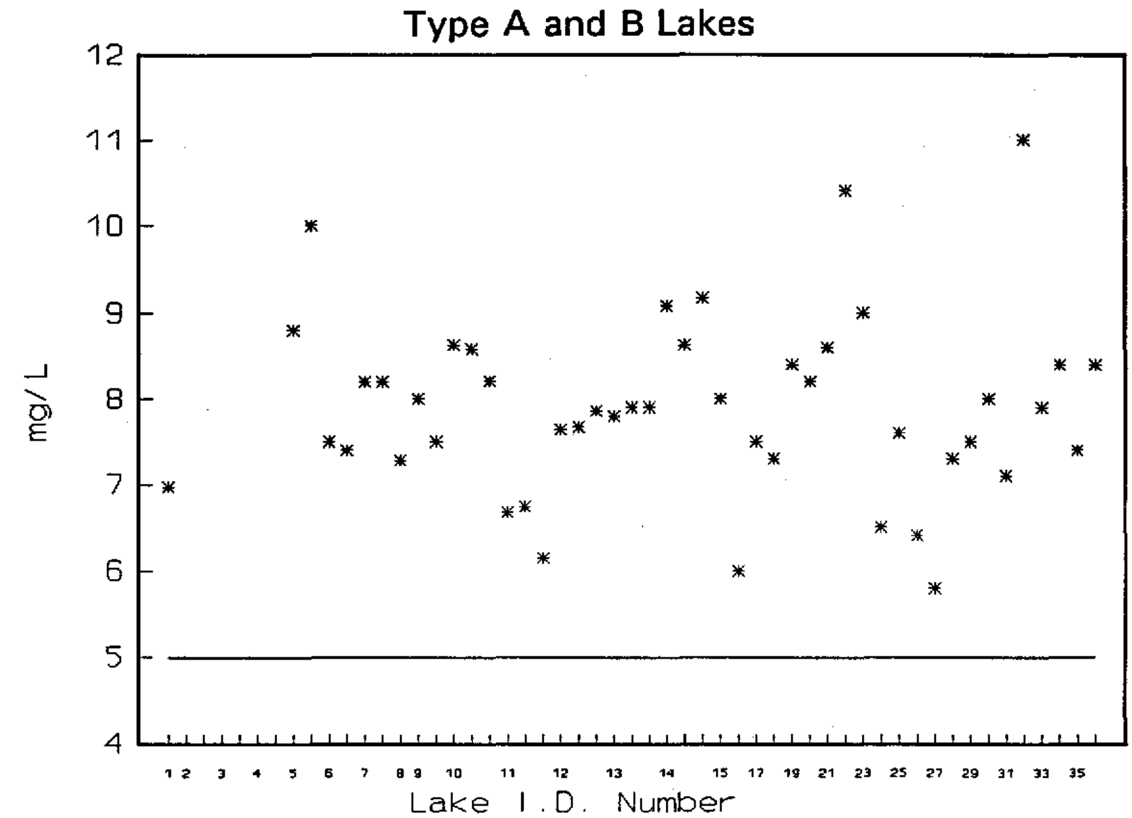


Figure B-4 - Dissolved Oxygen Data



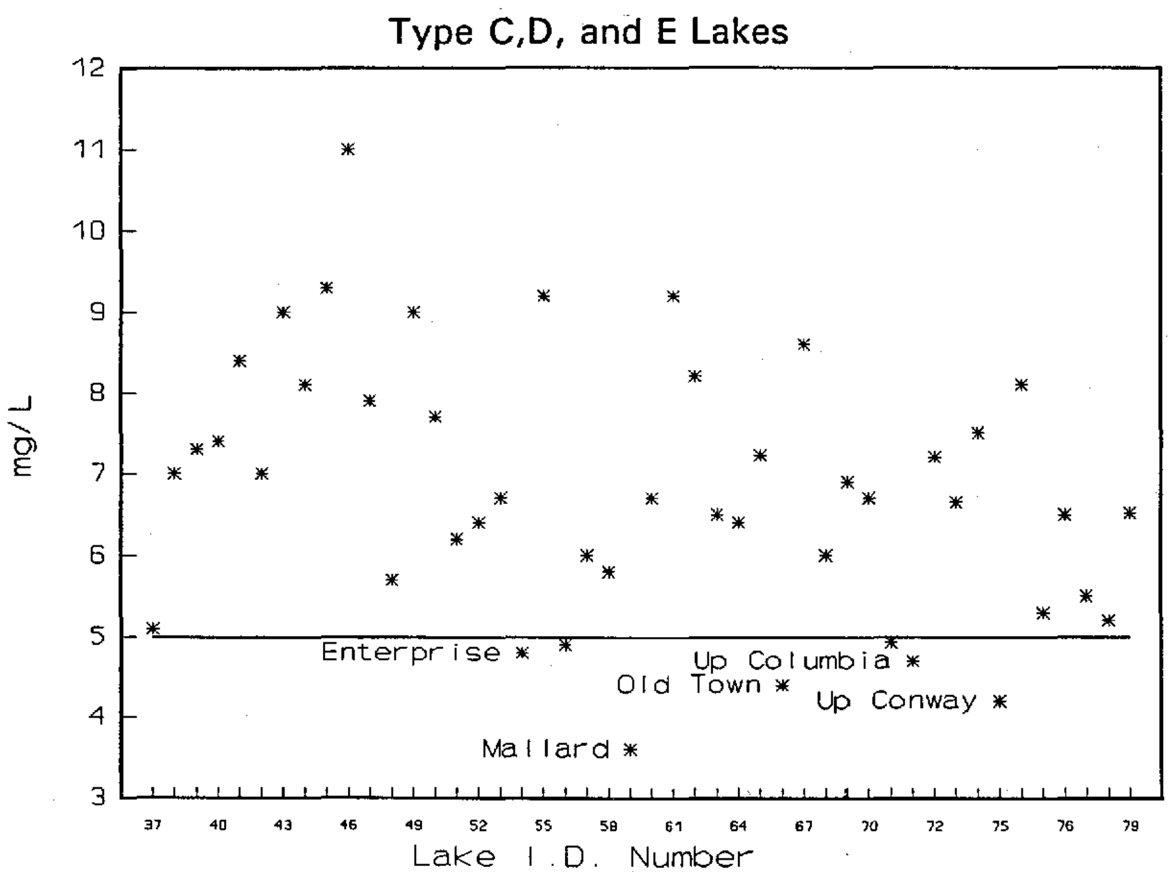
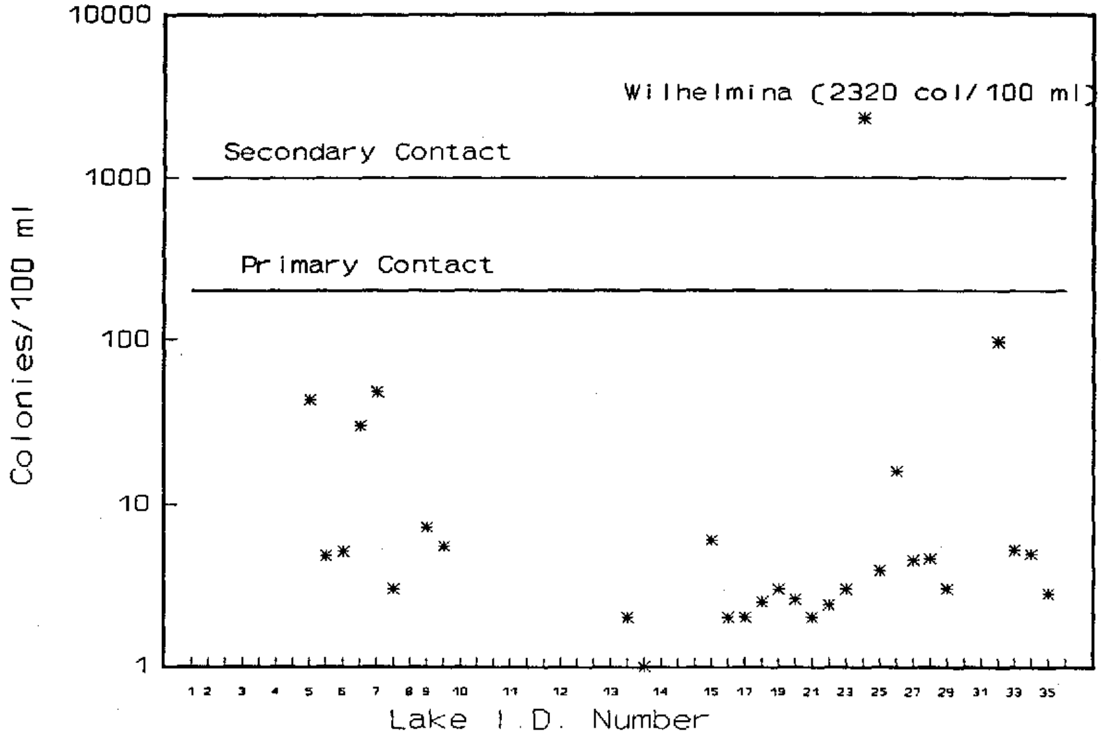


Figure B-5 - Fecal Coliform Data

Type A and B Lakes



Type C,D, and E Lakes

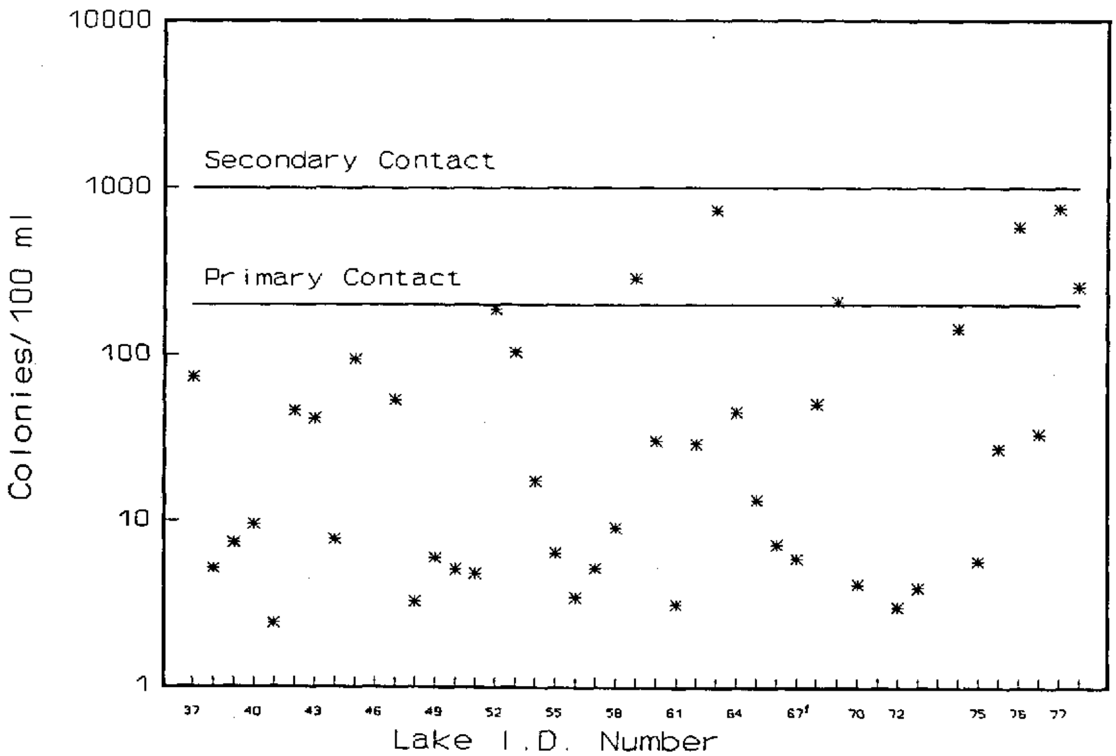
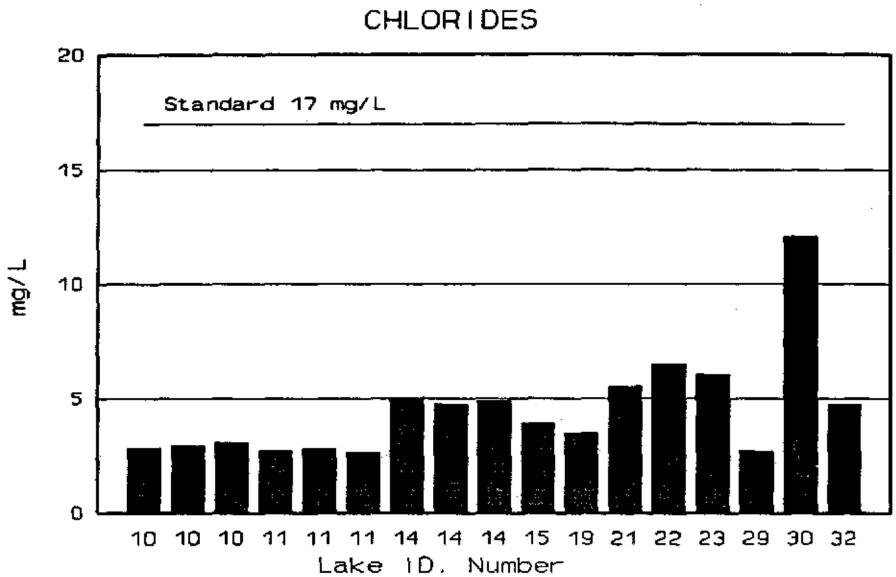
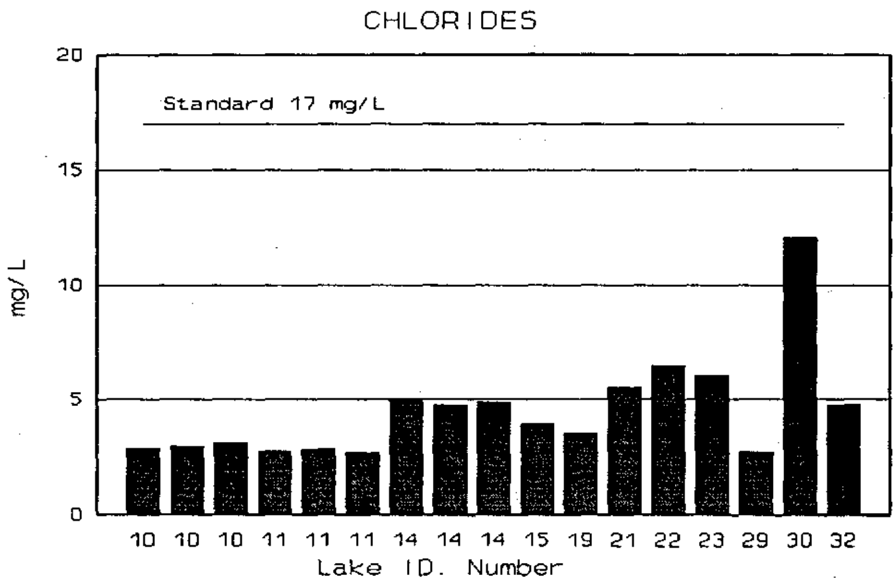


Figure B-6 Ozark Highlands Lakes - Minerals





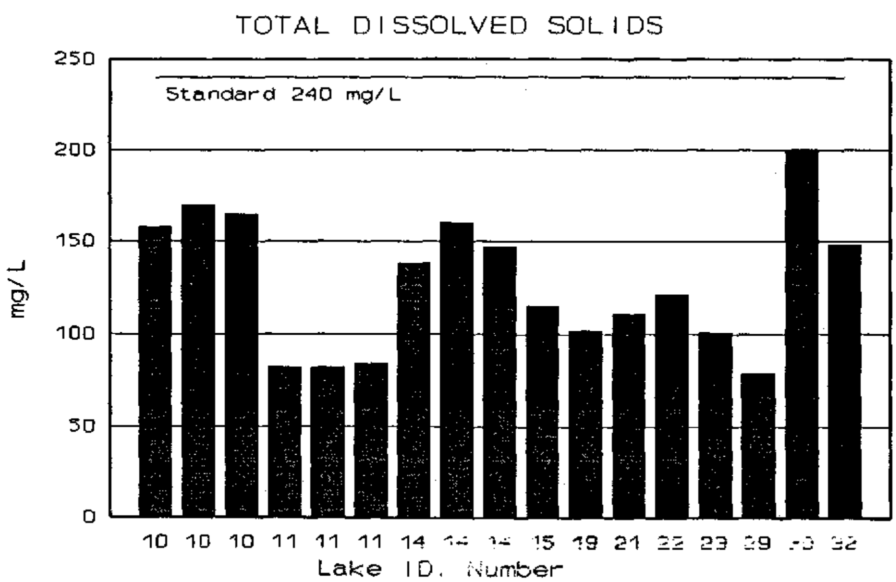
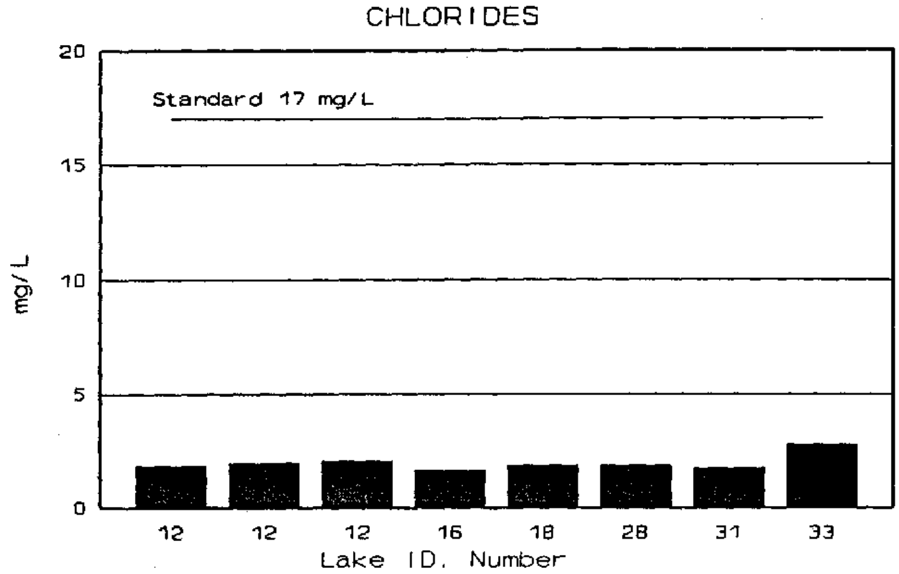
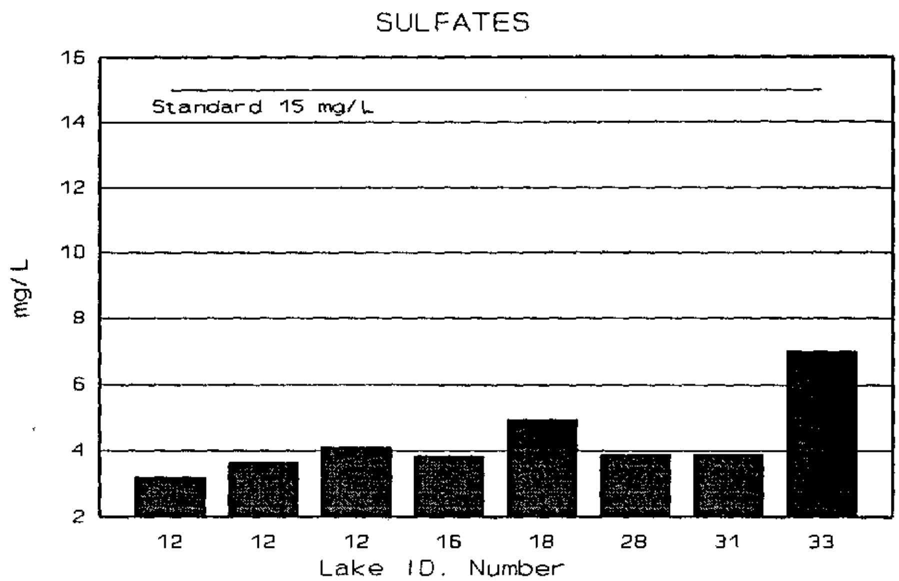


Figure B-7 Boston Mountains Lakes - Minerals





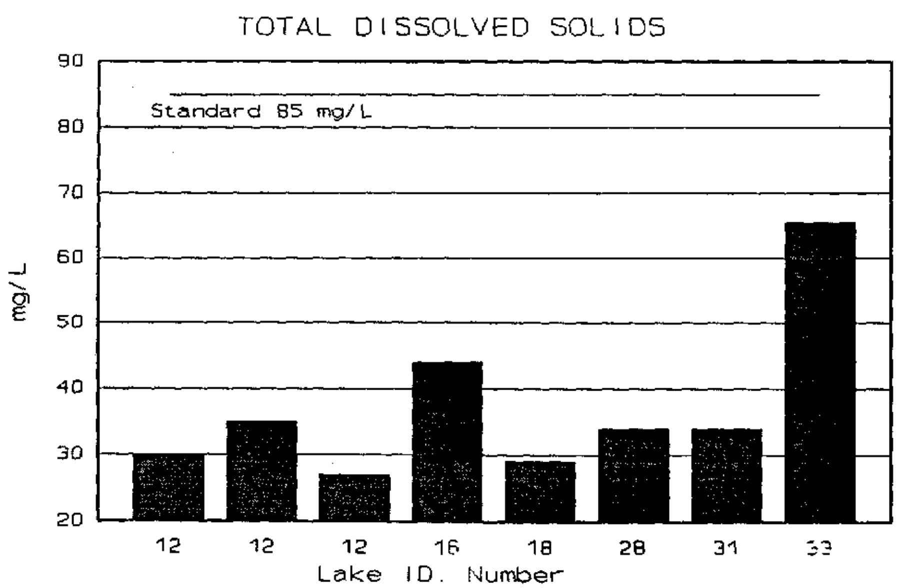


Figure B-8 Arkansas River Valley Lakes - Minerals

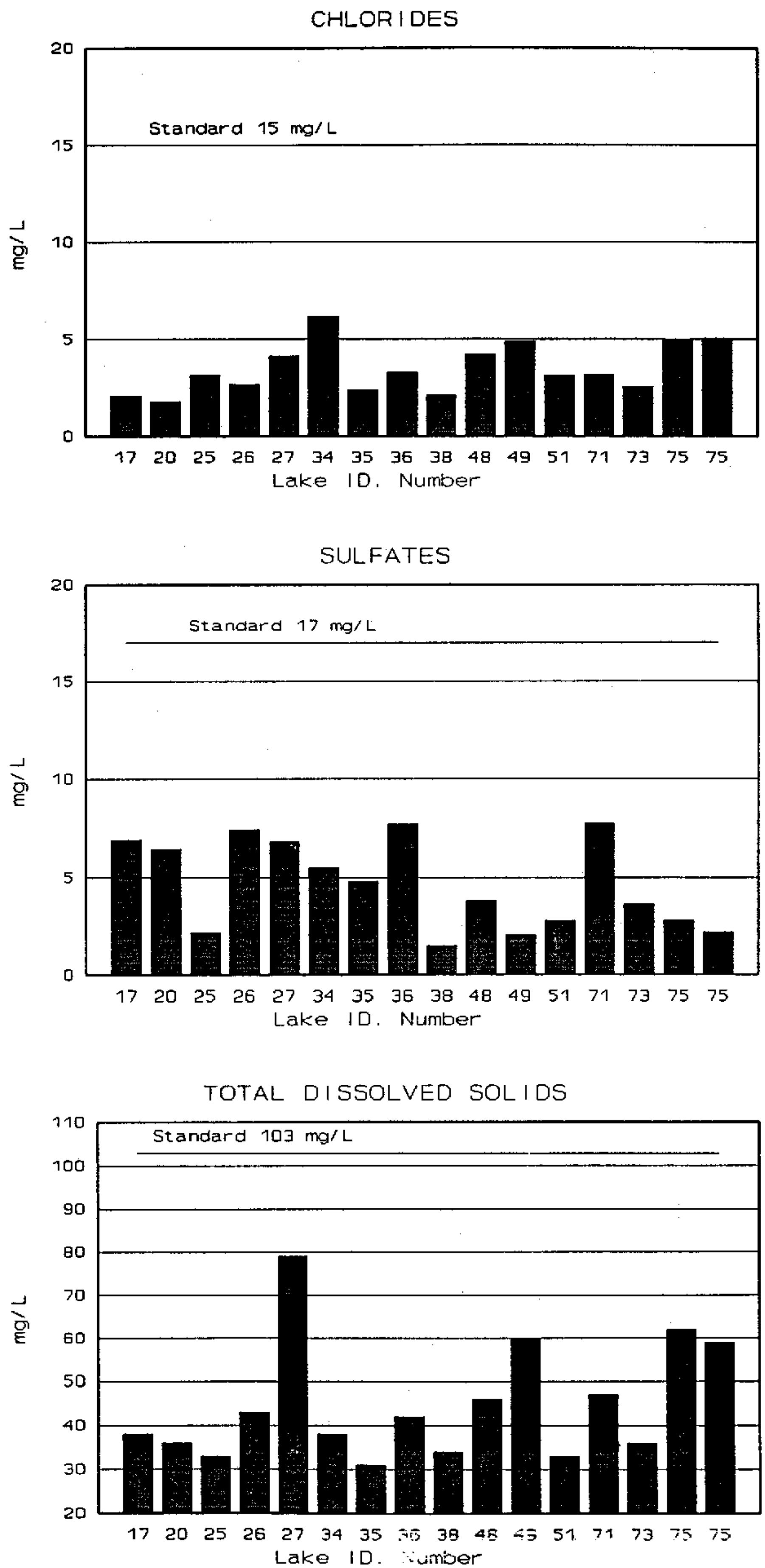
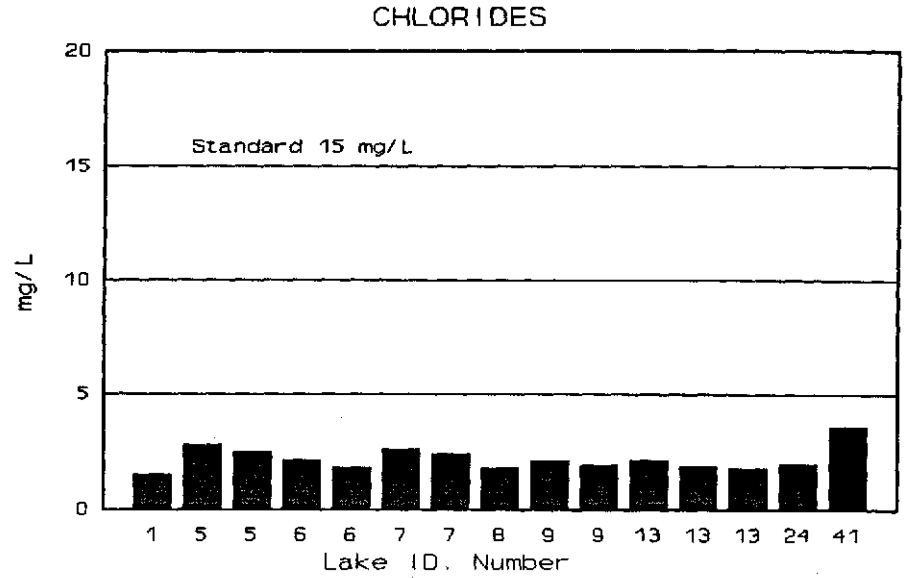
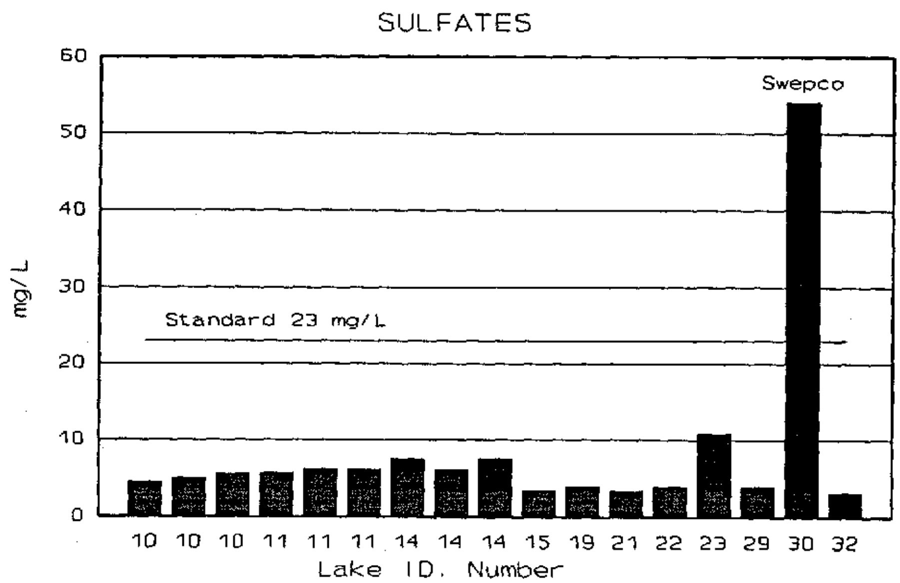


Figure B-9 Ouachita Mountains Lakes - Minerals





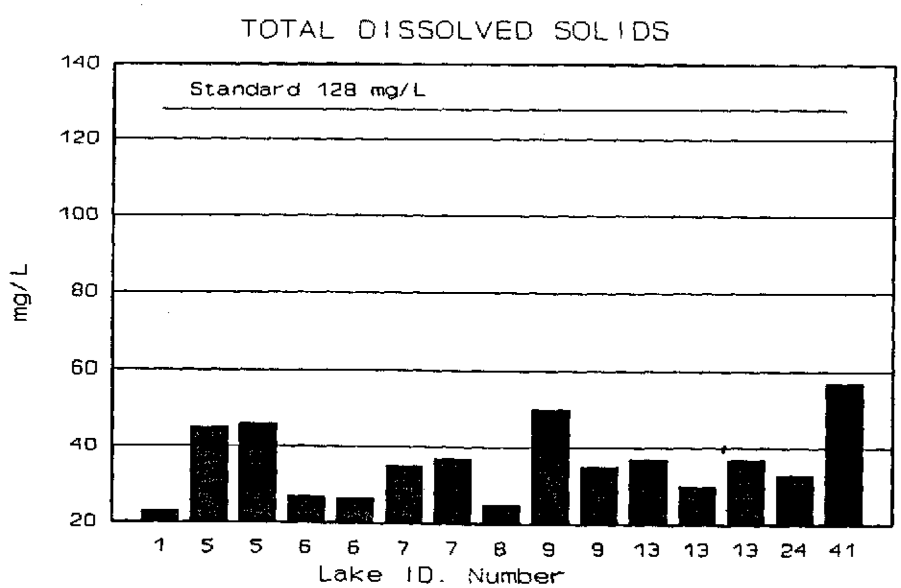


Figure B-10 Gulf Coastal Plains Lakes - Minerals

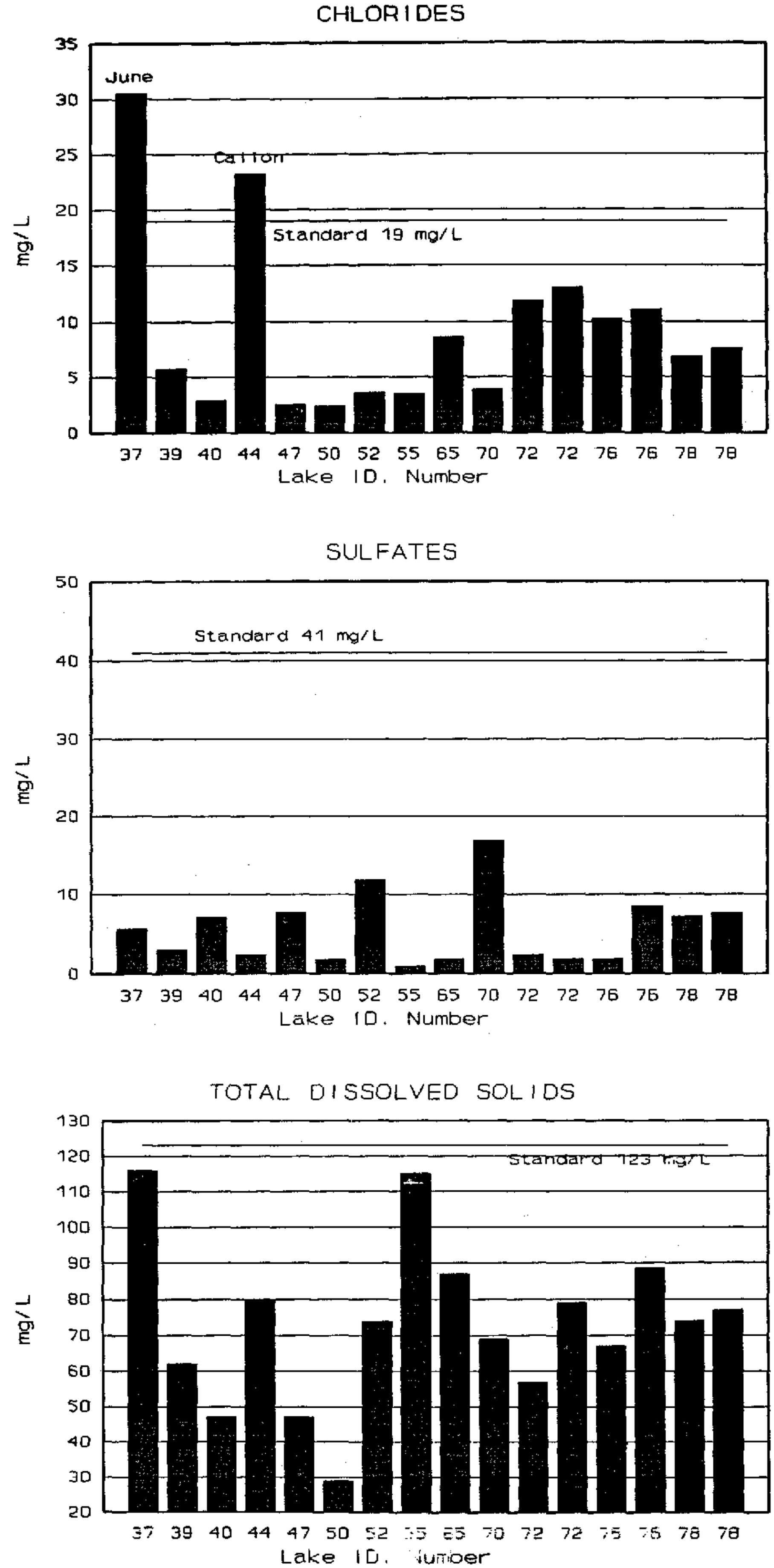
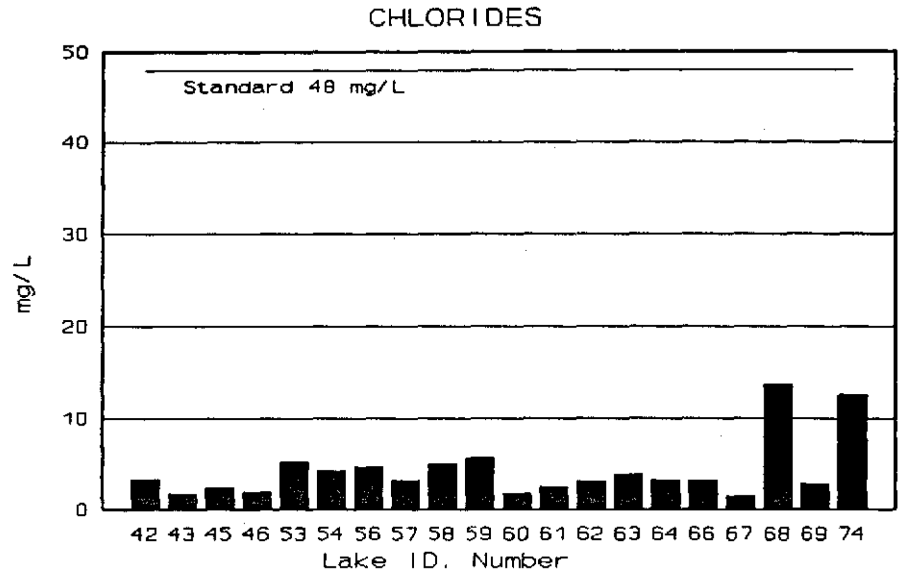
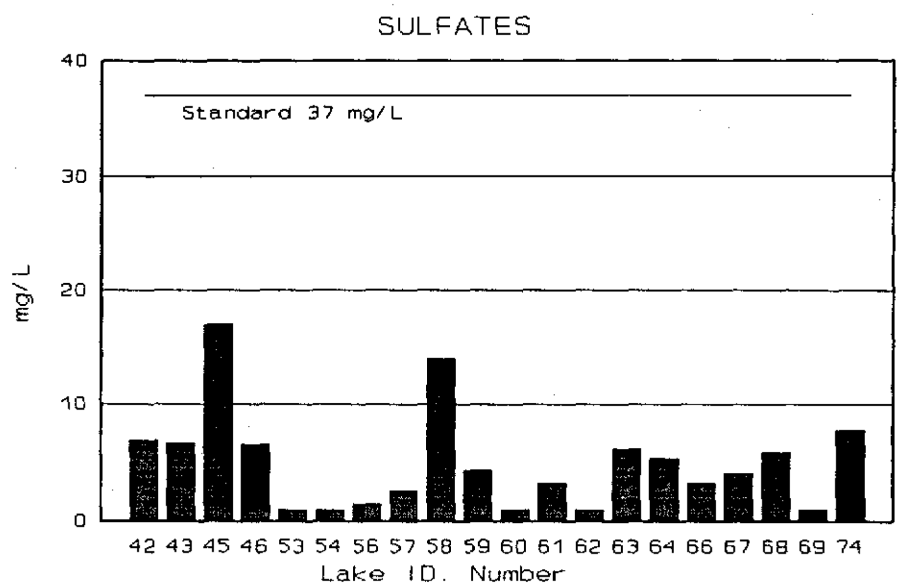
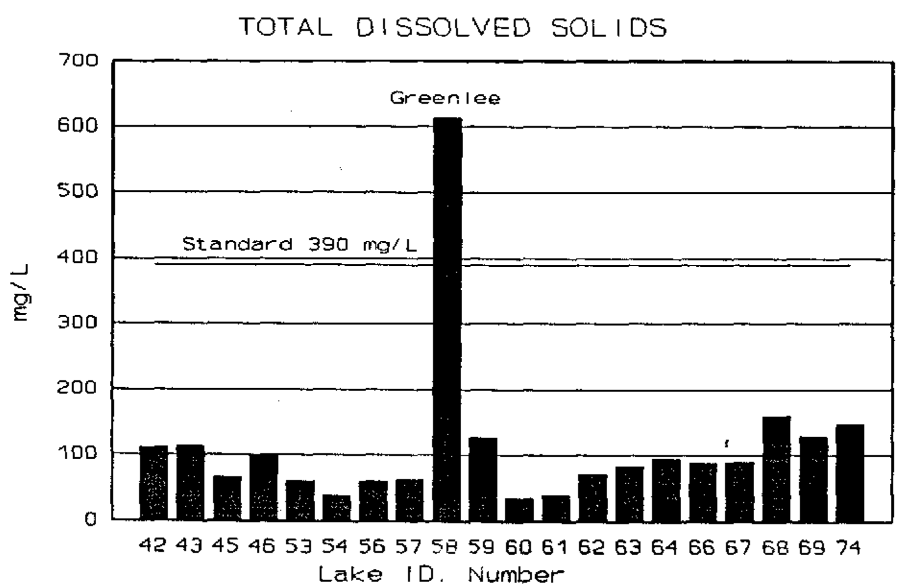


Figure B-11 Delta Lakes - Minerals







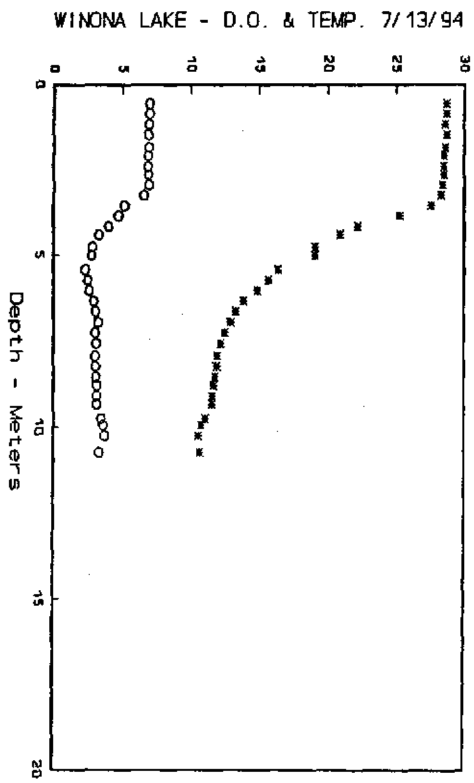
APPENDIX C

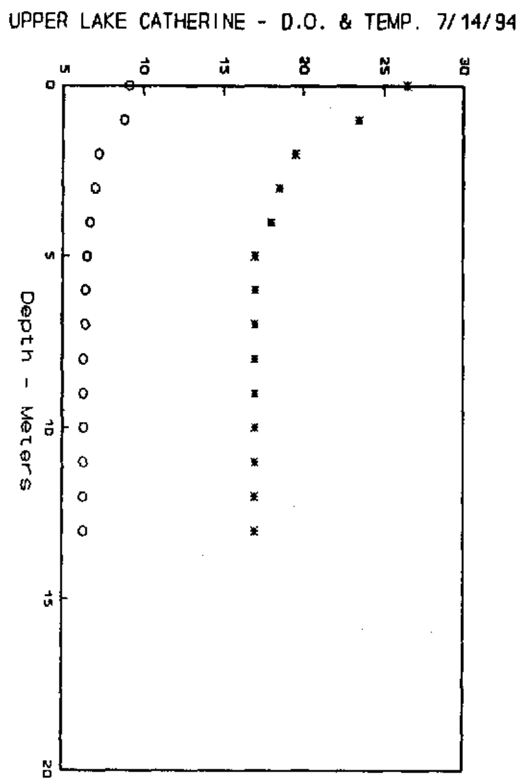
LAKES DISSOLVED OXYGEN and TEMPERATURE PROFILES

This appendix contains a graphic representation of the dissolved oxygen and temperature profile data collected from all lake stations sampled during this survey. The open circles represent the dissolved oxygen data in mg/L and the asterisk represents the temperature in degrees Celsius. Depths are designated in meters. Figures are printed in numeric order by lake identification number and/or station. Due to differences in the maximum depth of the lakes, the depth scale was frequently changed.

o = Dissolved Oxygen in mg/L
* = Temperature in degrees Celsius

Figure C-1


WINONA LAKE - D.O. & TEMP. 7/13/94
Depth - Meters


UPPER LAKE CATHERINE - D.O. & TEMP. 7/14/94
Depth - Meters

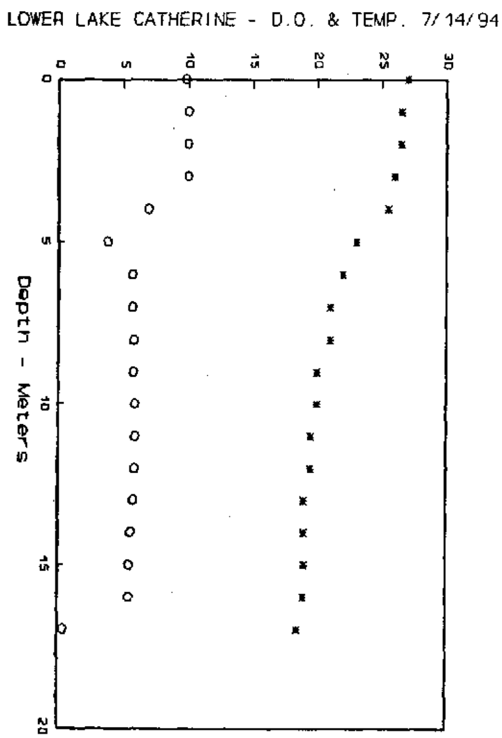

LOWER LAKE CATHERINE - D.O. & TEMP. 7/14/94
Depth - Meters

Figure C-2

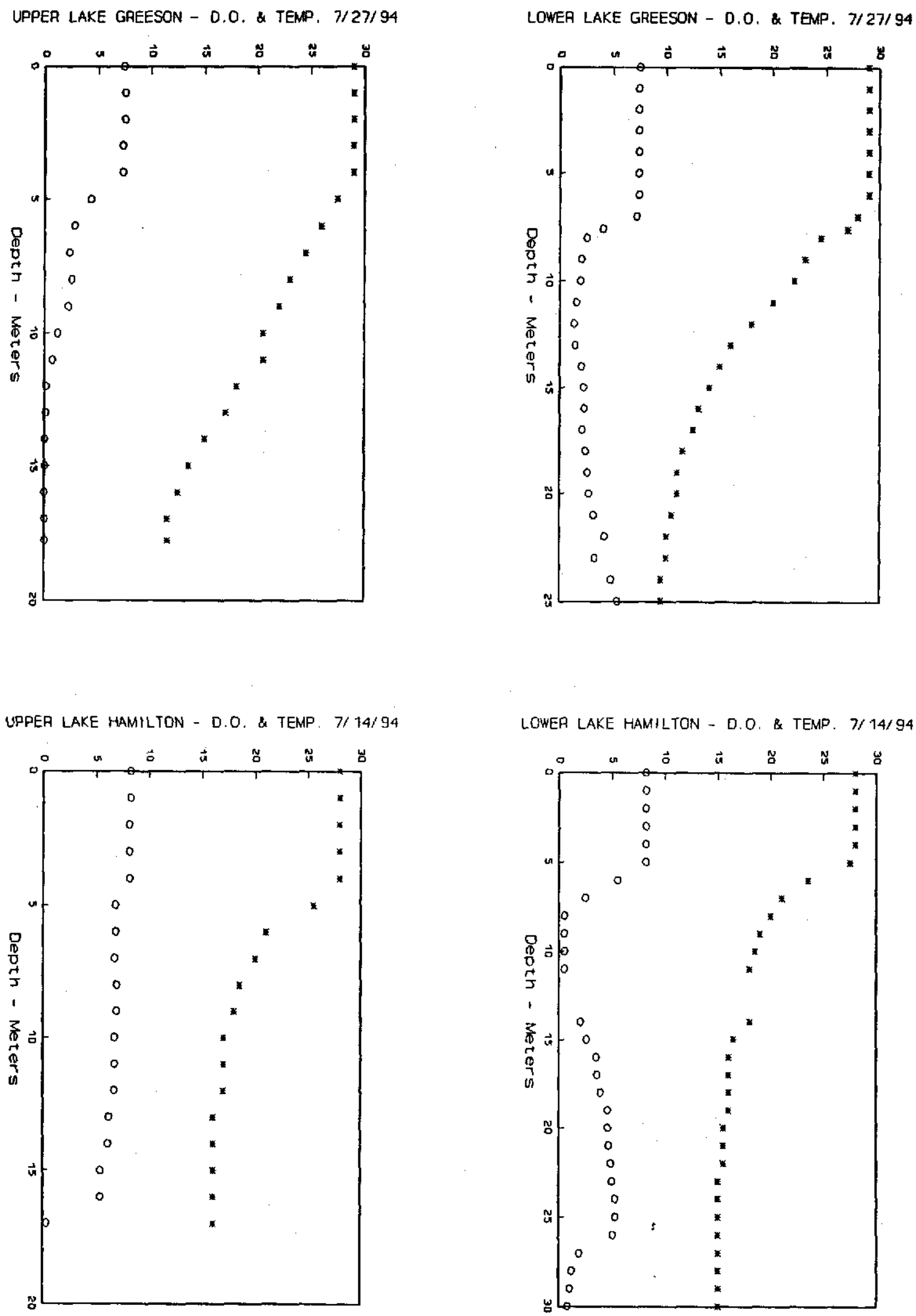
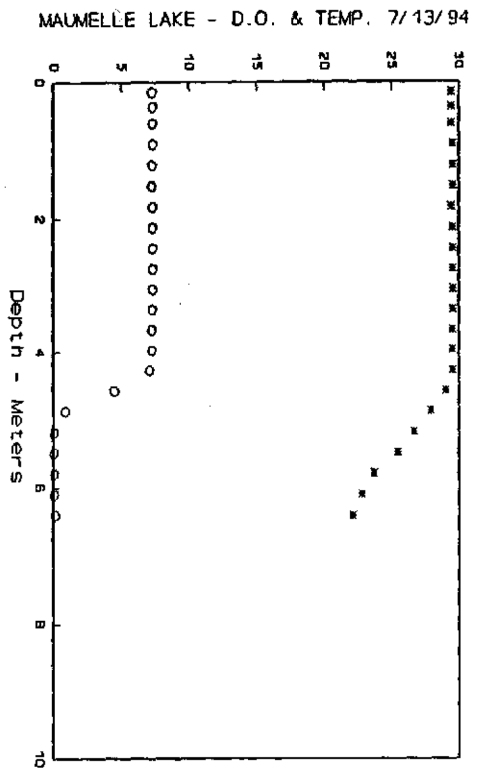
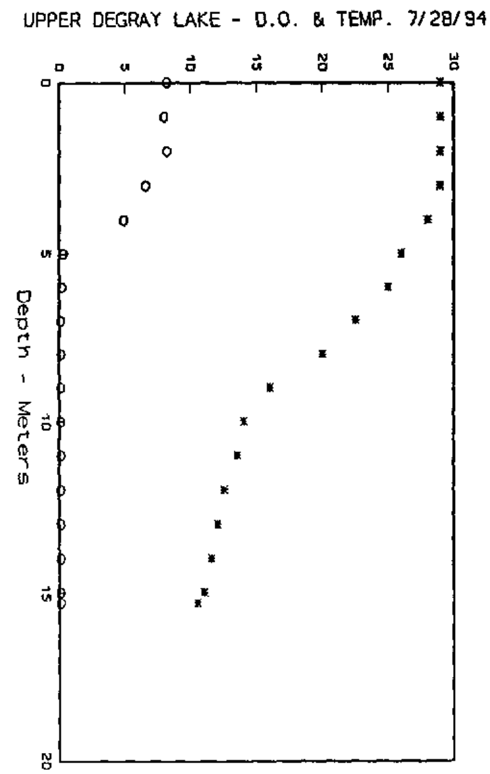
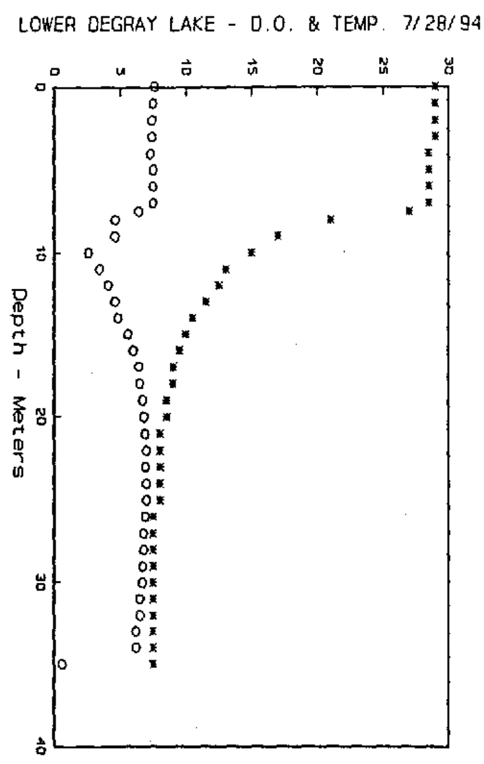

UPPER LAKE GREESON - D.O. & TEMP. 7/27/94
Depth - Meters
LOWER LAKE GREESON - D.O. & TEMP. 7/27/94
Depth - Meters
UPPER LAKE HAMILTON - D.O. & TEMP. 7/14/94
Depth - Meters
LOWER LAKE HAMILTON - D.O. & TEMP. 7/14/94
Depth - Meters

Figure C-3


MAUMELLE LAKE - D.O. & TEMP. 7/13/94
Depth - Meters


UPPER DEGRAY LAKE - D.O. & TEMP. 7/28/94
Depth - Meters


LOWER DEGRAY LAKE - D.O. & TEMP. 7/28/94
Depth - Meters

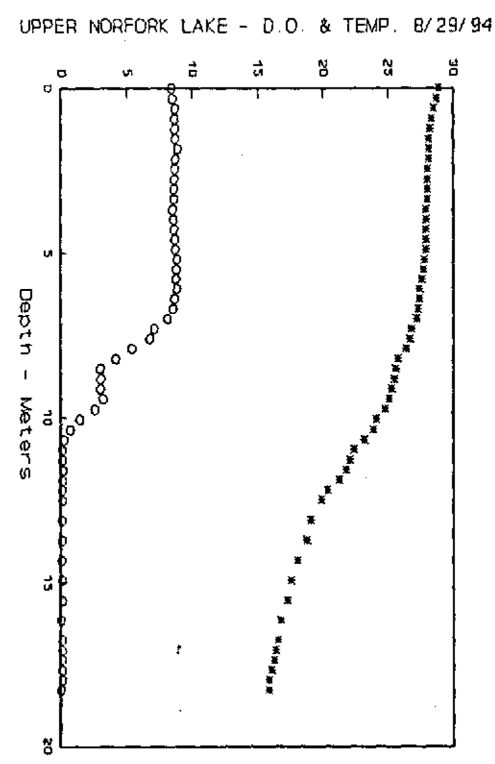

UPPER NORFORK LAKE - D.O. & TEMP. 8/29/94
Depth - Meters

Figure C-4

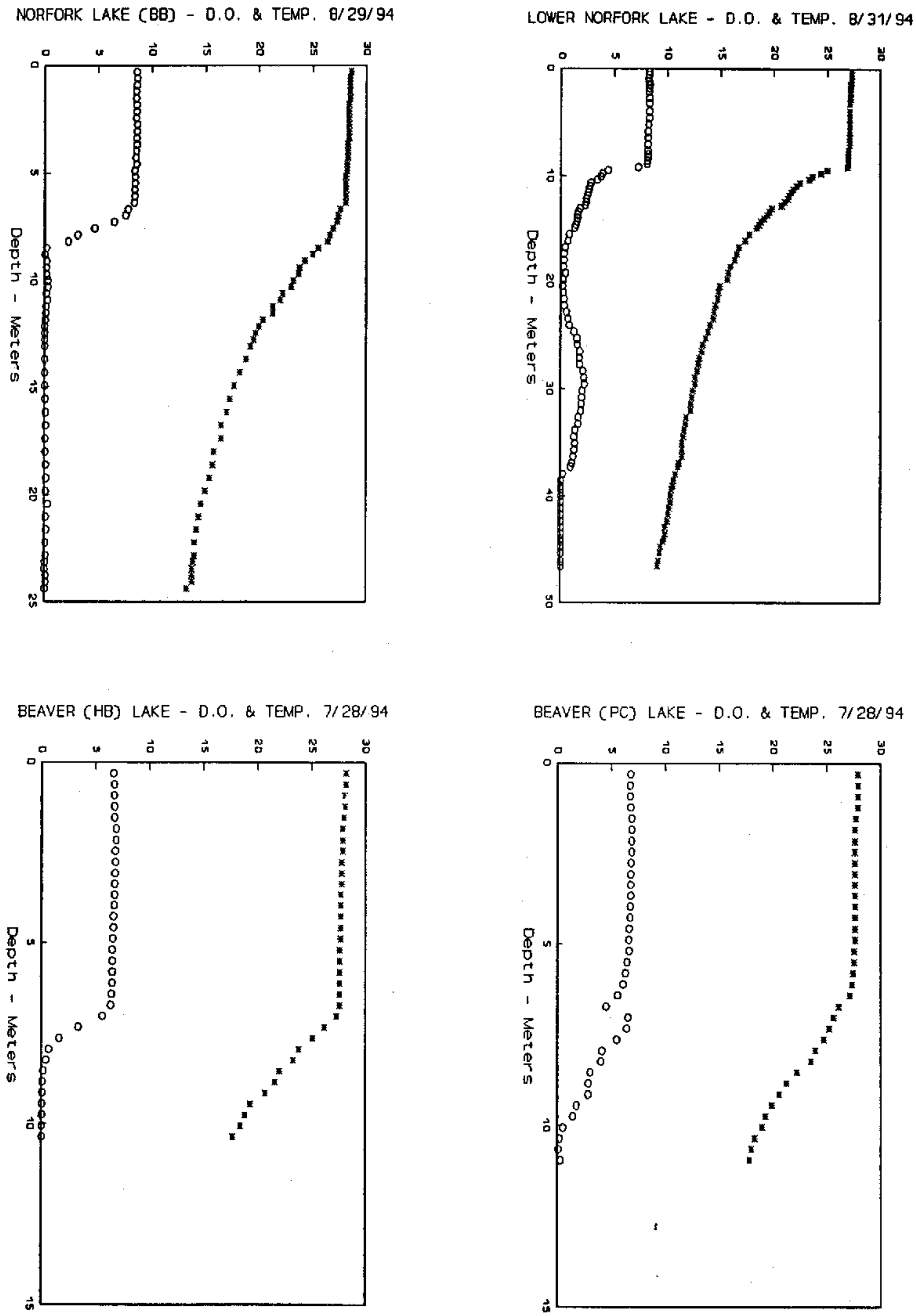
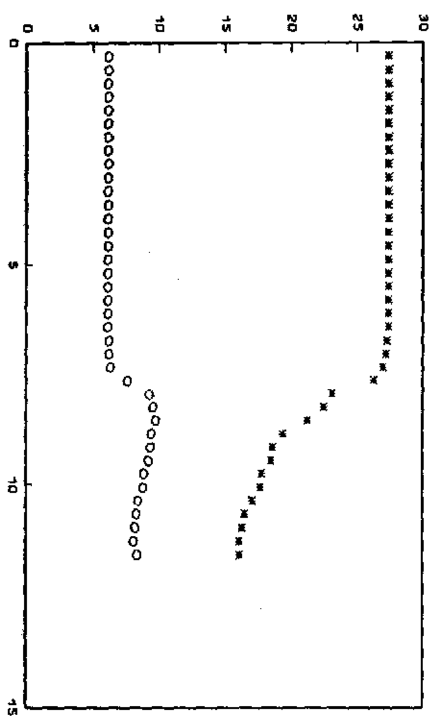
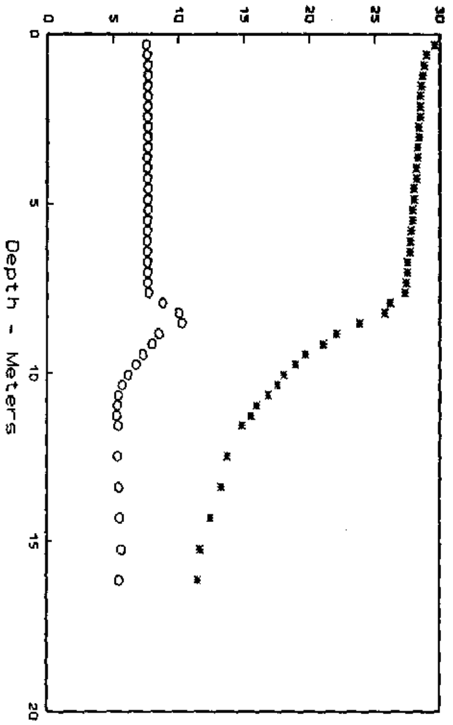

NORFORK LAKE (BB) - D.O. & TEMP. 8/29/94
LOWER NORFORK LAKE - D.O. & TEMP. 8/31/94
BEAVER (HB) LAKE - D.O. & TEMP. 7/28/94
BEAVER (PC) LAKE - D.O. & TEMP. 7/28/94
Depth - Meters

Figure C-5

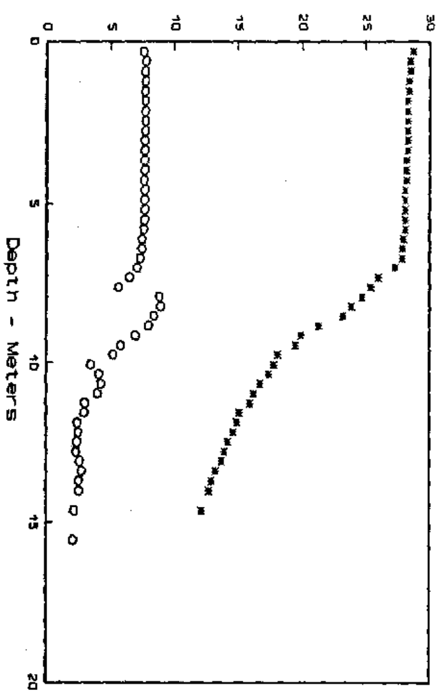
BEAVER (LB) LAKE - D.O. & TEMP. 7/28/94



GREERS FERRY (CA) LAKE - D.O. & TEMP. 8/02/94



GREERS FERRY (DF) LAKE - D.O. & TEMP. 8/02/94



GREERS FERRY DAM - D.O. & TEMP. 8/11/94

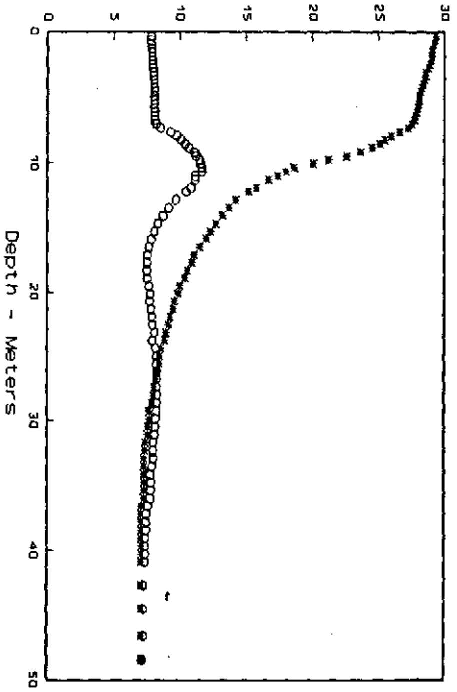
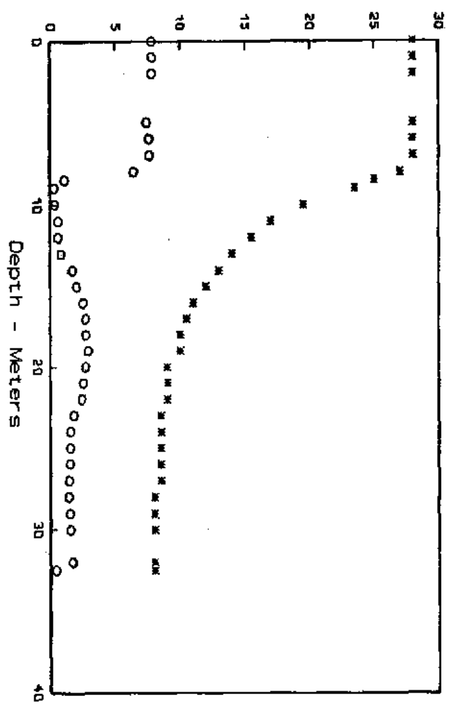
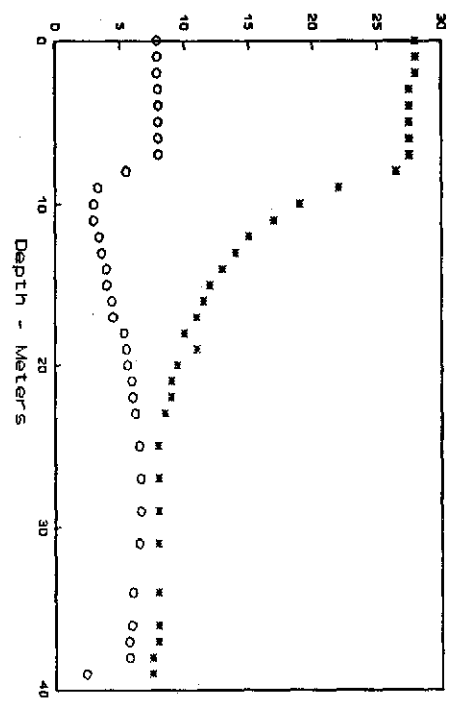


Figure C-6

UPPER OUACHITA LAKE - D.O. & TEMP. 8/09/94



MIDDLE OUACHITA LAKE - D.O. & TEMP. 8/09/94



LOWER OUACHITA LAKE - D.O. & TEMP. 8/09/94

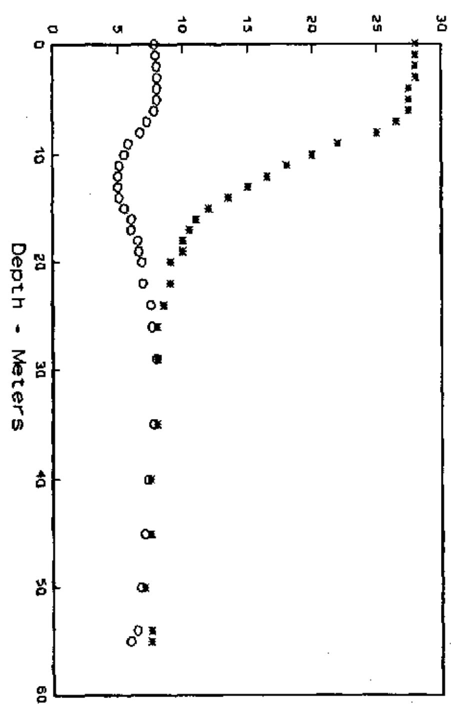
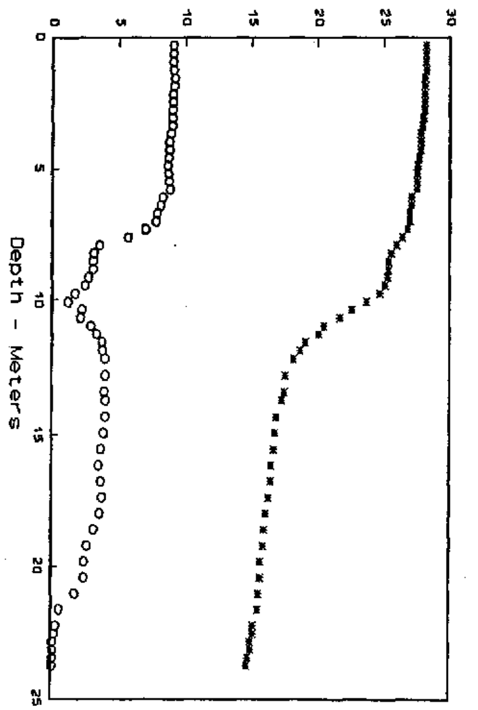
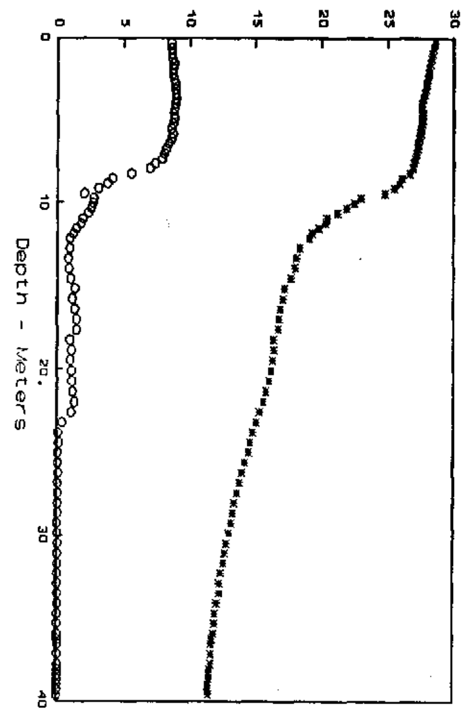


Figure C-7

BULL SHOALS (LH) - D.O. & TEMP. 8/30/94



BULL SHOALS (DA) - D.O. & TEMP. 8/30/94



BULL SHOALS (DAM) - D.O. & TEMP. 8/30/94

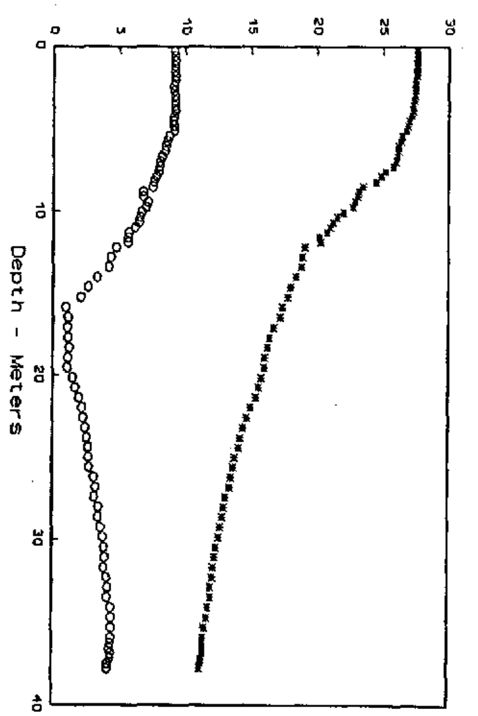
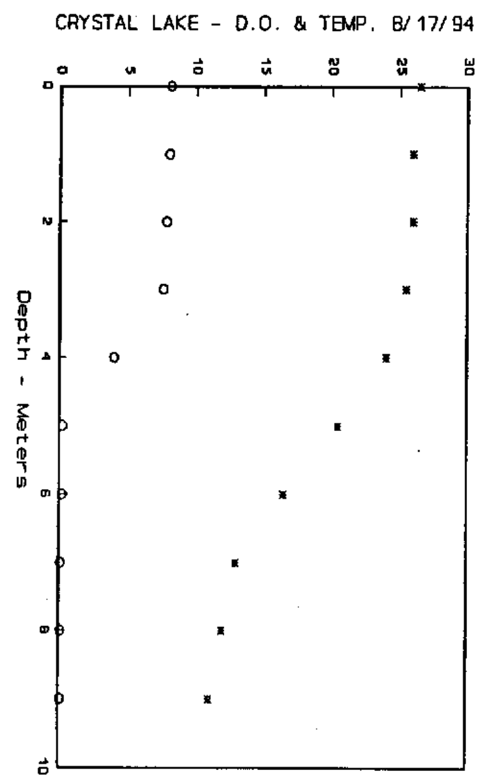
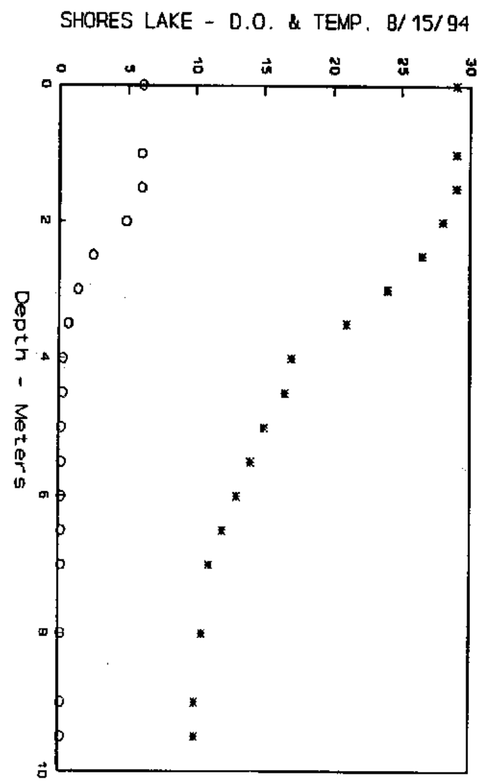
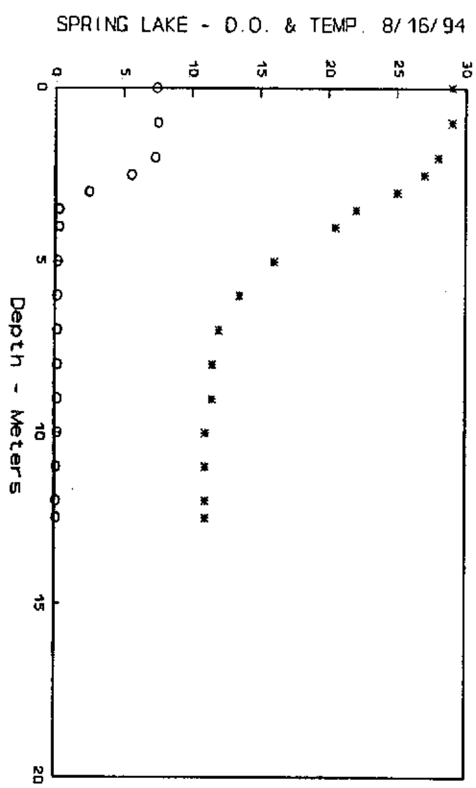


Figure C-8


CRYSTAL LAKE - D.O. & TEMP. 8/17/94
Depth - Meters


SHORES LAKE - D.O. & TEMP. 8/15/94
Depth - Meters


SPRING LAKE - D.O. & TEMP. 8/16/94
Depth - Meters

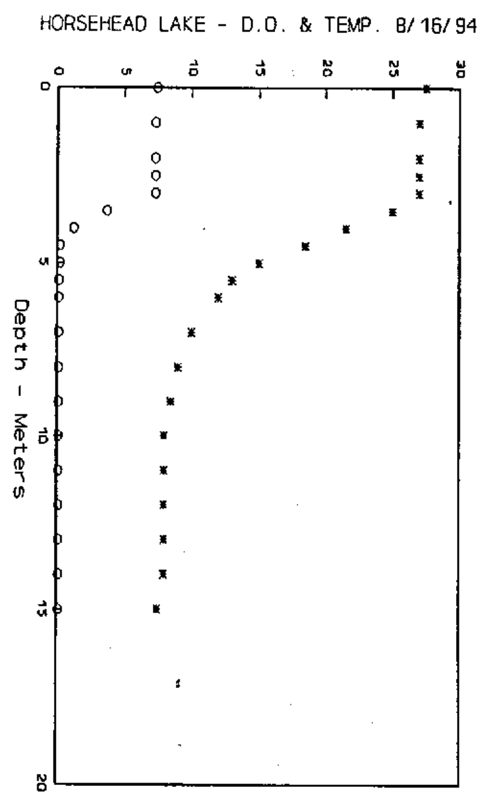
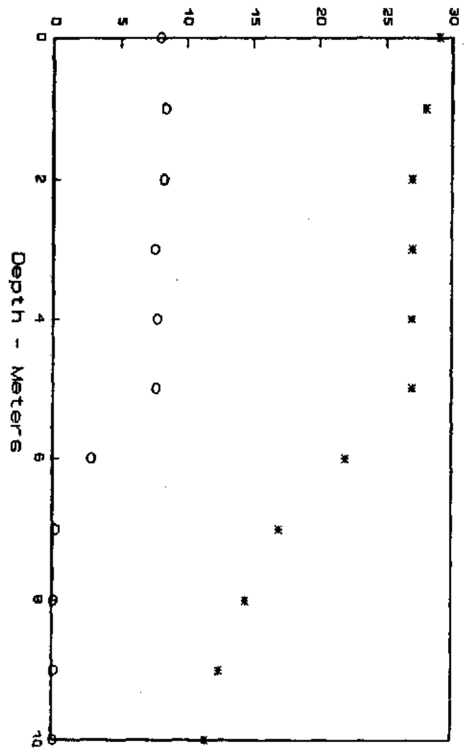
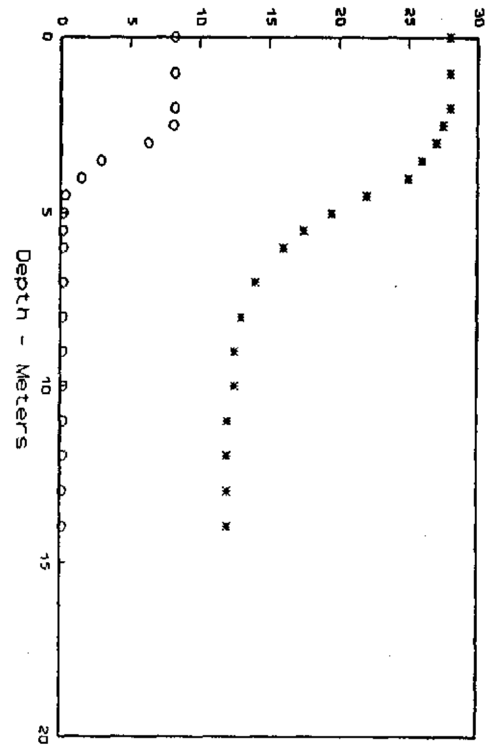

HORSEHEAD LAKE - D.O. & TEMP. 8/16/94
Depth - Meters

Figure C-9

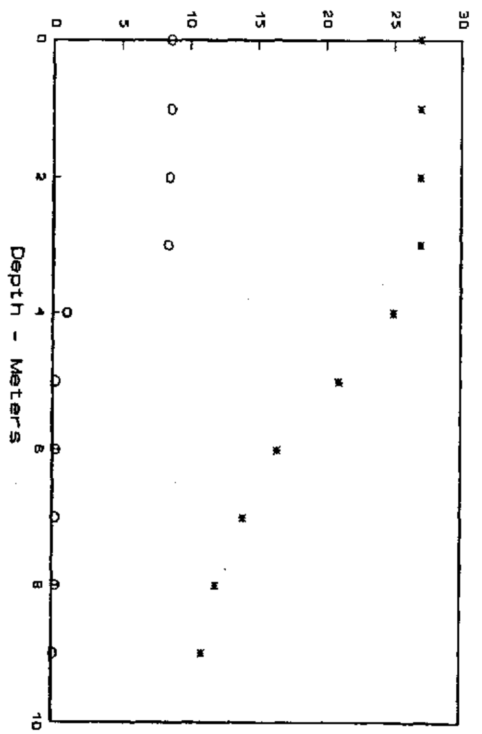
WEDDINGTON LAKE - D.O. & TEMP. 8/17/94



COVE LAKE - D.O. & TEMP. 8/16/94



ELMDALE LAKE - D.O. & TEMP. 8/18/94



FAYETTEVILLE LAKE - D.O. & TEMP. 8/18/94

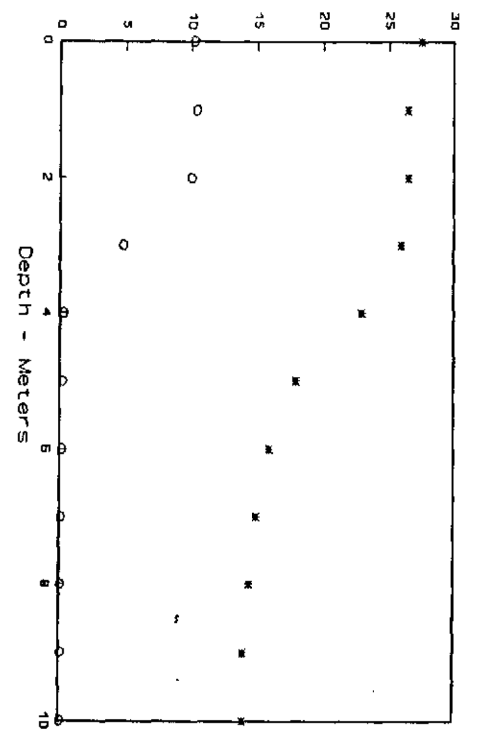
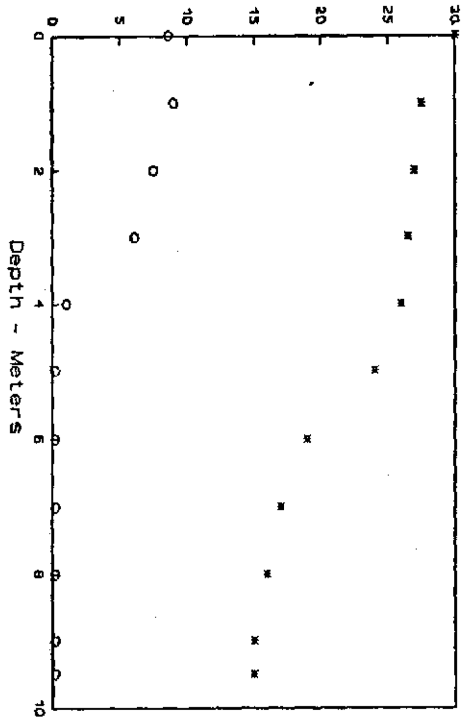
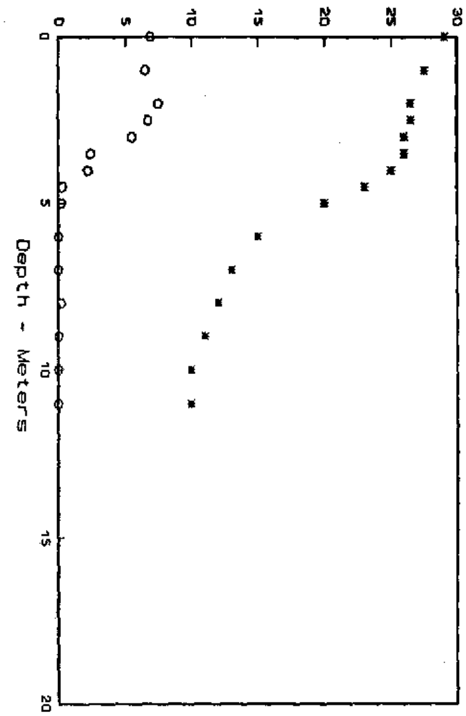


Figure C-10

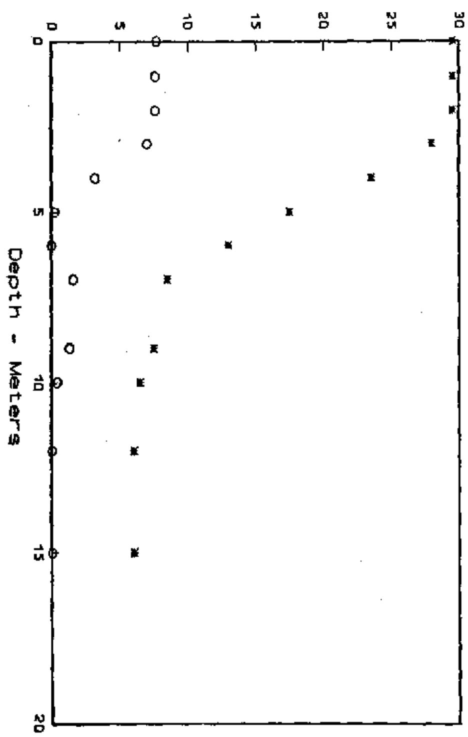
BOBB KIDD LAKE - D.O. & TEMP. 8/17/94



WILHELMINA LAKE - D.O. & TEMP. 8/08/94



BARNETT LAKE - D.O. & Temp. 7/12/94



SUGARLOAF LAKE - D.O. & TEMP. 8/08/94

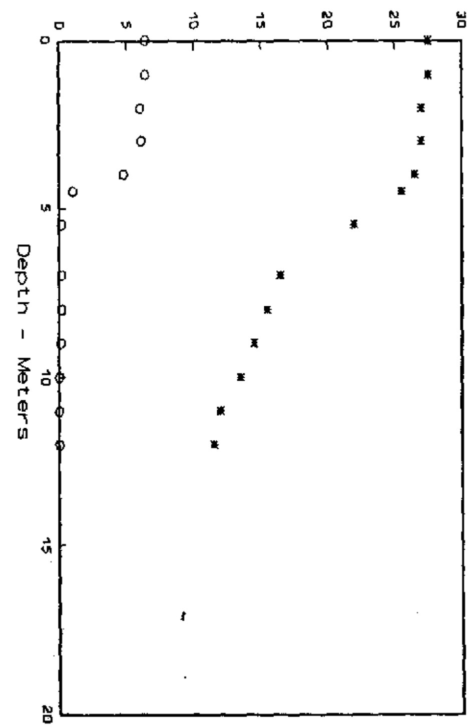


Figure C-11

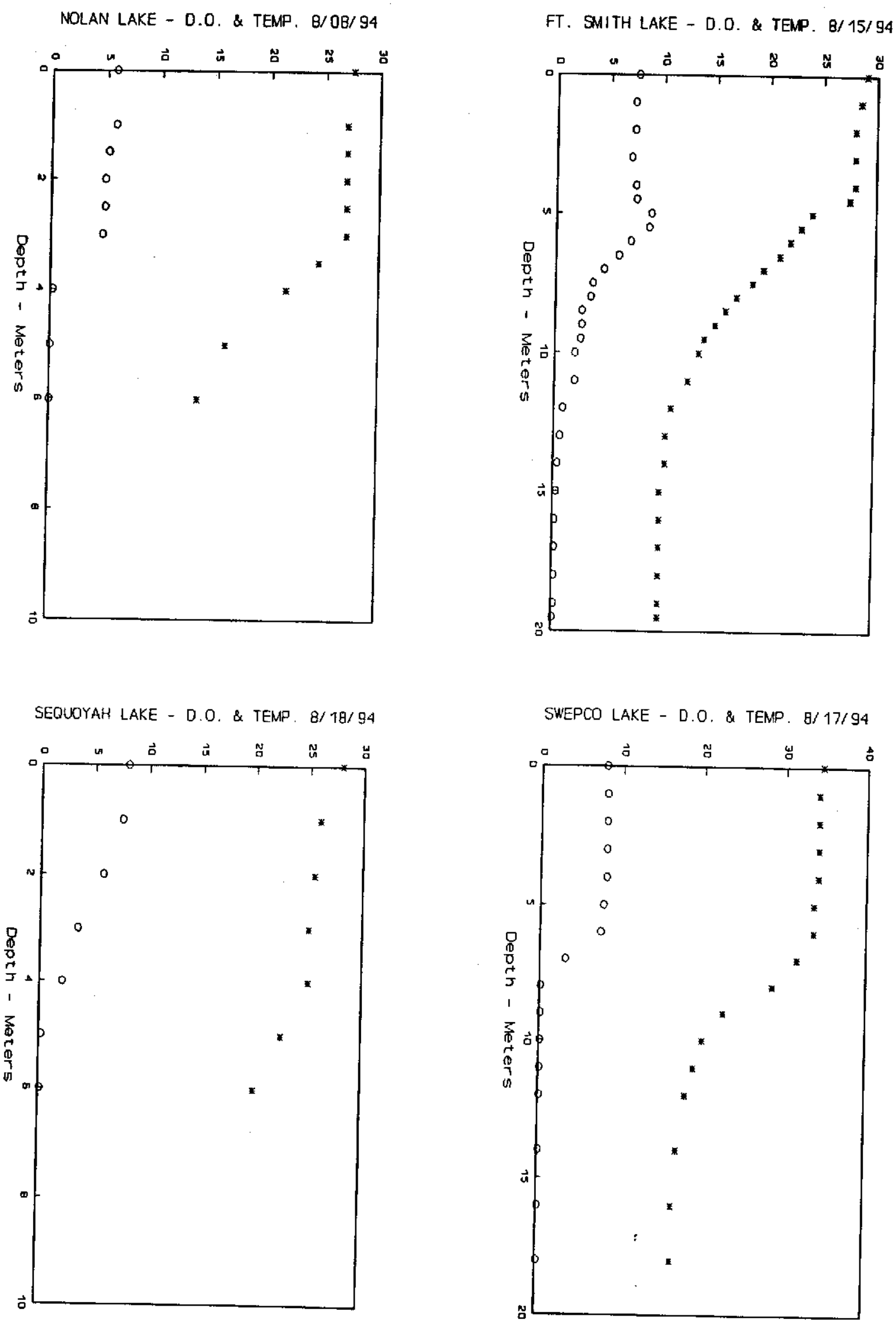
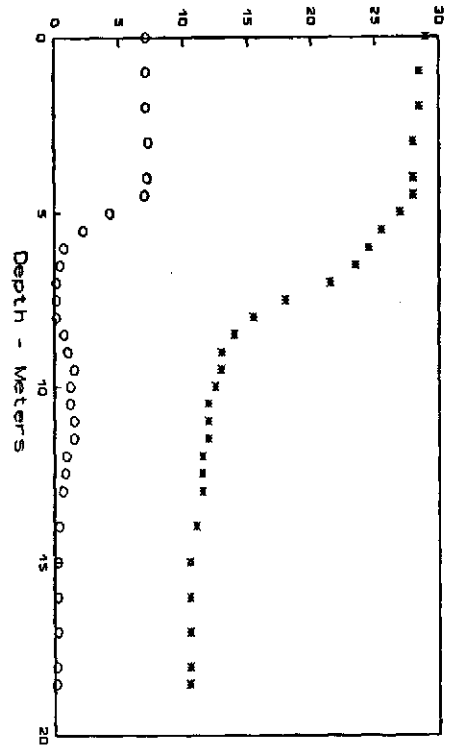
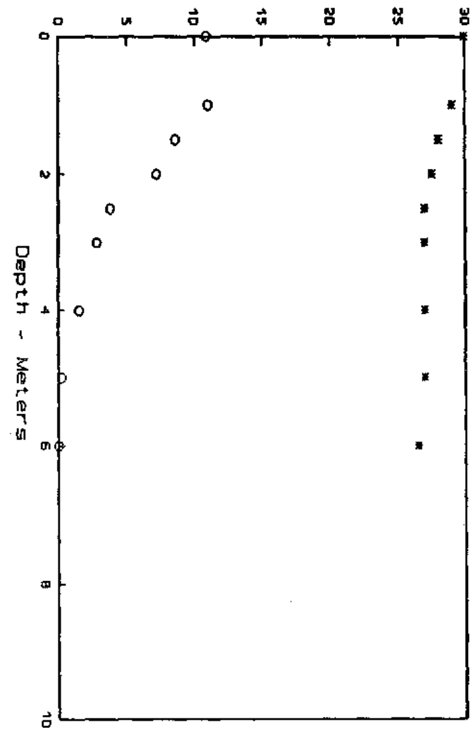

NOLAN LAKE - D.O. & TEMP. 8/08/94
Depth - Meters
FT. SMITH LAKE - D.O. & TEMP. 8/15/94
Depth - Meters
SEQUOYAH LAKE - D.O. & TEMP. 8/18/94
Depth - Meters
SWEPCO LAKE - D.O. & TEMP. 8/17/94
Depth - Meters

Figure C-12

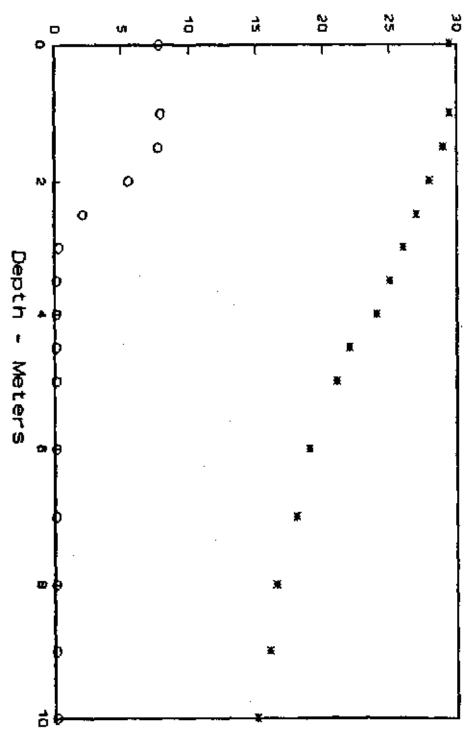
SHEPHERD SPRINGS LAKE - D.O. & TEMP. 8/15/94



CHARLES LAKE - D.O. & TEMP. 8/03/94



LEE CREEK LAKE - D.O. & TEMP. 8/15/94



BEAVERFORK LAKE - D.O. & TEMP. 8/11/94

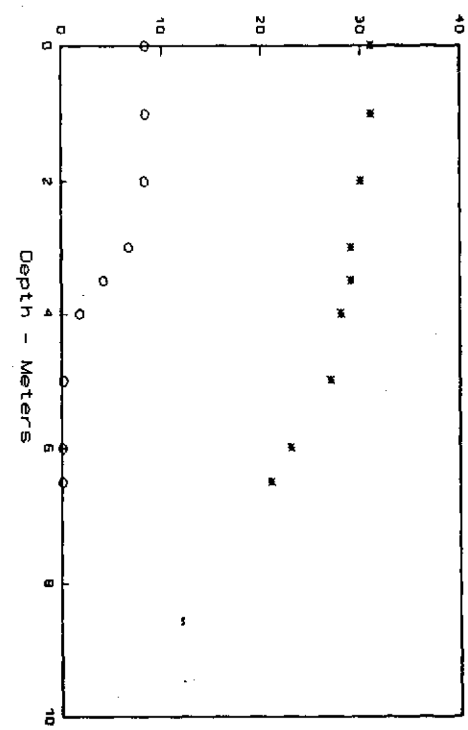
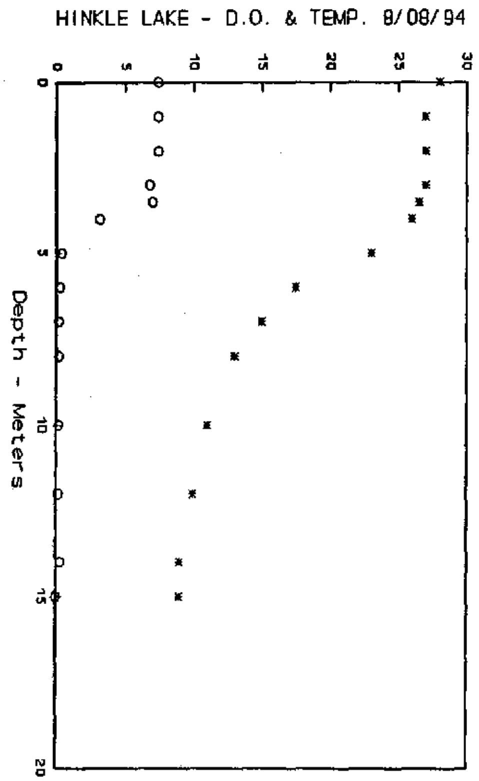
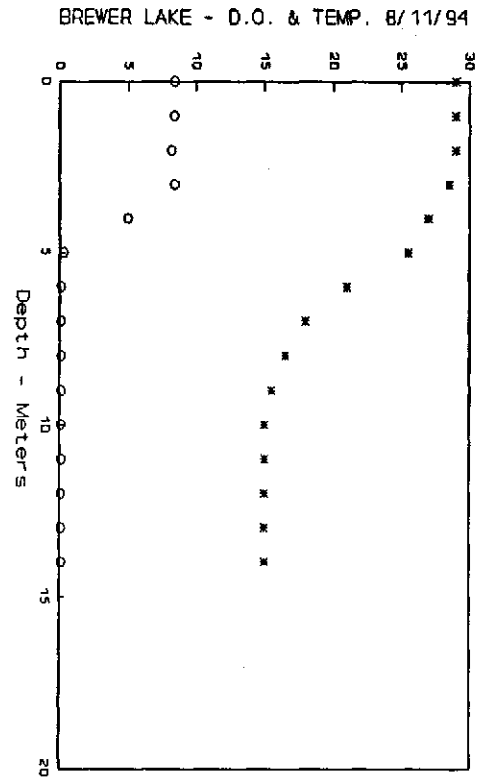


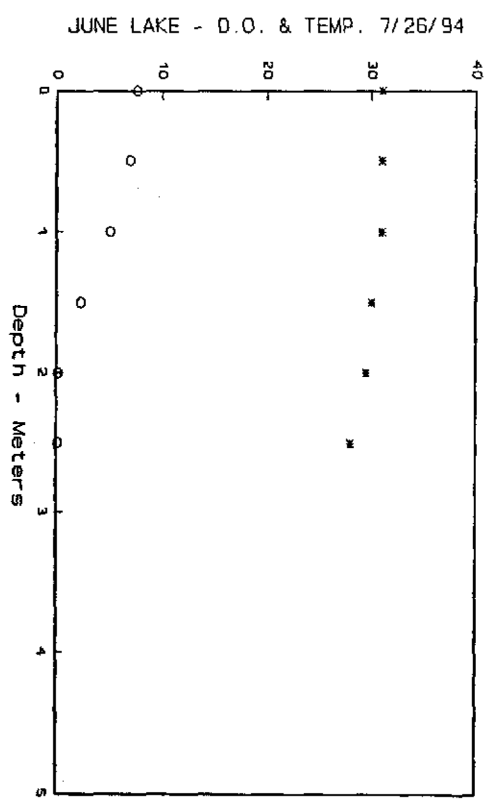
Figure C-13



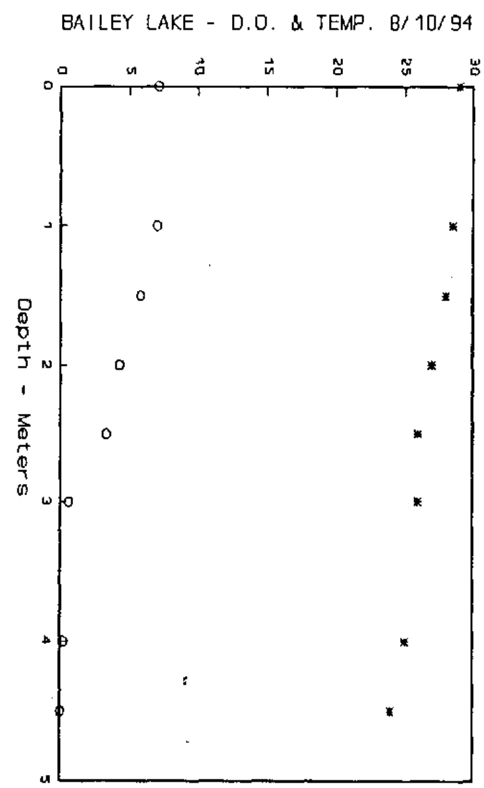
HINKLE LAKE - D.O. & TEMP. 8/08/94
Depth - Meters



BREWER LAKE - D.O. & TEMP. 8/11/94
Depth - Meters



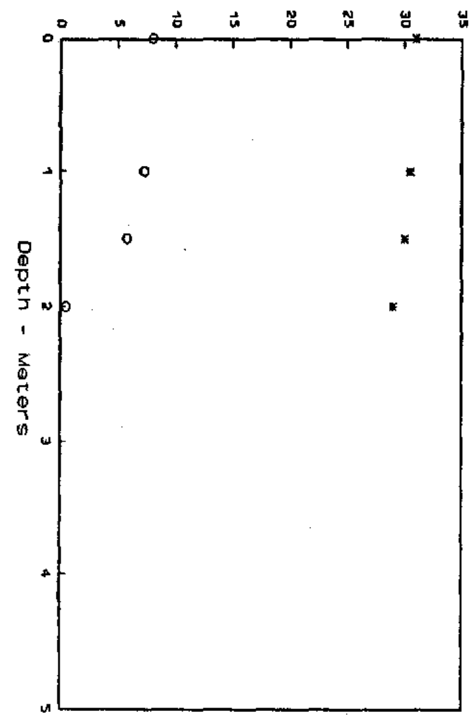
JUNE LAKE - D.O. & TEMP. 7/26/94
Depth - Meters



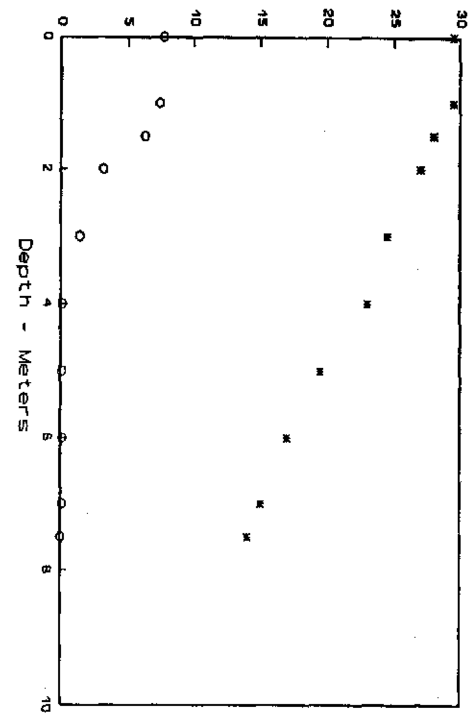
BAILEY LAKE - D.O. & TEMP. 8/10/94
Depth - Meters

Figure C-14

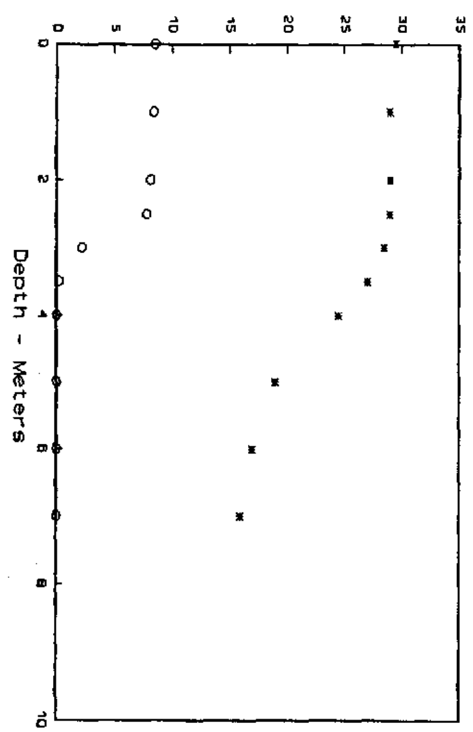
TRICOUNTY LAKE - D.O. & TEMP. 7/20/94



COX CREEK LAKE - D.O. & TEMP. 7/20/94



HURRICANE LAKE - D.O. & TEMP. 7/11/94



FRIERSON LAKE - D.O. & TEMP. 8/03/94

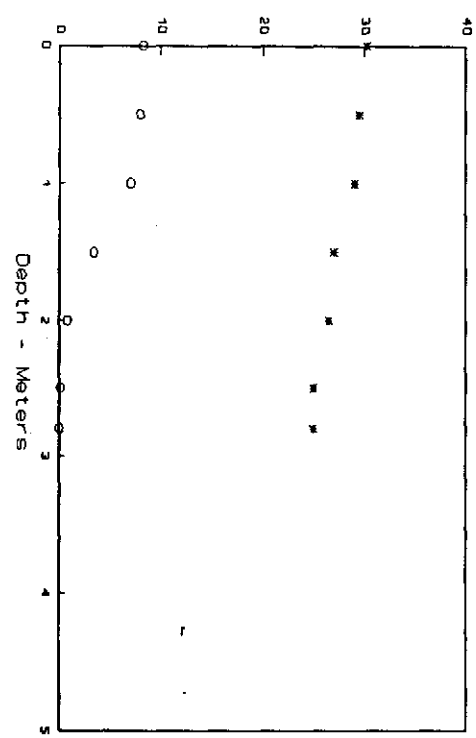
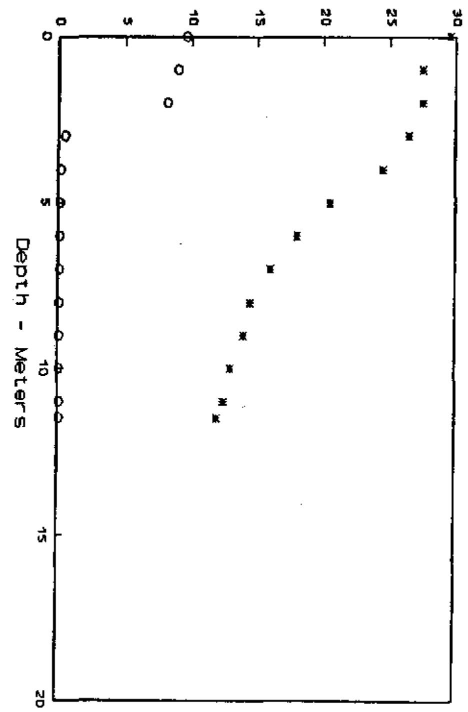
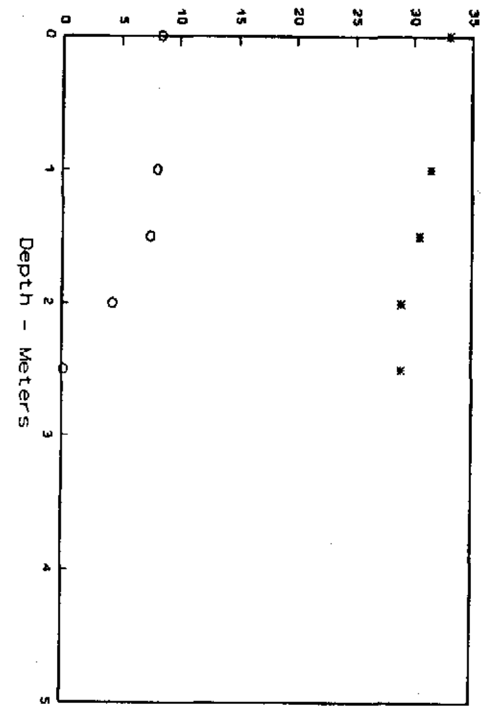


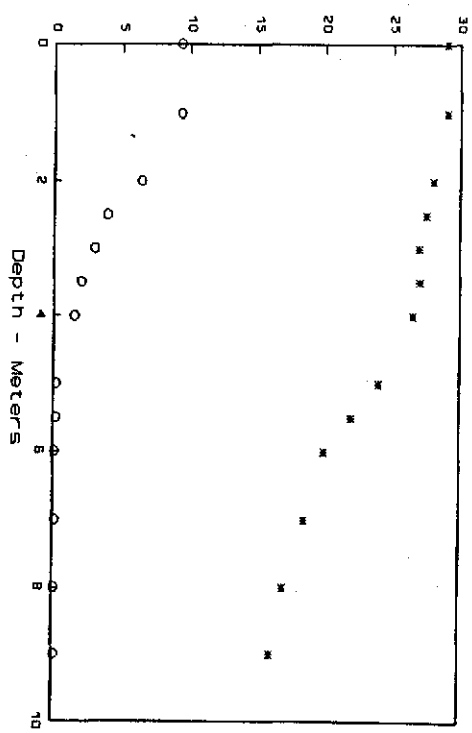
Figure C-15



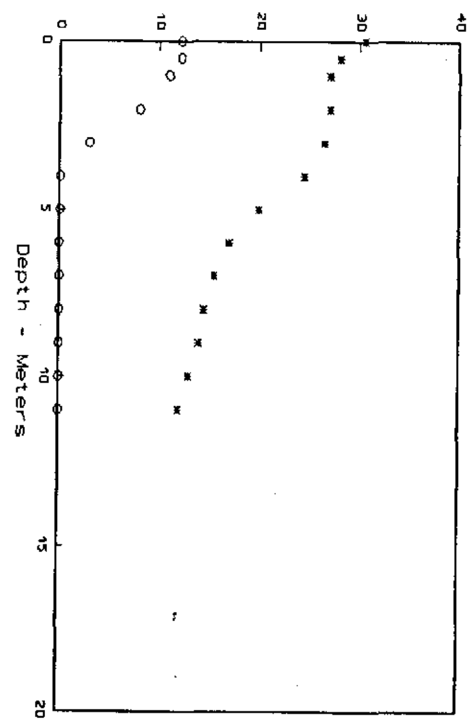
STORM CREEK LAKE - D.O. & TEMP. 8/01/94



CALION LAKE - D.O. & TEMP. 7/20/94



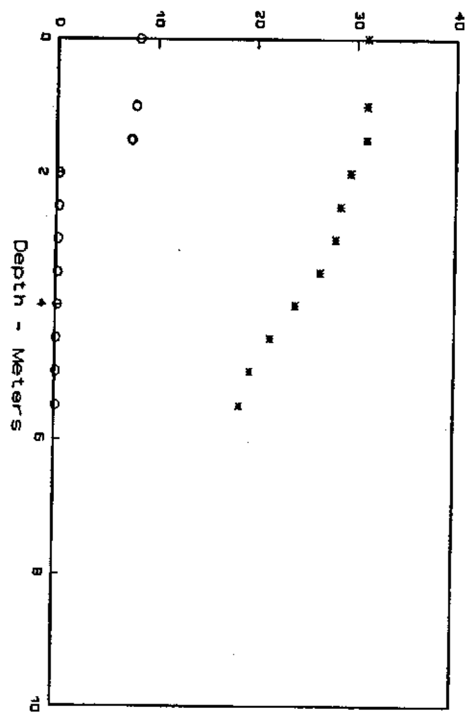
POINSETT LAKE - D.O. & TEMP. 8/04/94



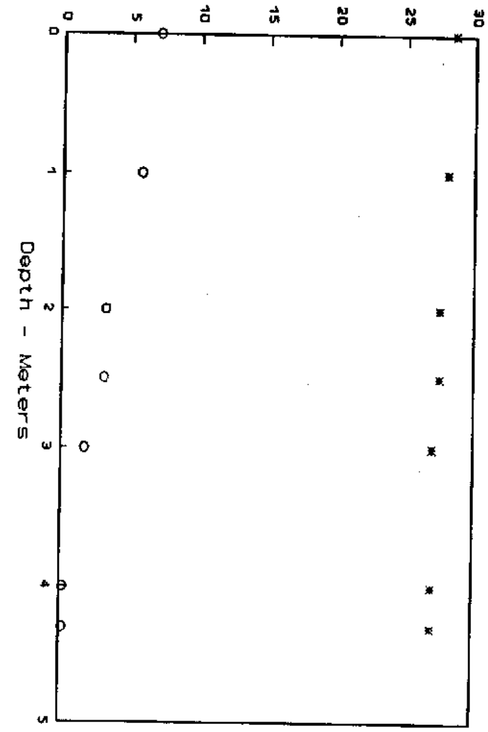
BEAR CREEK LAKE - D.O. & TEMP. 8/01/94

Figure C-16

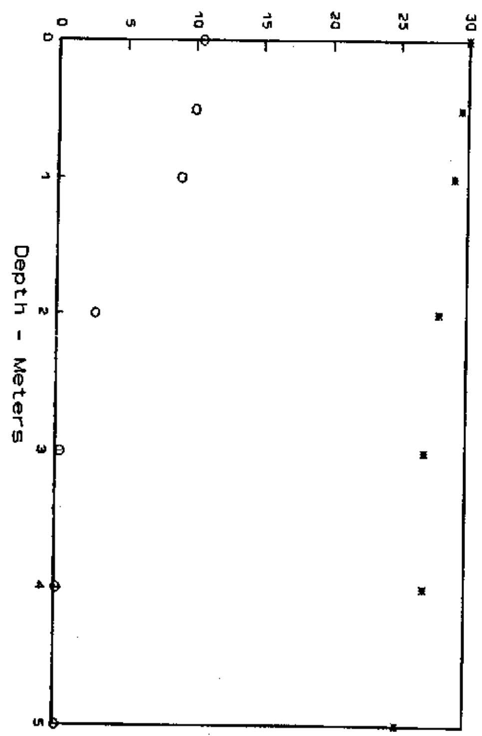
UPPER WHITE OAK - D.O. & TEMP. 7/25/94



ATKINS LAKE - D.O. & TEMP. 8/10/94



OVERCUP LAKE - D.O. & TEMP. 8/10/94



LOWER WHITE OAK - D.O. & TEMP. 7/25/94

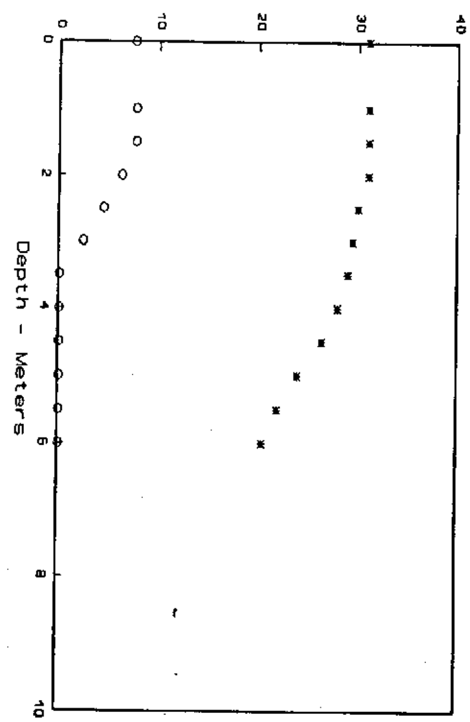
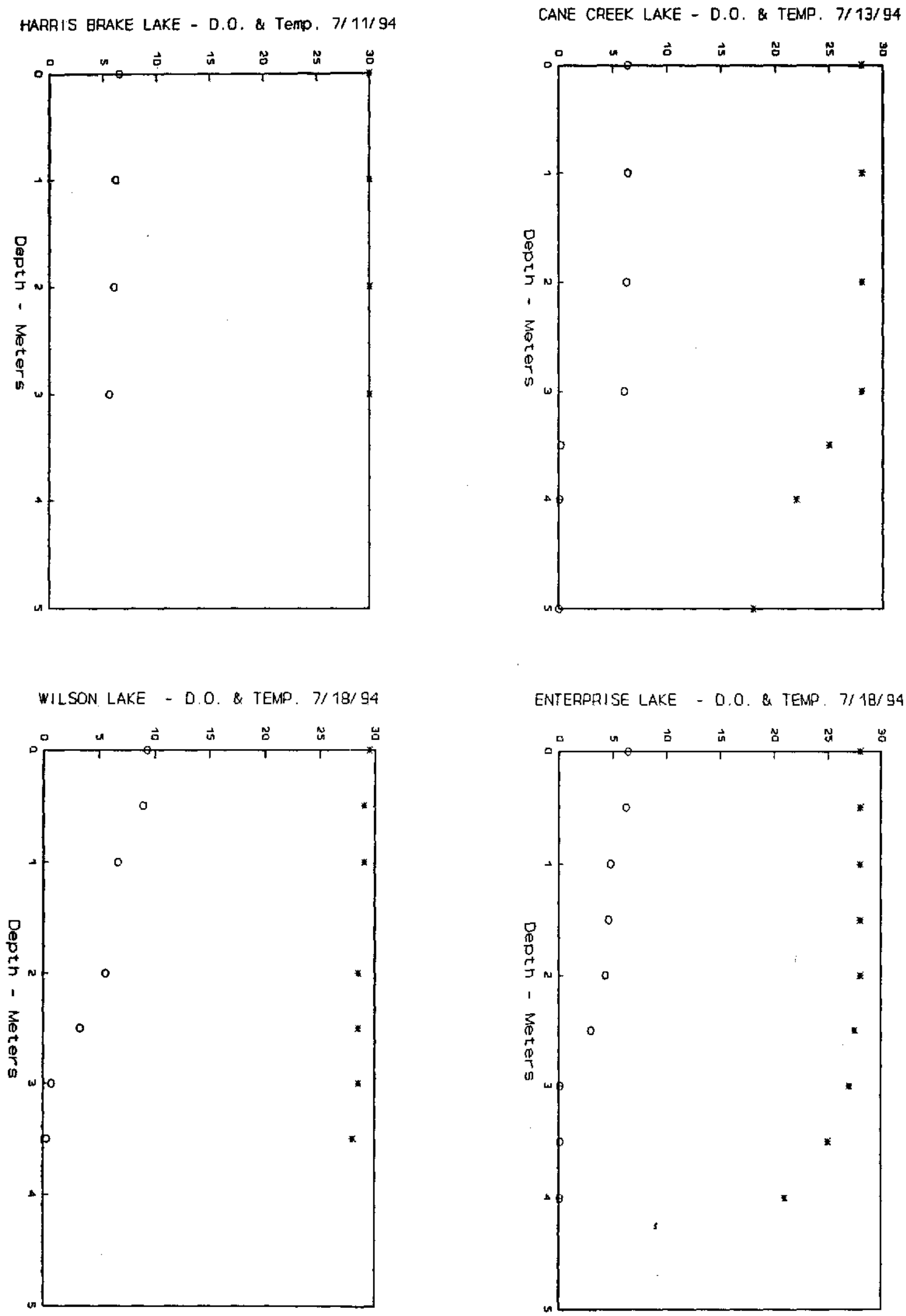


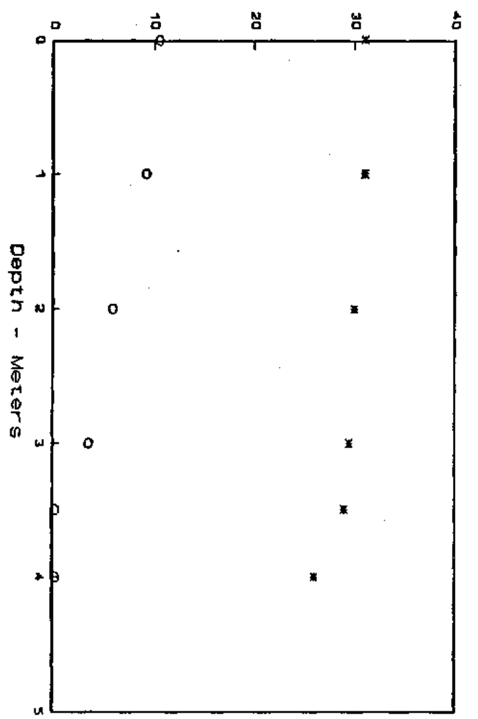
Figure C-17



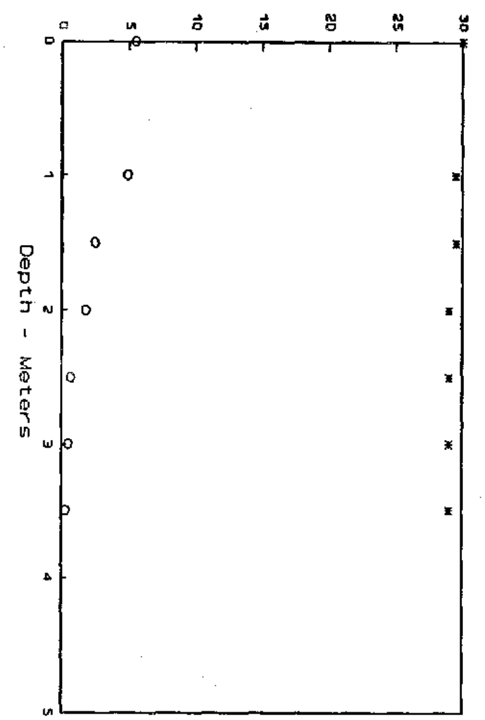
HARRIS BRAKE LAKE - D.O. & Temp. 7/11/94
Depth - Meters
CANE CREEK LAKE - D.O. & TEMP. 7/13/94
Depth - Meters
WILSON LAKE - D.O. & TEMP. 7/18/94
Depth - Meters
ENTERPRISE LAKE - D.O. & TEMP. 7/18/94
Depth - Meters

Figure C-18

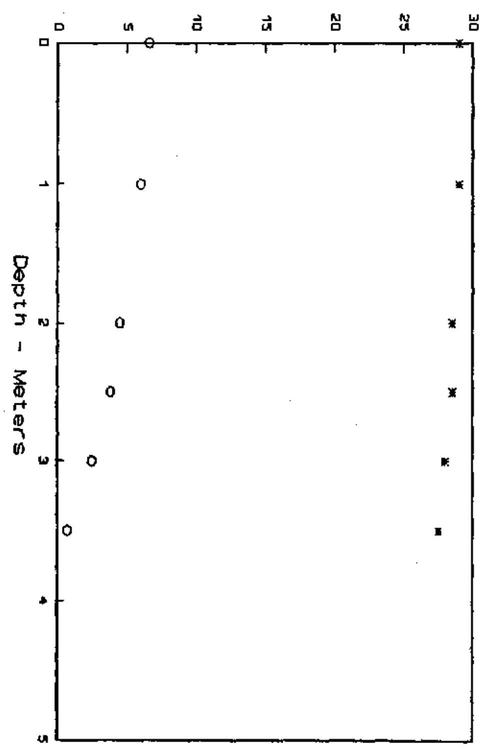
FIRST OLD RIVER - D.O. & TEMP. 7/27/94



PICKTHORNE LAKE - D.O. & TEMP. 7/12/94



HOGUE LAKE - D.O. & TEMP. 8/04/94



GREENLEE LAKE - D.O. & TEMP. 8/02/94

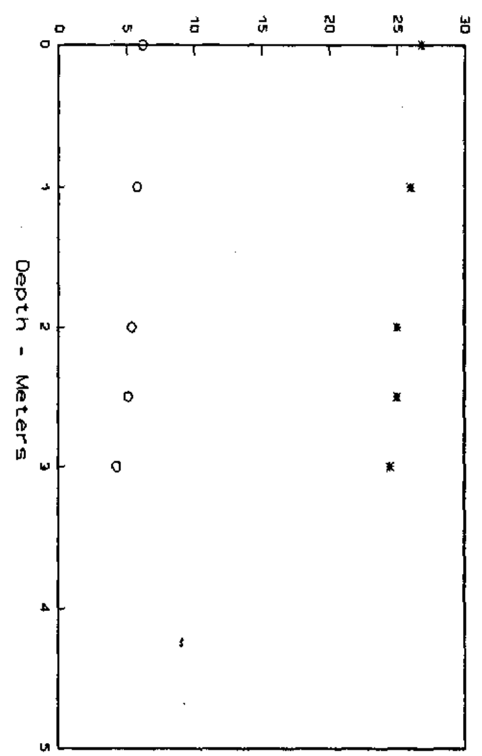


Figure C-19

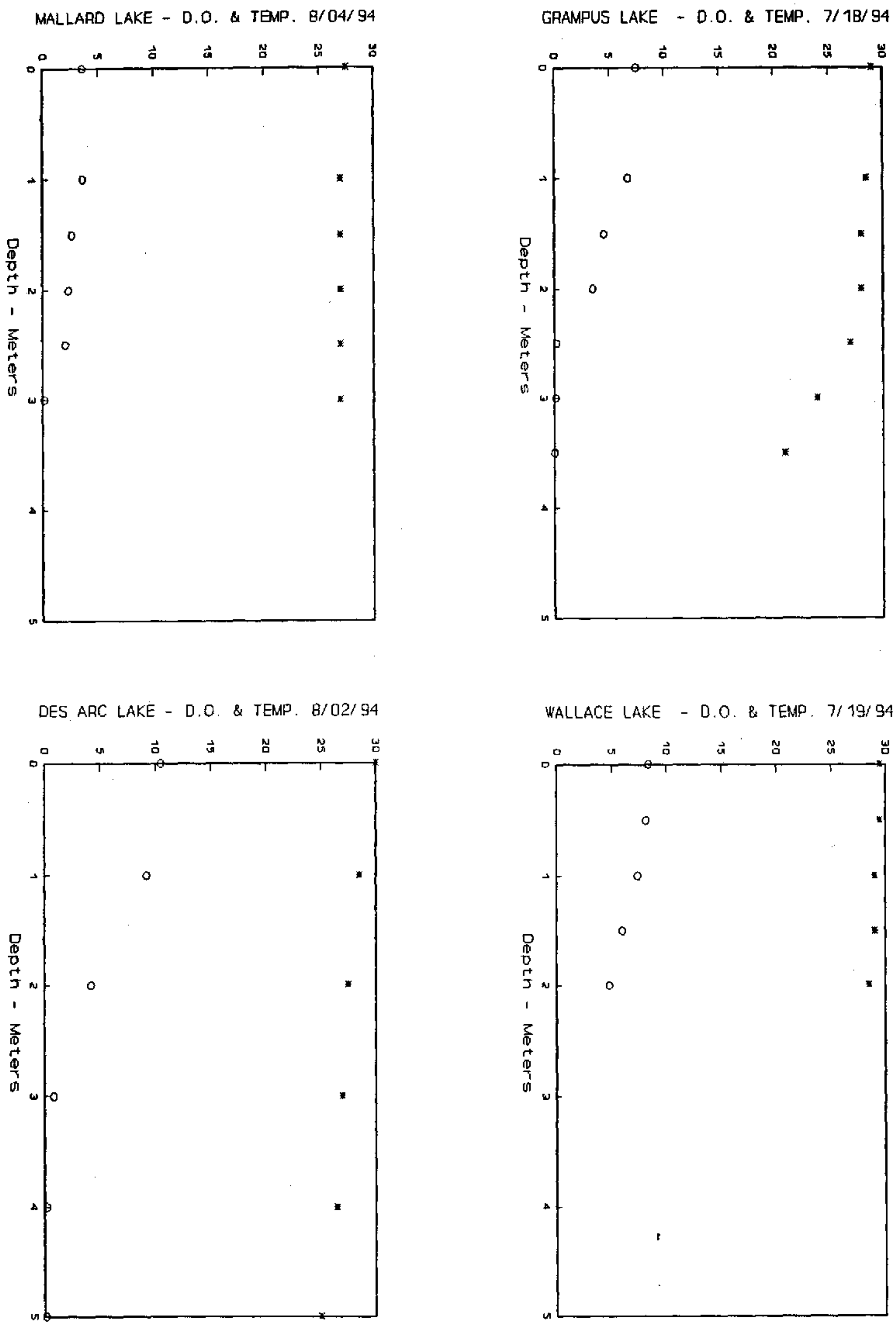

MALLARD LAKE - D.O. & TEMP. 8/04/94
GRAMPUS LAKE - D.O. & TEMP. 7/18/94
DES ARC LAKE - D.O. & TEMP. 8/02/94
WALLACE LAKE - D.O. & TEMP. 7/19/94
Depth - Meters

Figure C-20

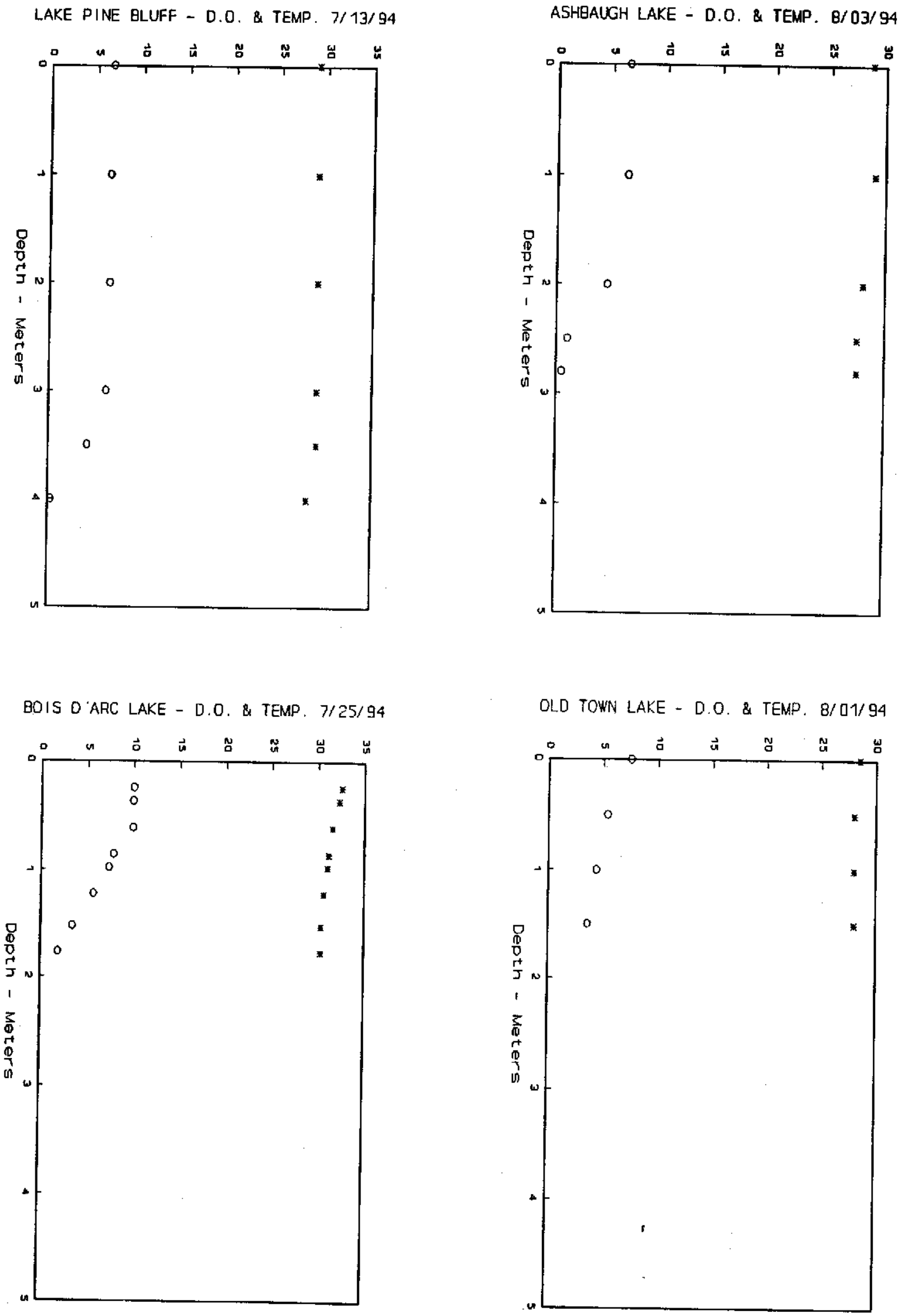
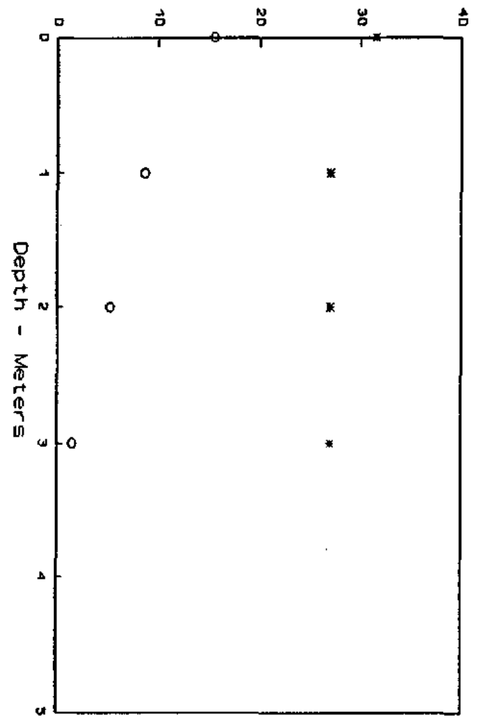
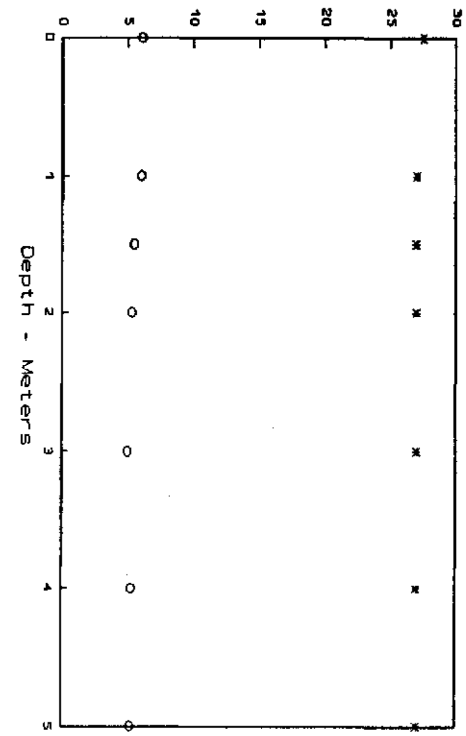

LAKE PINE BLUFF - D.O. & TEMP. 7/13/94
Depth - Meters
ASHBAUGH LAKE - D.O. & TEMP. 8/03/94
Depth - Meters
BOIS D'ARC LAKE - D.O. & TEMP. 7/25/94
Depth - Meters
OLD TOWN LAKE - D.O. & TEMP. 8/01/94
Depth - Meters

Figure C-21

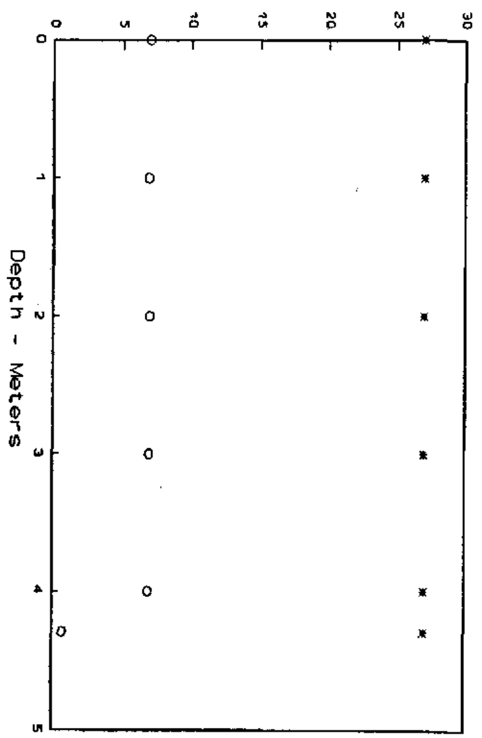
HORSESHOE LAKE - D.O. & TEMP. 8/01/94



UPPER CHICOT LAKE - D.O. & TEMP. 7/19/94



GRAND LAKE - D.O. & TEMP. 7/19/94



GA. PACIFIC LAKE - D.O. & TEMP. 7/21/94

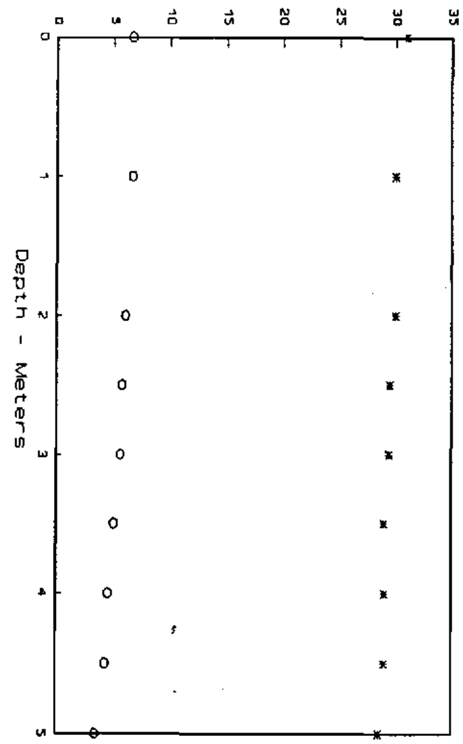


Figure C-22

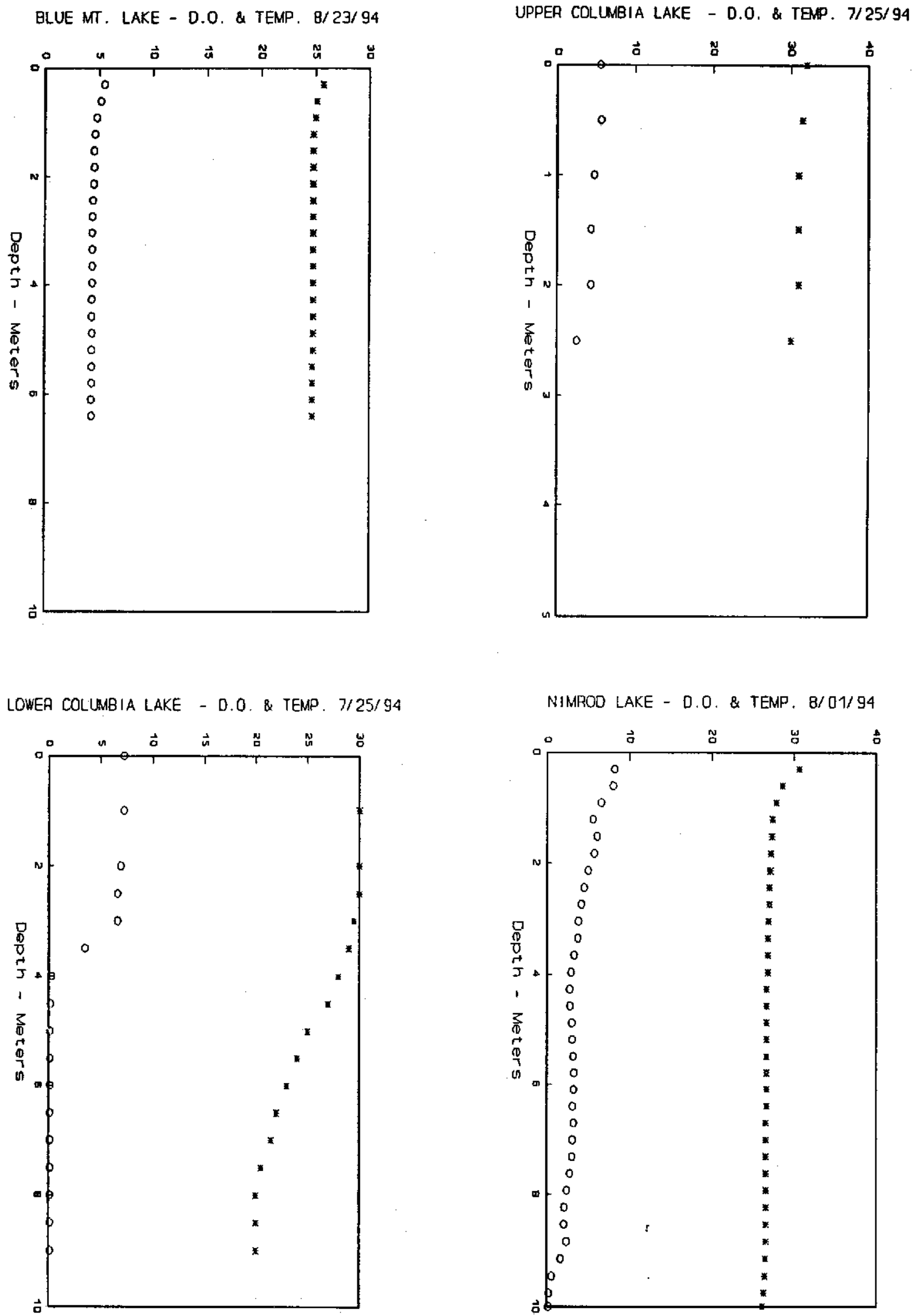
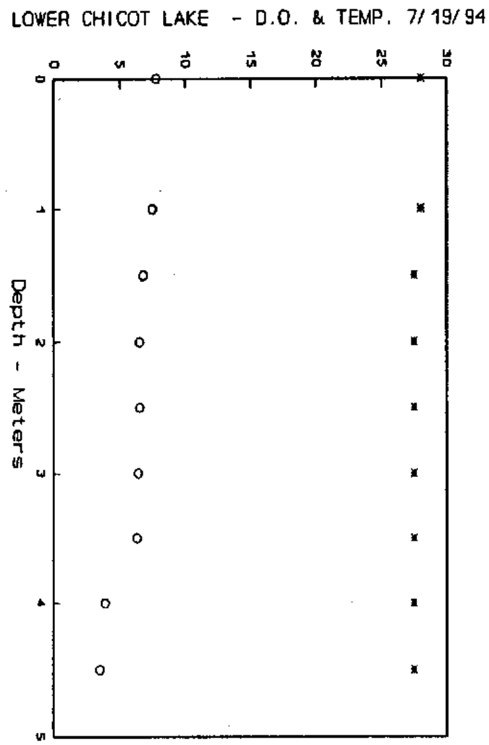
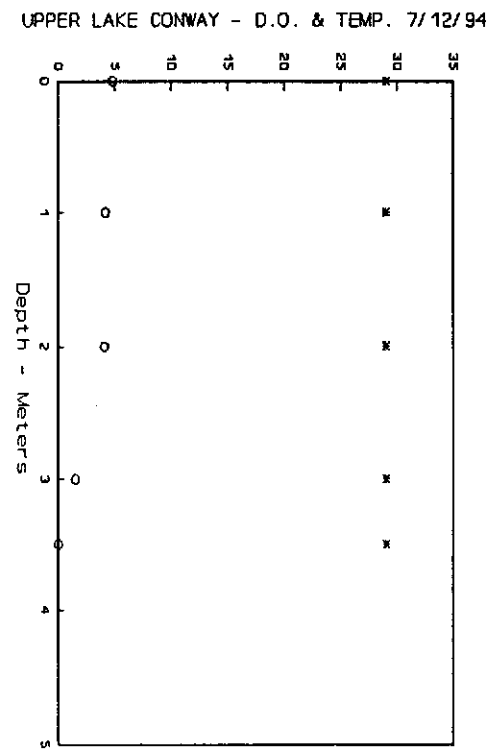

BLUE MT. LAKE - D.O. & TEMP. 8/23/94
Depth - Meters
UPPER COLUMBIA LAKE - D.O. & TEMP. 7/25/94
Depth - Meters
LOWER COLUMBIA LAKE - D.O. & TEMP. 7/25/94
Depth - Meters
NIMROD LAKE - D.O. & TEMP. 8/01/94
Depth - Meters

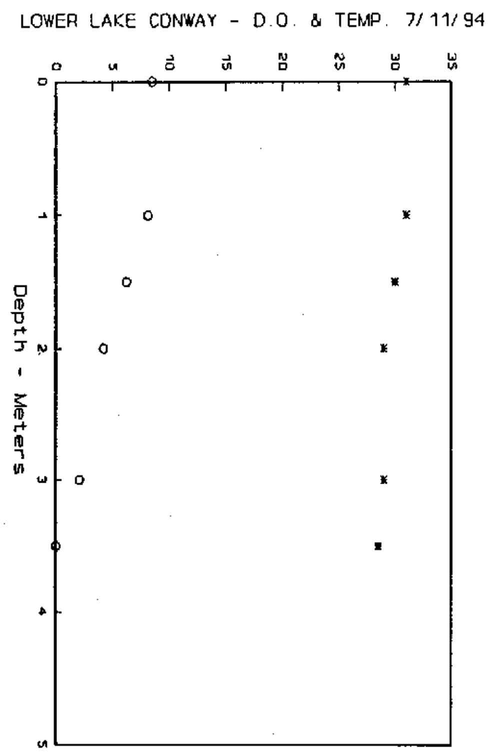
Figure C-23



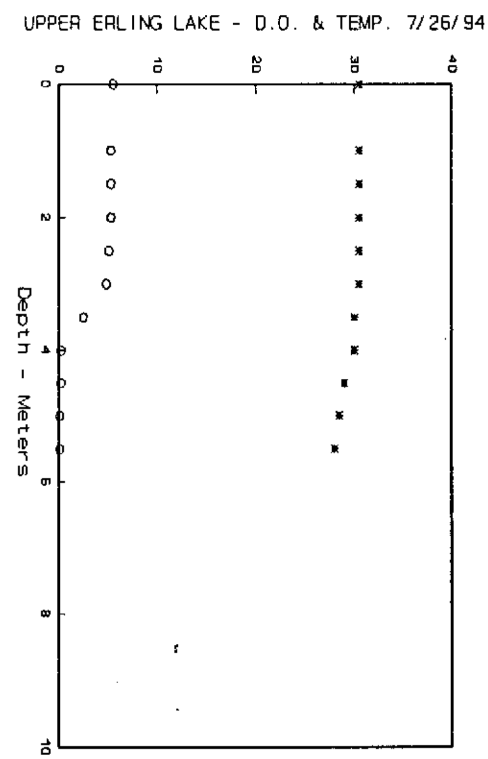
LOWER CHICOT LAKE - D.O. & TEMP. 7/19/94
Depth - Meters



UPPER LAKE CONWAY - D.O. & TEMP. 7/12/94
Depth - Meters

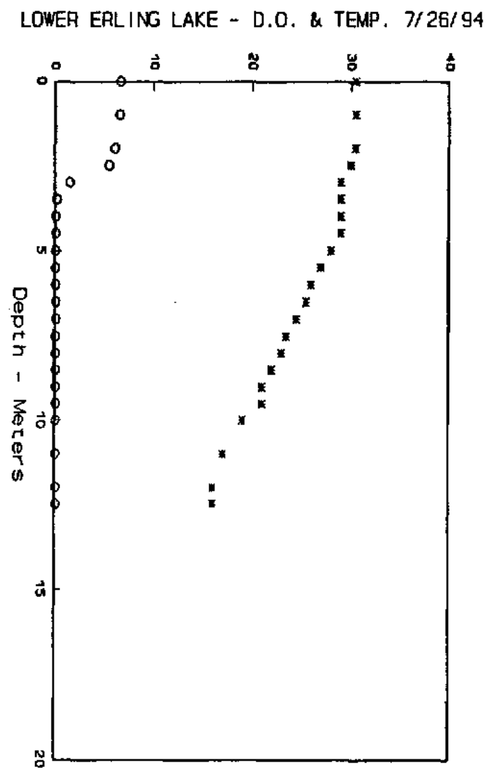


LOWER LAKE CONWAY - D.O. & TEMP. 7/11/94
Depth - Meters

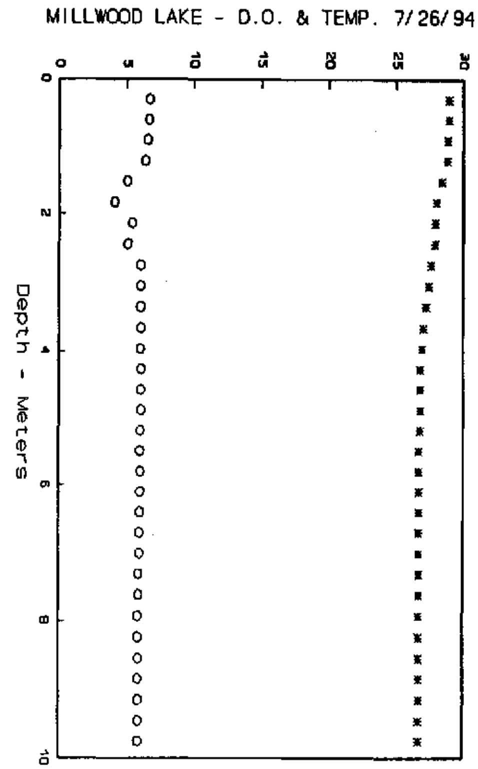


UPPER ERLING LAKE - D.O. & TEMP. 7/26/94
Depth - Meters

Figure C-24



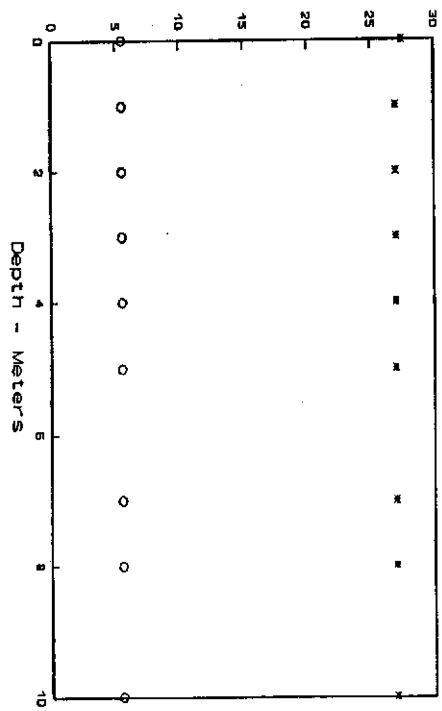
LOWER ERLING LAKE - D.O. & TEMP. 7/26/94
Depth - Meters



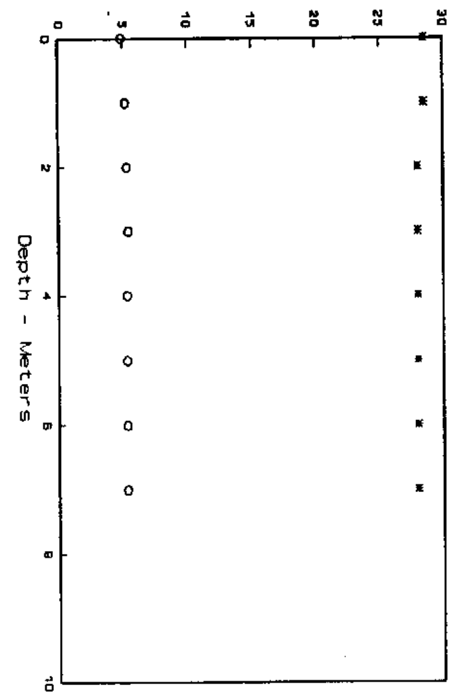
MILLWOOD LAKE - D.O. & TEMP. 7/26/94
Depth - Meters

Figure C-25

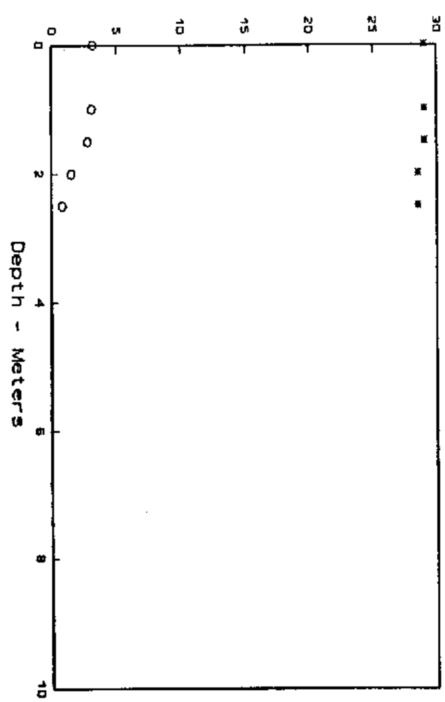
UPPER FELSENTHAL LAKE - D.O. & TEMP. 7/21/94



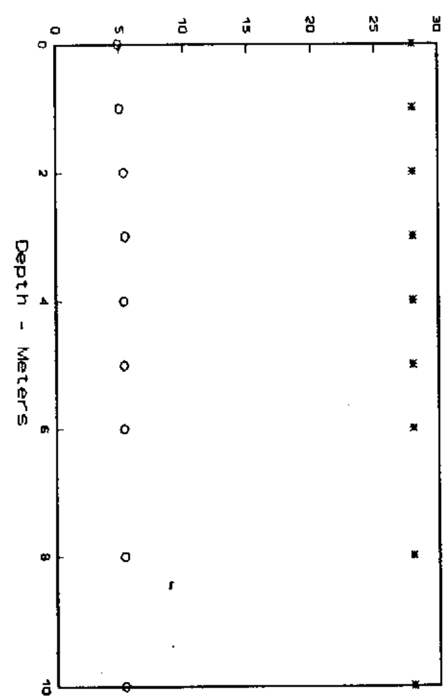
EAST FELSENTHAL LAKE - D.O. & TEMP. 7/21/94



WEST FELSENTHAL LAKE - D.O. & TEMP. 7/21/94



LOWER FELSENTHAL LAKE - D.O. & TEMP. 7/21/94



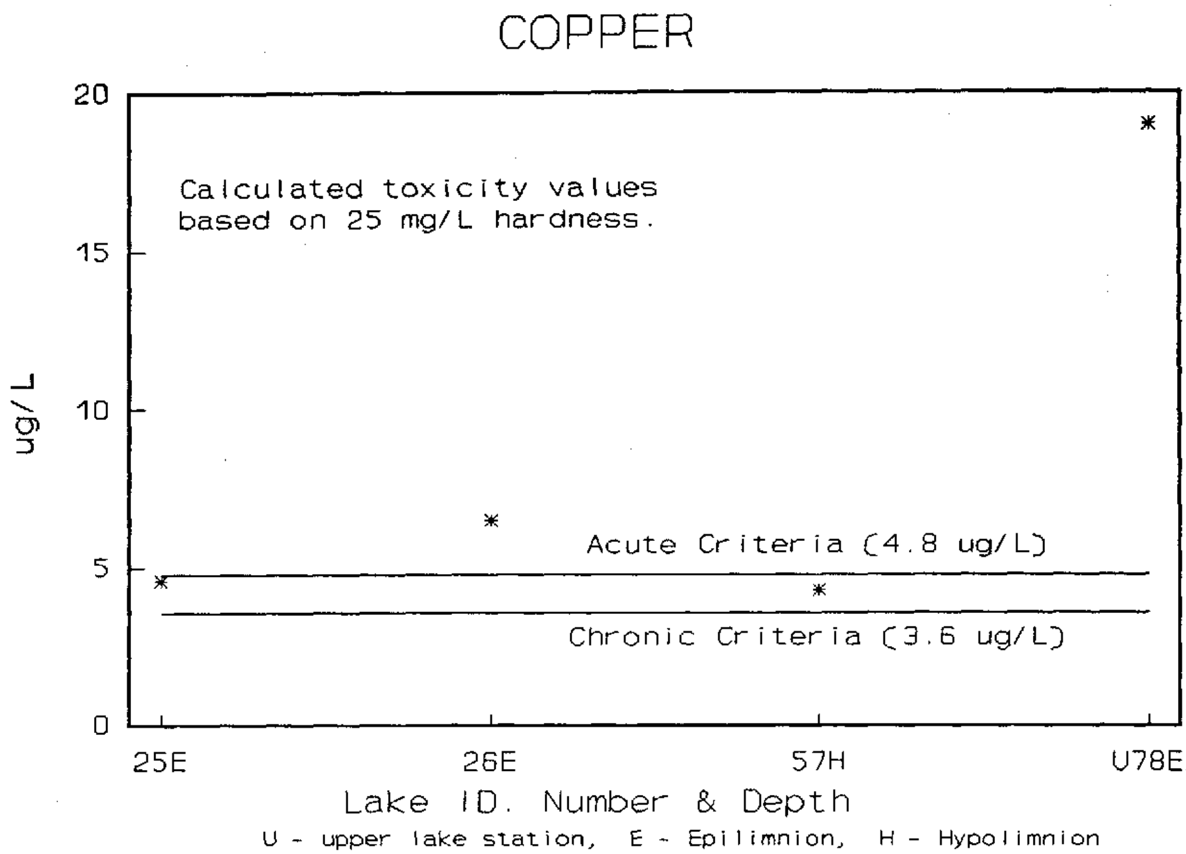
APPENDIX D

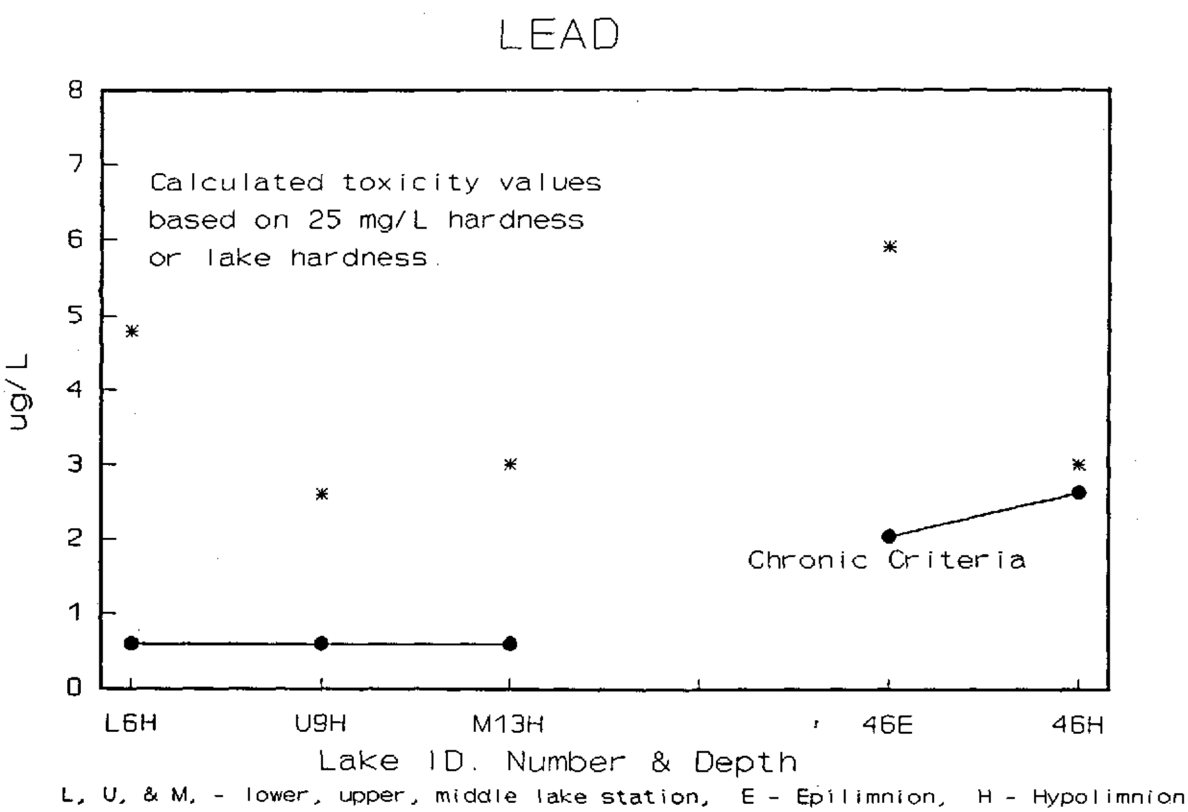
METALS TOXICITY IN LAKES

Metals concentrations which were above calculated values for acute and/or chronic toxicity criteria are plotted in the following figures. Lake identification numbers are used to identify the lake, an "E" or an "H" is used to identify it as either the epilimnion or hypolimnion sample and a "U", "M", or "L" is used to identify it as either the upper, middle, or lower lake station.

Example: M13H -- Middle Lake Ouachita hypolimnion sample.

Figure D-1 Metals Toxicity in Lakes





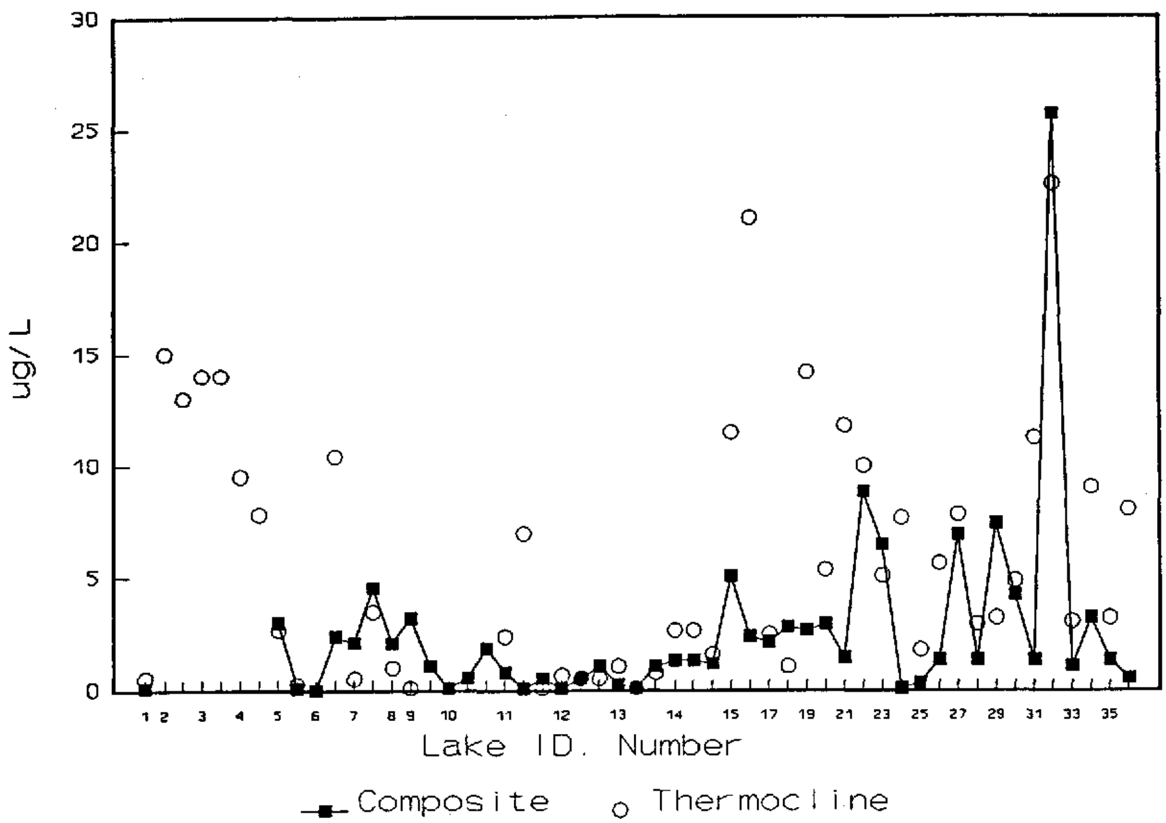
APPENDIX E

CHLOROPHYLL a DATA

COMPARISON BETWEEN EPILIMNION HYPOLIMNION LAKES DATA

Figure E-1 - Chlorophyll a

Type A and B Lakes



Type C,D, and E Lakes