CHLORIDE CONCENTRATIONS IN LILY CREEK/LAKE CUMBERLAND

by

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Division of Water

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TABLE OF CONTENTS

Introduction

On Thursday, October 6, 1988, Cliff Schneider, Terry Anderson, and Tom VanArsdall performed a chloride plume study on Lily Creek and Lake Cumberland. The chlorides come from the Union Underwear facility and pass through the Jamestown STP, which discharges to MP 7.35 of Lily Creek. This is about 1.75 miles above the impoundment. The purpose of the study was to follow the chlorides from the free - flowing portion of Lily Creek through the impounded portion of Lily Creek and then out into the main lake. A study plan was outlined (VanArsdall, 1988) and followed as closely as practical in the field. In general, chloride samples were taken at points identified by conductivity readings in the vertical profile (see field data in Appendix).

Results and Discussion

The day of the study was cool (40-55^{o}F) and sunny. According to the Corps of Engineers (1988), the lake elevation had been slowly dropping to 690.11 ft MSL on October 6. Average daily discharge through Wolf Creek Dam had been near 2100 cfs for several days. The first sample was taken at Site 1 in Lily Creek near the Hwy 619 bridge (MP 5.3) at 1035 hours. The last sample was taken near the state park water intake (Site 9) at 1922 hours. Due to failing daylight, sampling across a transect at Site 8 was not performed - only the in-channel station near the west bank was sampled.

Results of the sampling are provided in Figures 1 and 2, Table 1, and partially in Table 2. The Kentucky Division of Water (DOW) data in Table 1 includes only one representative profile at each transect. Table 1 also includes data collected by Kenvirons on September 29, 1988. Table 2 presents data routinely collected by DOW's lakes program. The graphs in Figures 1 and 2 represent chloride concentrations derived from: 1) sampling

results, and 2) calculations based on the relationship found between specific conductance and chloride (at depths where samples were not taken).

Chlorides were rapidly diluted from 2120 mg/l (a load of 17 tons/day) at Site 1 in Lily Creek to less than 100 mg/l in the headwaters of the impounded portion of Lily Creek (Site 2). While the plume was well-mixed in these shallow headwater waters, the highest levels further downstream toward the main lake tended to be found at 13 - 20 m. The highest chloride concentration (81 mg/l) found at MP 2.0 of Lily Creek (Site 3) was at 13 m. This indicates that fairly high chloride concentrations can persist in the impounded portion of Lily Creek upstream of the influence of the main lake. It is also evident that the highest chloride levels were found just above the zones of maximum temperature change at about 14 m and 18 m (see field data sheets in Appendix). Water above 14 m (the epilimnion) was well mixed, as seen by temperature changes of only about 0.3°C.

Near the mouth of Lily Creek (Site 4 at MP 0.15), the highest chloride levels of 18-19 mg/l were found from 16-28 m, depending on the location across the transect (Figure 1). As the chlorides then move into the main lake, they were diluted even further, as evidenced by maximum chloride levels of about 10 mg/l at Site 7 at 14 m (Figure 2). The control or background stations in the main lake above Lily Creek (Sites 5 and 6) had chloride concentrations of about 7 mg/l (Figure 2), so the increase of chlorides in the main lake was only 3 mg/l.

Kenvirons (1988) also collected chloride data in the Lily Creek embayment and main lake on September 29, 1988. Their data (Table 1) was for the most part very similar to that found in the present study. At MP 3.8 of Lily Creek, a maximum chloride concentration of 58 mg/l was found at 2 m. At MP 2.2, 85 mg/l was found at 14.6 m, and at the mouth of Lily Creek, 18.5 mg/l was present at 15.2 m.

The DOW maintains a lake ambient sampling station at MP 3.8 of Lily Creek. Data since 1987 is presented in Table 2; however, only a few chloride observations are available.

One surprising observation from the Kenvirons work was the 163.5 mg/l of chlorides found at MP 3.2 at 11.3 m. This could indicate a buildup of chlorides near the bottom in the headwaters of the Lily Creek embayment, and it is this layer that moves on out into the lake at a slightly greater depth. Another possibily is that at times a higher chloride loading is entering the lake. It is obvious from the DOW's July 1988 sample at MP 3.8 (Table 2) that there were greater chlorides present at that time than during the present study.

The data collected in September and October indicate that chloride concentrations were slightly elevated in the epilimnion, but were mostly contained at a depth just above the thermocline. These sort of autumn conditions tend to distribute some of the chloride load in the epilimnion, although the highest concentrations were usually found just above the thermocline. In the summer, the temperature changes much more rapidly between 5 and 10 meters, resulting in a shallower epilimnion, which is segregated both thermally and chemically from the denser effluent that is discharged into the lake. Thus, one would expect to find a narrower, more concentrated layer of chlorides during stratified conditions of summer. This would probably result in higher summertime chloride concentrations above the thermocline in the main lake than was found in the present study. However, as the chloride plume approaches the mouth of Lily Creek and is diluted by water from the main lake, it is likely that chlorides are only slightly higher in the main lake at any time of the year.

Bibliography

Kentucky Division of Water. 1988. Ambient Lakes Sampling Program Data for Lake Cumberland, September 28, 1988.

Kenvirons. 1988. Summary of Sampling Data - Chloride Measurements, Lake Cumberland, Lake Elevation 690.5, September 29, 1988.

U.S. Army Corps of Engineers. 1988. Personal communication October 11, 1988.

VanArsdall, T. C. 1988. Plan of Study of Chloride Plume from City of Jamestown STP into Lily Creek and Lake Cumberland, October 5, 1988. Kentucky Division of Water, Frankfort, Kentucky.

Table 1. Chloride Concentrations in Lily Creek and Lake Cumberland, Fall 1988

Ky Division of Water - October 6, 1988

Location	Site	Depth (m)	Chloride (mg/l)
Lily Creek MP 5.3 (stream sample)	1	Surface	2120
Lily Creek MP 3.8 (headwater of lake)	2	Composite	63.7
Lily Creek MP 2.0	3	1.0	41.2
		9.0	43.5
		13.0	81.0
		21.0	55.5

Kenvirons - September 29, 1988

Location	Depth (m)	Chloride (mg/l)
Lily Creek MP 3.8	0.6	45
	2.1	58
Lily Creek MP 3.2	0.6	40
	2.1	41.5
	7.3	61.5
	11.3	163.5
Lily Creek MP 2.7	0.6	34
	3.0	37
	7.3	45.5
	15.2	92.5
Lily Creek MP 2.2	0.6	27
	3.0	32.5
	7.3	43
	14.6	85
Lily Creek MP 1.7	0.6	22
	3.0	26
	7.3	32.5
	15.2	35.5

Table 1. Chloride Concentrations in Lily Creek and Lake Cumberland, Fall 1988 (Cont'd.)

Ky Division of Water - October 6, 1988				Kenvirons - September 29, 1988		
Location	Site	Depth (m)	Chloride (mg/l)	Location	Depth (m)	Chloride (mg/l)
				Lily Creek MP 0.9	0.2	14
					3.0	15
					7.3	22
					15.2	43.5
					30.5	29.5
Lily Creek MP 0.2	4	1.0	11.9			
		12.0	10.8			
		16.0	17.1			
		21.0	8.6			
		28.0	18.5			
Cumberland River	5	1.0	6.6	Wolf Creek	0.6	8.5
MP 477.0		12.0	7.1	MP 0.0 or	3.0	8.5
(control station)		20.0	5.2	Cumberland River	7.3	8.5
		25.0	5.1	MP 476.1 (control station)		
Wolf Creek MP 0.2	6	1.0	6.7	Lily Creek MP 0.0	0.2	9.0
(control station)		12.0	7.5	or	3.0	9.0
		20.0	5.0	Cumberland River	7.3	16.0
		32.0	5.5	MP 475.7	15.2	18.5
					27.4	7.5
Cumberland River	7	1.0	7.7	Cumberland River	0.2	9.0
MP 475.5		12.0	8.7	MP 475.5	3.0	9.0
(100 m from north bank)		14.0	9.1		7.3	12.5
		36.0	6.4		15.2	15.0
					30.5	10.0
Cumberland River	8	1.0	8.4			
MP 474.3		10.0	8.5			
		20.0	5.1			
		35.0	5.8			
Cumberland River	9	1.0	7.5			
MP 473.1		10.0	7.7			
		20.0	4.9			
		30.0	5.8			

Table 2. Water Quality Characteristics of the Upper Lily Creek Embayment, MP 3.8.[a]

	Temperature (°C)	Dissolved Oxygen (mg/l)	Specific Conductance (umhos/cm)	Cl^- (mg/l)
May 19, 1987				
1m	25.7	10.2	206	
4m	23.8	10.2	250	
5m	22.4	6.9	509	
6m	20.8	4.7	628	
7m	18.2	3.4	531	
10m	14.8	0.6	502	
12.3m (near bottom)	12.5	0.4	340	
August 4, 1987				
1m	30.6	8.1	273	
4m	30.2	5.8	340	
5m	29.7	2.0	566	
6m	29.0	0.4	615	
7m	26.4	0.1	583	
8m (near bottom)	24.5	0.1	508	
October 7, 1987				
1m	20.1	8.6	362	
4m	19.7	8.5	436	
4.5m (near bottom)	16.6	7.6	>1500	98
May 10, 1988				
1m	20.3	13.4	254	
7m	17.5	11.3	350	
8m	17.2	10.5	470	
8.9m (near bottom)	18.8	7.8	1844	136
July 27, 1988				
1m	29.3	10.6	452	
3m	28.8	4.3	525	
4m	28.8	3.4	647	
5m	27.5	4.5	1930	
5.2m (near bottom)	27.4	4.5	1957	183

Table 2 (Con't).
Water Quality Characteristics of the
Upper Lily Creek Embayment, MP 3.8.[a]

	Temperature (°C)	Dissolved Oxygen (mg/l)	Specific Conductance (umhos/cm)	Cl^- (mg/l)
September 28, 1988				
1m	24.4	9.5	410	
2m (near bottom)	24.2	8.2	435	
October 6, 1988				
1m	21.7	9.7	413	
2m	20.2	10.0	426	64
2.3m (near bottom)	19.9	9.1	425	

a Data from Kentucky Division of Water, Ambient Lakes Sampling Program

FIGURE 1. CHLORIDE CONCENTRATIONS IN LILY CREEK, OCTOBER 6, 1988

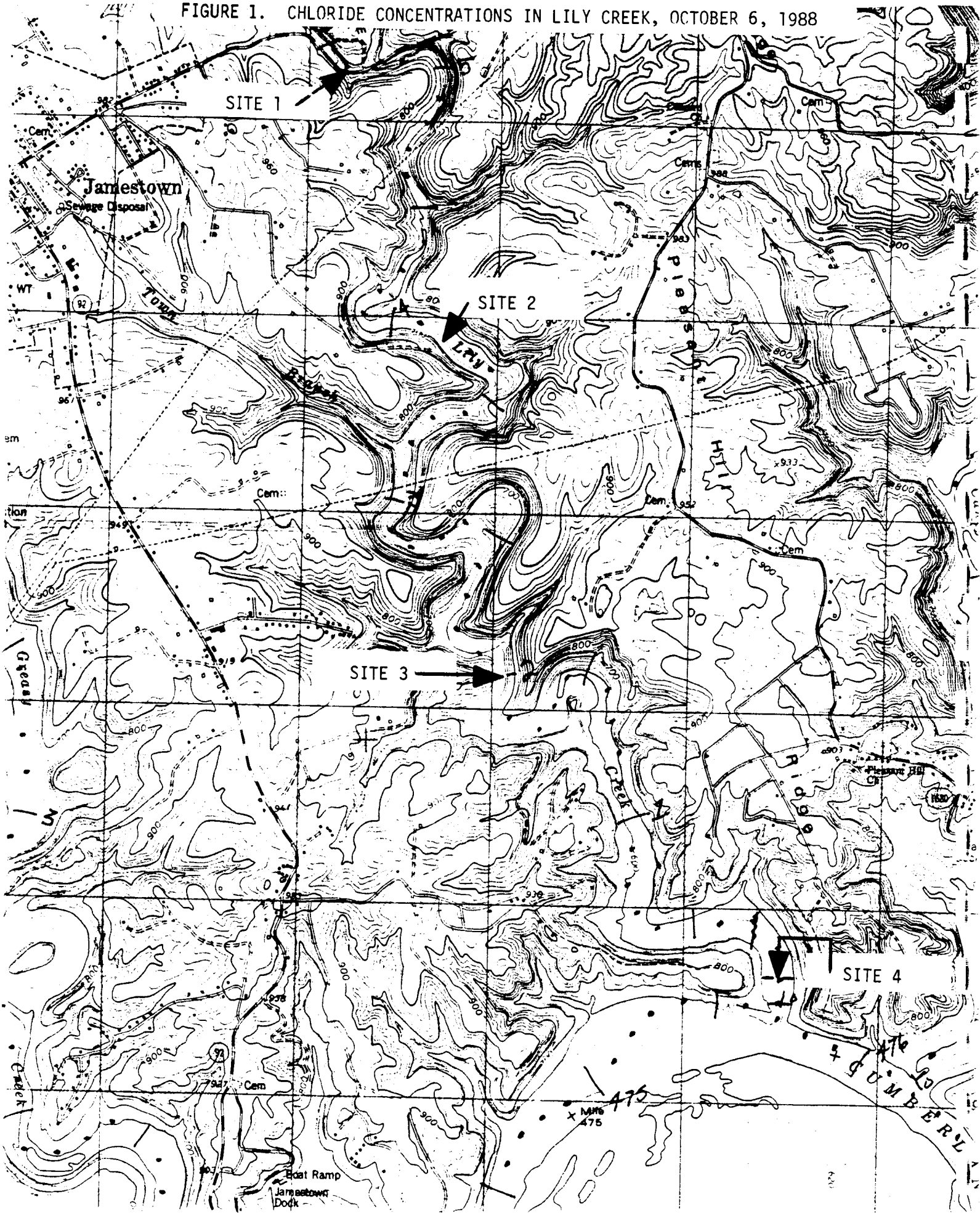


FIGURE 1 (cont)

SITE 1. Chloride = 2120 mg/l (stream sample)

SITE 2A. Chloride = 64 mg/l (sample composited vertically)

SITE 2B. Chloride = 56 mg/l (sample composited vertically)

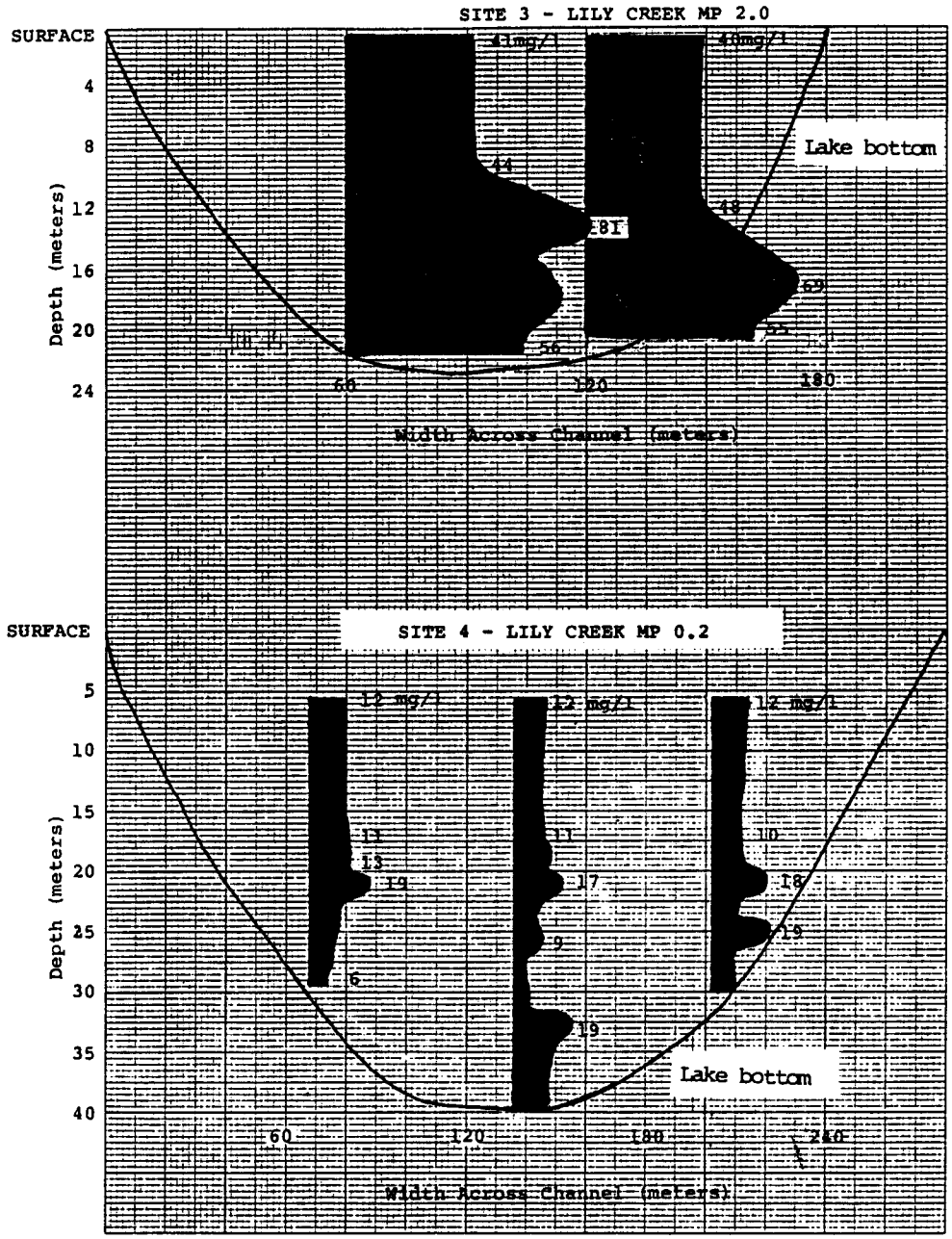


FIGURE 2. CHLORIDE CONCENTRATIONS IN LAKE CUMBERLAND, OCTOBER 6, 1988

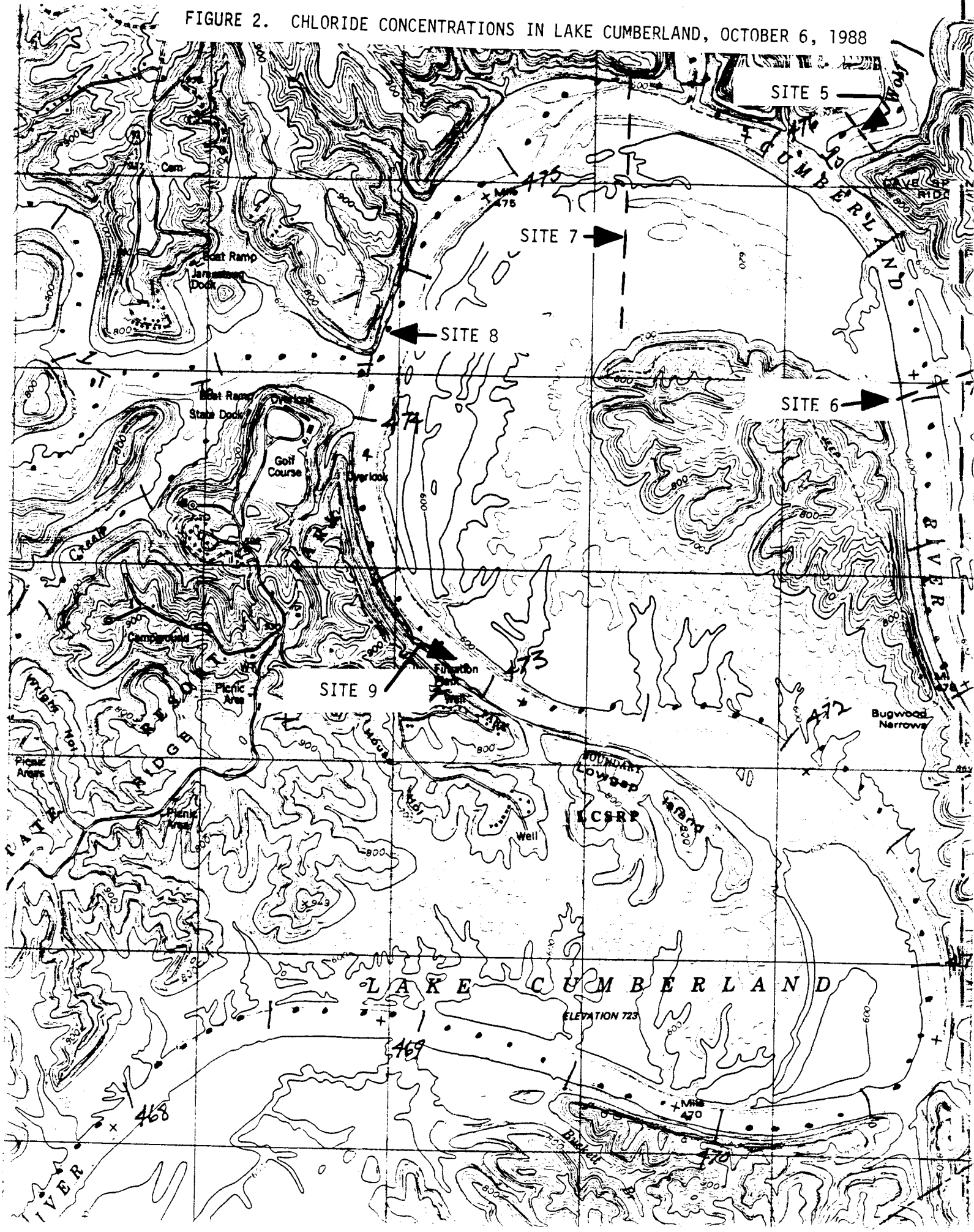
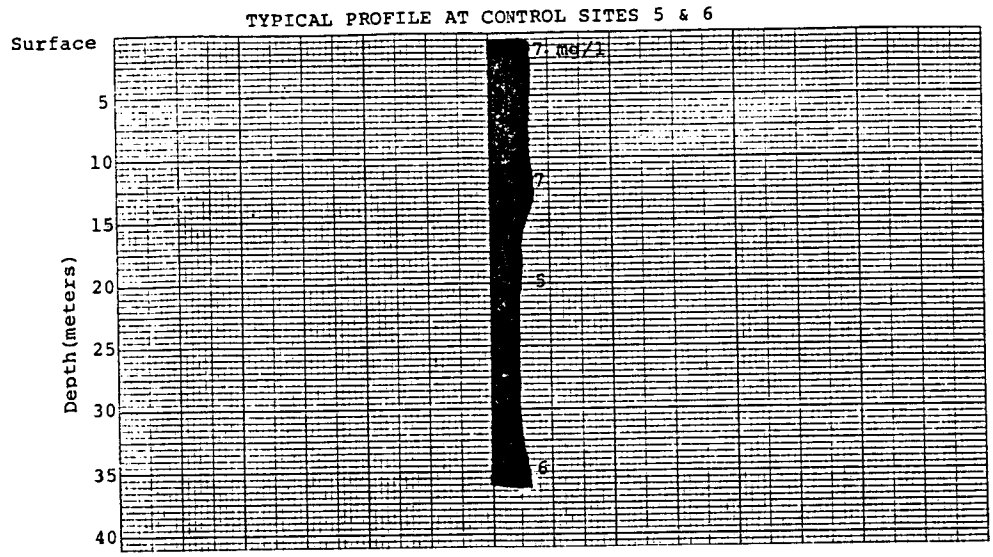
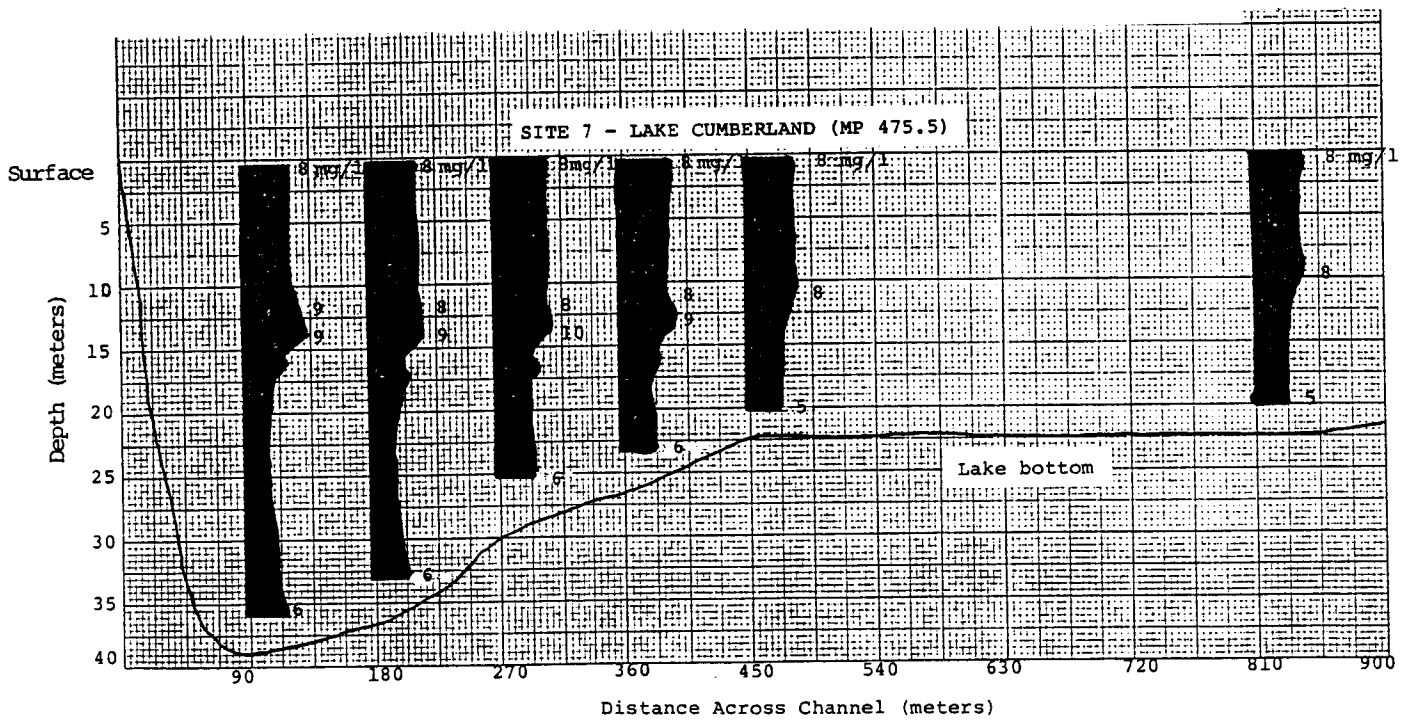


FIGURE 2 (Cont)





SITE 8. Maximum chloride concentration of 9 mg/l

SITE 9. Maximum chloride concentration of 8 mg/l

APPENDIX

Field Data Sheets

~~LAKE~~ Lilly Creek @ 619 Bridge				DATE 10-6-88		TIME 10:35	
Station 1							
: ☆ Flow on Back –							
Z	Temp	pH	D.O.	Cond.			
S	11.9	8.2	11.1	7320		Ft. Candles	
					Z		
					Surface		
						(1%)	
					METERS		
					Secchi-depth (ft)		

FIELD NOTES

Site 1 - Lily Cr @ 619 Bridge

Tape	STATION	DEPTH	WIDTH	REV	TIME (sec)	fps	FLOW (CFS)
20	1	1.1	1'	6	44	0.14	0.068
18	2	1.2	2'	5	41	0.12	0.299
16	3	1.2	2'	7	43	0.16	0.372
14	4	1.25	2'	8	41	0.20	0.495
12	5	1.2	2'	8	41	0.20	0.444
10	6	1.2	2'	7	41	0.17	0.420
8	7	0.9	2'	9	40	0.23	0.312
6	8	0.55	2'	8	41	0.20	0.162
4	9	0.4	2'	6	42	0.14	0.027
3.5		0.3	0.5	7	41	0.17	0.002
3	bank	0	0.5	0		0	
20.5		1.15	0.5	4	40	0.10	0.007

2.995 cfs

(1.932 mgd)

Cl⁻ Loading = 1.932 mgd × 8.345 × 2120 mg/L

= 34,180 lbs/day Cl⁻

(Annual Cl load ≈ 25 tons)

LAKE	Lilu Creek, Lake Cumberland	DATE	10-4-00	TIME	11:46
Station	2 (A)(LB)				

Z (m)	Temp	pH	D.O.	Cond.
S	21.6	8.6	10.0	416
1	21.7	8.7	9.7	413
2	20.2	8.7	10.0	426
2.3 Bottom	19.9	8.8	9.1	425

Z
Surface

Ft. Candles

(1%)

METERS

Secchi-depth (ft)

FIELD NOTES

LB - Looking Downstream from 50ft

LAKE Lily Creek Lake Cumber				DATE 10-6-88		TIME	
Station 2 (B) RB							
Z m	Temp	pH	D.O.	Cond.			
5	21.6	8.9	9.8	411		Ft. Candles	
1	21.7	8.8	9.8	412			
1.5	21.5	8.8	9.8	412			
2.3					Z		
					Surface		
						(1%)	
					METERS		
					Secchi-depth (ft)		

FIELD NOTES

60 ft off RB

LAKE	Cumberland			DATE	10/16/00	TIME	12 30
Station	3 (A) LB Light						
Z	Temp	pH	D.O.	Cond.			
Surface	[illegible]	8.4	[illegible]	36[illegible]		Ft. Candles	
1	22.7		[illegible]	362			
2	22.7	8.3	8.1	362			
3	22.7	8.2	7.9	363	Z		
4	22.7	8.3	7.9	367	Surface		
5	22.7	8.2	7.9	369			
6	22.7	8.1	7.8	370		(1%)	
9	22.7	8.1	7.7	370			
12	22.2	7.6	4.8	564	METERS		
13	21.6	7.4	4.1	630			
14	20.1	6.9	0.8	484			
15	18.6	7.2	0.3	403 *	Secchi-depth (ft)		
18	14.6	7.1	0	448 *			
21	11.2	7[illegible]	0	385			
bottom -2	10.9	7.1	0	375			

FIELD NOTES * double checked – true readings

LAKE Cumberland				DATE 10/6/88		TIME 1245	
Station #3 B B							
Z(m)	Temp	pH	D.O.	Cond.			
5.5	22.7	8.0	8.3	347		Ft. Candles	
3	22.7	8.2	7.8	358			
6	22.7	8.1	7.7	368			
9	22.6	8.1	7.6	364	Z		
12	22.5	8.1	7.3	382	Surface		
15	18.7	7.5	0.2	414			
16	16.8	7.1	0	433		(1%)	
17	15.7	7.0	0	448			
18	15.1	7.0	0	448	METERS		
19	12.5	7.1	0	412			
20	12.1	7.1	0	410			
21	11.5	7.1	0	395	Secchi-depth (ft)		
~							

FIELD NOTES

0

LAKE	Cumberland			DATE	10/6/88	TIME	1220
Station	4 (A) LB						
Z	Temp	pH	D.O.	Cond.			
Surface	22.4	8.0	9.2	237		Ft. Candles	
3	22.4	8.2	8.9	237			
6	22.4	8.1	8.6	236			
9	22.4	8.1	8.4	236	Z		
12	22.4	8.1	8.3	236	Surface		
14	20.0	7.5	3.8	246			
15	18.0	7.2	3.8	228		(1%)	
16	16.5	7.0	2.3	262			
17	14.9	7.0	3.0	240	METERS		
18	14.0	7.0	3.0	227			
21	11.0	7.1	1.8	224			
24	9.5	7.2	1.6	203	Secchi-depth (ft)		
27	8.8	7.2	1.4	209			
29	8.8	7.2	0.7	233			
~							

FIELD NOTES Double check cond.

LAKE	Cumberland			DATE	10/6/80	TIME	1144
Station	4 (E) middle						
Z	Temp	pH	D.O.	Cond.			
Surf	22.4	8.0	9.4	239		Ft. Candles	
3	22.5	8.1	8.9	237			
6	22.4	8.1	8.6	238			
9	22.4	8.1	8.2	243	Z		
12	22.4	8.0	8.2	236	Surface		
13	22.1	7.4	7.6	237			
14	19.9	7.3	3.8	243		(1%)	
~~15~~ 8				239			
10				240	METERS		
11				237			
15	18.4	7.5	3.7	231			
16	17.2	7.1	2.5	268			
17	15.2	7.1	3.0	238	Secchi-depth (ft)		
18	14.0	7.1	3.2	220			
19				201			
20				223			
21	11.9	7.1	1.8	226			
22				210			
23				210			
24	9.4	7.2	1.5	201			
25				205			
26				212			
27	9.0	7.1	0.6	247			
28				220			
29				227			
30	8.6	7.1	0.5	252			
31							
34	8.5	7.1	0.0	233			

b. Am 24.5

FIELD NOTES

LAKE	Cumberland			DATE	10/6/88	TIME	220
Station	4 (C) RB						
Z	Temp	pH	D.O.	Cond.			
Surf	22.5	8.1	9.1	240		Ft. Candles	
3	22.5	8.2	9.1	237			
6	22.4	8.2	8.7	242			
7				241	Z		
8				240	Surface		
9	22.4	8.0	8.2	239			
10				239		(1%)	
11				237			
12	22.3	8.0	8.1	235	METERS		
13				236			
14				234			
15	18.6	7.3	3.4	244	Secchi-depth (ft)		
16				274			
17				229			
18	14.4	7.2	3.3	213			
19				202			
20				257			
21	11.0	7.1	1.8	228			
22				200			
23				204			
24	9.2	7.2	1.6	202			
25				222			
26	9.1	7.7	9.7	222			

FIELD NOTES

wind blowing [illegible] Cr

LAKE	Cumberland			DATE	10/6/88	TIME	3:06
Station	5(A) LB						
Z	Temp	pH	D.O.	Cond.			
Surface	22.5	8.1	9.3	223		Ft. Candles	
3	22.5	8.1	8.9	223			
6	22.4	8.1	8.7	223			
9	22.3	8.1	8.5	224	Z		
12	22.3	8.0	8.2	222	Surface		
13				222			
14				222			
15	18.2	7.3	4.1	216		(1%)	
16				210			
17				208			
18	14.1	7.2	3.7	204	METERS		
19				203			
20				202			
21	11.2	7.3	2.5	201			
22				201			
23				200	Secchi-depth (ft)		
24	9.4	7.3	1.5	200			
25				201			
26				202			
27	8.9	7.3	1.5	203			
28				203			
29				203			
30	8.7	7.3	1.5	203			
35	7.3	7.3	1.3	208			
39	7.1	7.3	1.2	209			

FIELD NOTES

LAKE	Cumberland			DATE 10/6/88		TIME 3:34	
Station	5 (E) MC						
Z	Temp	pH	D.O.	Cond.			
Surf	22.5	8.0	9.2	223		Ft. Candles	
5	22.5	8.2	9.0	223			
5	22.7	8.2	8.9	223			
10	22.3	8.0	8.5	223	Z		
11				223	Surface		
12				223			
13				223		(1%)	
14				220			
15	18.1	7.4	4.2	215	METERS		
16				210			
17				210			
18				205			
19				202	Secchi-depth (ft)		
20	11.7	7.3	3.0	201			
21				200			
22				200			
23				200			
23.4	9.4	7.3	1.5	200			
Bottom							

FIELD NOTES

LAKE	Cumberland			DATE	12/6/82	TIME	4:00
Station	5C (RB)						
Z	Temp	pH	D.O.	Cond.			
surf	22.5	7.9	2.8	222		Ft. Candles	
5	22.4	8.1	2.9	222			
10	22.3	8.1	8.16	224			
11				224	Z		
12				223	Surface		
13				223			
14				222		(1%)	
15	18.0	7.5	4.3	215			
16				211	METERS		
17				210			
18				205			
19				202	Secchi-		
20	11.8	7.4	3.1	202	depth (ft)		
21				200			
22				200			
23				201			
24				201			
25	4.2	7.4	1.5	202			
26				201			
27				201			
28	8.9	7.4	1.4	203			
28.3							

FIELD NOTES

LAKE	Cumberland - Wolf Cr MF 0.1			DATE	10/6/98	TIME	4:48
Station	6 (MC) 27 5 7 0 E						
Z	Temp	pH	D.O.	Cond.			
5	23.4	8.1	9.1	220		Ft. Candles	
5	22.4	8.0	8.7	222			
10	22.4	8.0	8.5	224			
11				223	Z		
12				224			
13				224	Surface		
14				222			
15	18.0	7.4	4.4	215			
16				211			
17				207		(1%)	
18				206			
19				202			
20	11.8	7.3	2.7	202	METERS		
21				201			
22				201			
23				201	Secchi-depth (ft)	14.0	
24				201			
25	9.4	7.3	1.6	201			
26				201			
27				203			
28				204			
29				208			
30	8.4	7.4	1.4	208			
35	8.3	7.3	1.3	208			
Bottom							

FIELD NOTES Calm Day

LAKE	Cumberland MP 475.5			DATE	10/6/88	TIME	4:50
Station	7-1 RB 300ft						
Z	Temp	pH	D.O.	Cond.			
0	22.4	8.4	9.1	226		Ft. Candles	
1				226			
2				225			
3	22.5	8.3	8.7	225	Z		
4				225	Surface		
5				227			
6	22.4	8.2	8.5	226		(1%)	
7				227			
8				227	METERS		
9	22.4	8.1	8.4				
10				227			
11				226	Secchi-depth (ft)		
12	22.4	8.0	8.1	227			
13				227			
14				231			
15	18.1	7.4	4.0	221			
16				211			
17				212			
18	14.4	7.2	2.0	208			
19				206			
20				204			
21	11.0	7.2	2.2	202			
22				202			
23				201			
24	9.4	7.4	1.6	202			
25				203			
26				204			
27	8.8	7.3	1.4	205			
28				209			
29							
30	8.5	7.3	1.3	207			
35	8.3	7.3	1.4	208			
L. Hor. @39	8.2	7.4	1.4	207			

FIELD NOTES

LAKE	Cumberland MP 475.5			DATE	10/6/88	TIME	5:20
Station	72) 600' from north bank						
Z	Temp	pH	D.O.	Cond.			
Surf	22.4	8.0	9.1	225		Ft. Candles	
1				225			
2				225			
3	22.4	8.0	8.9	225	Z		
4				225	Surface		
5				225			
6	22.4	8.1	8.8	226			
7				227		(1%)	
8				227			
9	22.4	8.1	8.6	227			
10				227			
11				227	METERS		
12	22.3	8.0	8.2	227			
13				230			
14				230			
15	18.2	7.4	3.9	224	Secchi-		
16				212	depth (ft)		
17				211			
18	14.8	7.3	3.6	216			
19				204			
20				205			
21	11.2	7.3	2.3	201			
22				201			
23				201			
24	9.4	7.3	1.6	201			
25				202			
26				203			
27	8.7	7.3	1.6	204			
30	8.5	7.3	1.5	208			
35	8.2	7.3	1.5	206			
L. Hon 37							

FIELD NOTES

LAKE	Cumberland MP 475.5			DATE	10/5/82	TIME	5:40
Station	7B) 300yds from south bank						
Z	Temp	pH	D.O.	Cond.			
Surf	22.2	7.9	8.9	225		Ft. Candles	
1				225			
2				226			
3	22.4	8.0	8.7	226	Z		
4				226 227	Surface		
6	22.4	8.1	8.6	228			
7 8				227 227		(1%)	
9	22.3	8.1	8.6	227			
10 11				227 229	METERS		
12	22.3	8.0	8.3	227			
13 14				229 225			
15	17.8	7.2	3.7	222	Secchi- depth (ft)		
16				211			
17				221			
18	14.3	7.1	3.6	210			
19				208			
20				204			
21	11.0	7.2	3.3	203			
22				201			
23				202			
24	9.3	7.3	1.6	203			
25				203			
26				204			
27	8.7	7.3	1.5	206			
28				206			
29				208			
Bottom 30	8.5	7.3	1.5	207			

FIELD NOTES

LAKE Cumberland				DATE 1/6/82		TIME 6:00	
Station 7(4) 400 yds from N bank							
Z	Temp	pH	D.O.	Cond.			
[illegible]	22.4	8.0	9.2	226		Ft. Candles	
1				225			
2				225			
3	22.4	8.1	8.9	226	Z		
4				226	Surface		
5				226			
6	22.4	8.1	8.8	226		(1%)	
7				227			
8				227	METERS		
9	22.2	8.1	8.6	226			
10				227			
11				227			
12	22.2	8.0	8.3	227	Secchi-depth (ft)		
13				229			
14				223			
15	17.7	7.3	4.0	219			
16				214			
17				216			
18	17.1	7.2	3.3	206			
19				202			
20				201			
21							
22							
23							
24							
25							
26							

FIELD NOTES [illegible] 90' (27m)

LAKE Cumberland	DATE 10/6/88	TIME 6:20
Station 7(5) 500 yds from N bank		

Z	Temp	pH	D.O.	Cond.
Surf	22.3	8.1	9.4	226
1				226
2				226
3	22.4	8.1	9.0	226
4				226
5				226
6	22.4	8.1	8.8	227
7				227
8				227
9	22.3	8.1	8.5	227
10				227
11				227
12	22.3	8.0	8.3	228
13				228
14				228
15	17.5	7.4	4.0	215
16				214
17				214
18	14.2	7.3	3.6	209
19				203
20	12.0	7.3	3.1	204
Bottom 23	9.7	7.3	2.0	202

	Ft. Candles	
Z Surface		
	(1%)	
METERS		
Secchi-depth (ft)		

FIELD NOTES

LAKE	Cumberland MP 475.5			DATE	10/6/88	TIME	6:35
Station	7(6) 250 yds. from S Bank						
Z	Temp	pH	D.O.	Cond.			
Surf	22.3	8.0	9.1	226		Ft. Candles	
1				226			
2				227			
3	22.1	8.1	8.8	227	Z		
4				226	Surface		
5				226			
6	22.4	8.1	8.6	227		(1%)	
7				227			
8				227	METERS		
9	22.3	8.1	8.3	227			
10				227			
11				228	Secchi-depth (ft)		
12	22.2	7.9	8.0	228			
13				227			
14				226			
15	18.6	7.5	4.6	215			
16				212			
17				209			
19	12.6	7.2	3.4	205			
20		~~7.5~~	~~1.4~~	~~205~~			
Bottom 3	9.4	7.3	1.4	205			

FIELD NOTES

LAKE	Cumberland MF 474.3			DATE	10/6/82	TIME	6:55
Station	8(1) (130 yds from W Bank						
Z	Temp	pH	D.O.	Cond.			
Surf	22.2	8.2	9.3	228		Ft. Candles	
1				229			
2				229			
3	22.4	8.2	9.1	229	Z		
4				229	Surface		
6	22.4	8.2	9.1	229			
7				229		(1%)	
8				229			
9	22.4	8.2	9.0	229			
10				229	METERS		
11							
12	22.4	8.2	8.9	229			
13				229			
14							
15	18.0	7.5	3.9	219	Secchi-depth (ft)		
16				217			
17							
18	13.8	7.3	3.6	210			
19				206			
20	11.3	7.4	2.7	206			
25	9.2	7.4	1.8	204			
30	8.3	7.4	1.7	209			
35	8.2	7.4	1.7	208			
bottom 40	8.1	7.4	1.8	206			

FIELD NOTES

LAKE	Cumberland MP 473.0			DATE 10/3/88		TIME 7:20	
Station	9(1) 150ft from W/bank						
Z	Temp	pH	D.O.	Cond.			
Surf	22.5	9.4	9.3	227		Ft. Candles	
1				222			
2				228			
3	22.4	8.7	7.1	228	Z		
4				227 227	Surface		
6	22.4	8.5	9.1	228			
7 8				227 227		(1%)	
9	22.3	8.2	8.6	227			
10 11				227 227	METERS		
12	22.2	8.1	8.3	227			
13 14				226 218			
15	18.2	7.5	4.7	215	Secchi-depth (ft)		
16 17				211 210			
18	15.9	7.4	3.9	207			
19	11.6	7.4	3.1	204 204			
25	9.0	7.4	2.1	204			
30	8.4	7.5	2.0	207			
bottom 33	8.2	7.5	2.0	207			

FIELD NOTES