

WATER QUALITY STUDY

Kaw Lake Arkansas River, Oklahoma

by

**S.L. Burks
Aquatic Life Consultants, Inc.
1978**



**US Army Corps
of Engineers
Southwestern Division
Tulsa District**

FILED ON STORET BY:

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Final Completion Report
Contract No. DACW56-78-C-0194

Water Quality Study
Kaw Lake, Arkansas River, Oklahoma

for

Tulsa District, Corps of Engineers

by

S. L. BURKS
Aquatic Life Consultants, Inc.

Scope of Project.

Aquatic Life Consultants, Inc. conducted field collections and laboratory analyses of water samples from 11 locations on the Arkansas River and Kaw Lake from June to September, 1978. Interim reports were provided to the Tulsa District, Corps of Engineers' Offices by the 20th day of each month following a collection.

Location of Sampling Stations.

Station A was located on the Arkansas River at the west end of Highway 60 bridge (Figure 1) and (Figure 2a and 2b). Station B was located at the buoy line upstream from the Kaw Lake Dam (Figure 1) and (Figure 3a and 3b). Depth of water at this station was 75 feet (Figure 12). Samples were collected at surface (1M), 11M, 20M and at 22M (bottom) for laboratory analyses.

Station C was located at the mouth of a small cove west of Kaw City (Figure 1) and (Figure 4a and 4b). Depth of water at this station varied from 37 to 55 feet in the deepest channel (Figure 12). Water samples were collected at surface (1M), 11M and bottom.

Station D was located in the deepest portion of the lake northeast of Burbank landing (Figure 1) and (Figure 5a and 5b). Depth of water at this station was 50 feet (Figure 12). Water samples were collected at surface (1M), 11M and bottom.

Station E was located northeast of Washunga Bay beneath a county bridge that crossed the Beaver Creek channel (Figure 1) and (Figure 6a and 6b). Depth of water at this station was 45 feet in the channel (Figure 12). Samples were collected at surface (1M) and bottom.

Station F was located in the upper end of Beaver Creek arm of Kaw Lake (Figure 1) and (Figure 7a and 7b). Depth of water at this station

was 39 feet in the channel (Figure 12). Samples were collected at surface (1M) and bottom.

Station G was located north of Kaw City (Figure 1) and (Figure 8a and 8b). Depth of water was 36 to 38 feet (Figure 12). Samples were collected at surface (1M) and bottom.

Station H was located near the mouth of Bear Creek Cove (Figure 1) and (Figure 9a and 9b). Depth of water was only 8 to 15 feet at this location (Figure 12). Samples were collected at surface (1M) and bottom.

Station I was located south of county road bridge due east of Newkirk (Figure 1) and (Figure 10a and 10b). Depth of water at this station was so shallow that only one collection was made by boat, the remainder of the samples were collected from the bridge. Only surface (1M) samples were collected.

Station J was located on the Arkansas River below Highway 77 bridge near Arkansas City, Kansas (Figure 1) and (Figure 11a). Only surface water samples were collected.

Station K was located on Walnut River below Highway 166 bridge near Arkansas City, Kansas (Figure 1) and (Figure 11b). Only surface water samples were collected.

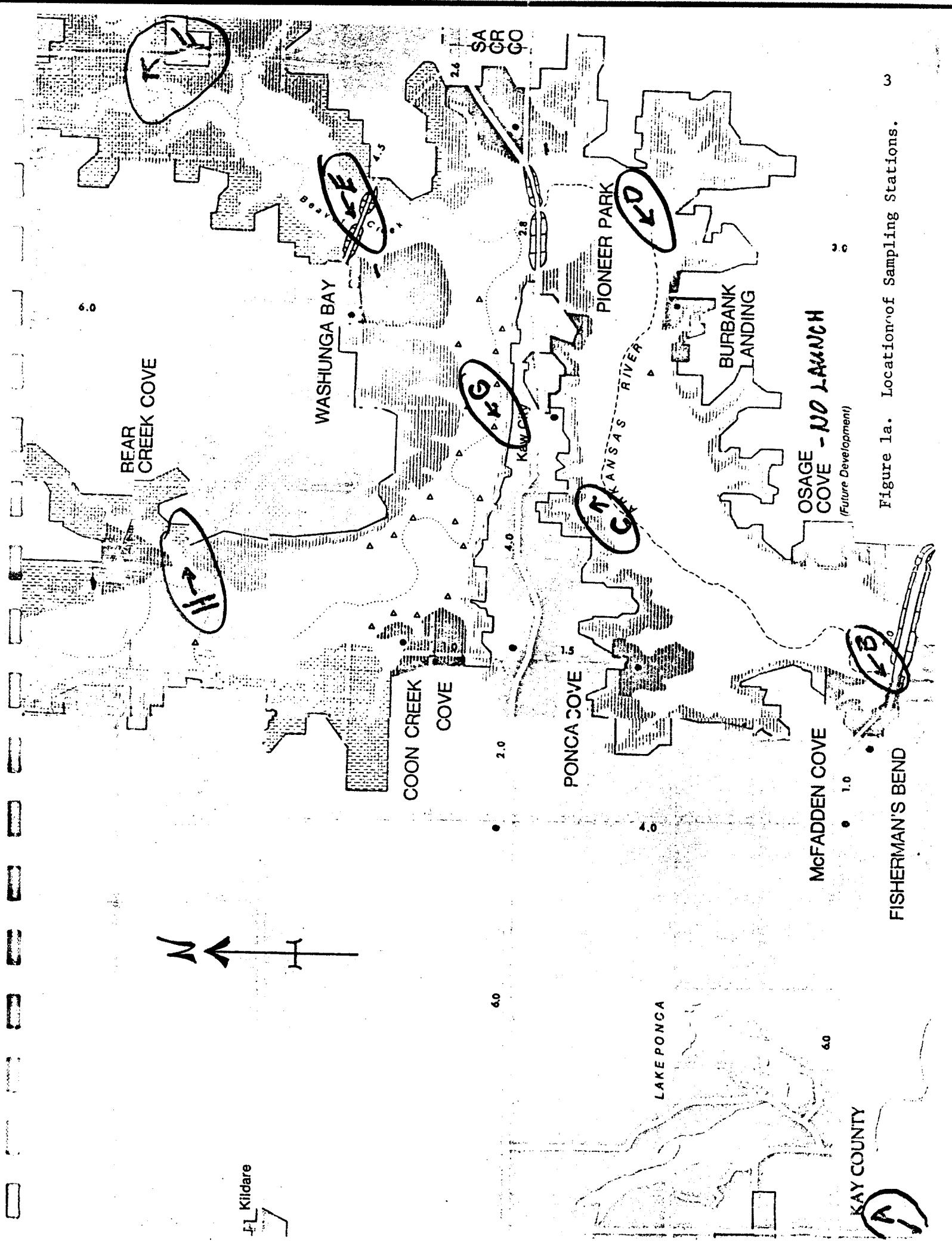


Figure 1a. Location of Sampling Stations. 3

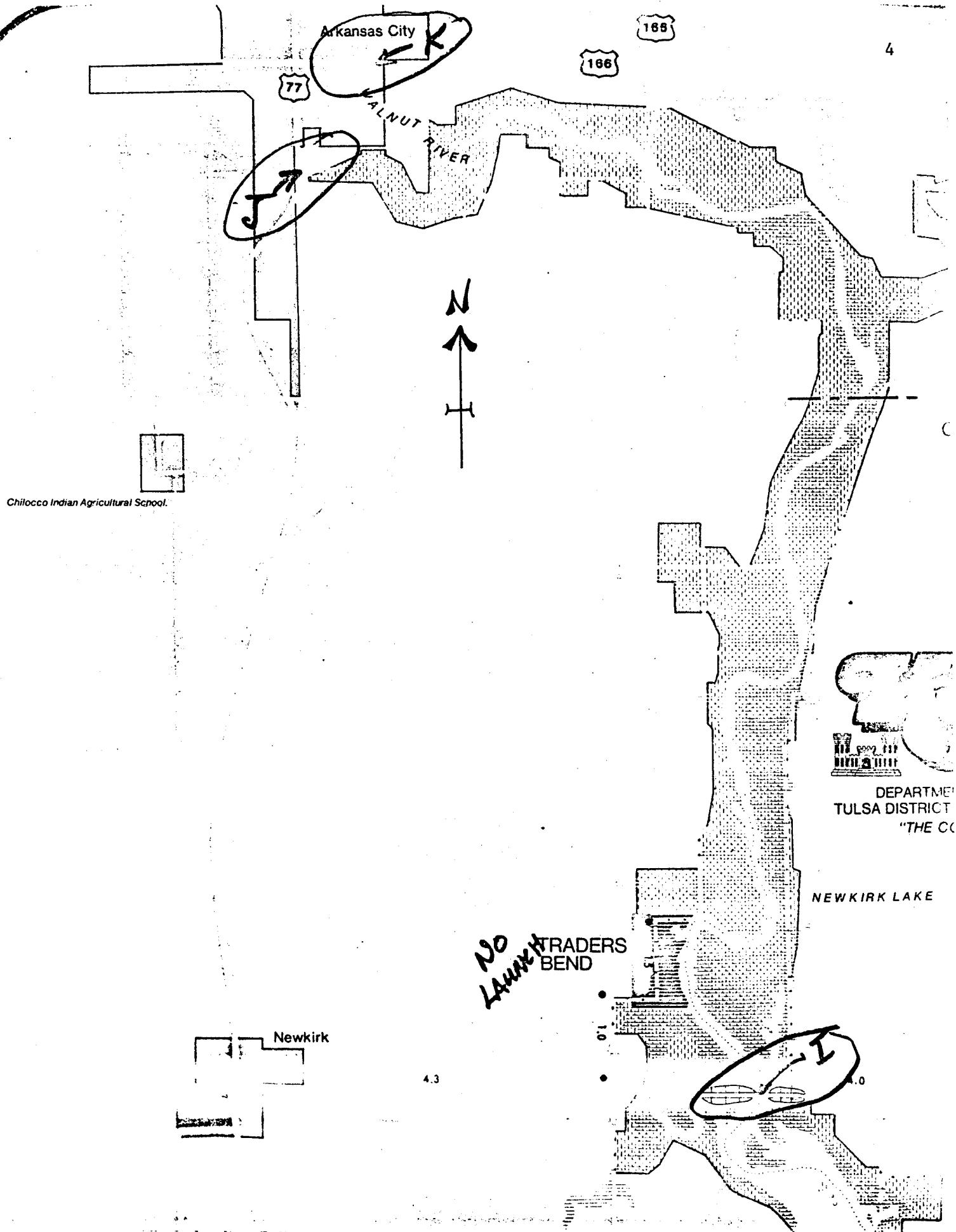


Figure 1b. Location of Sampling Stations.

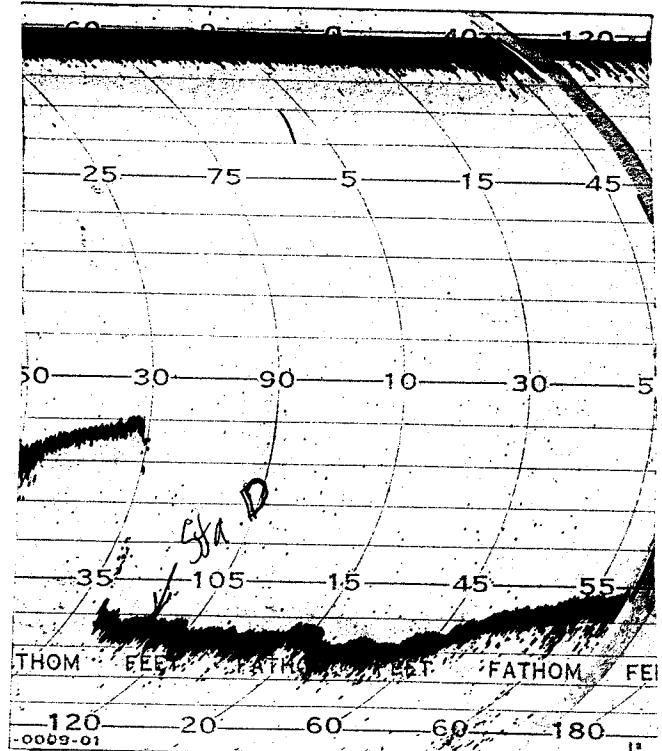
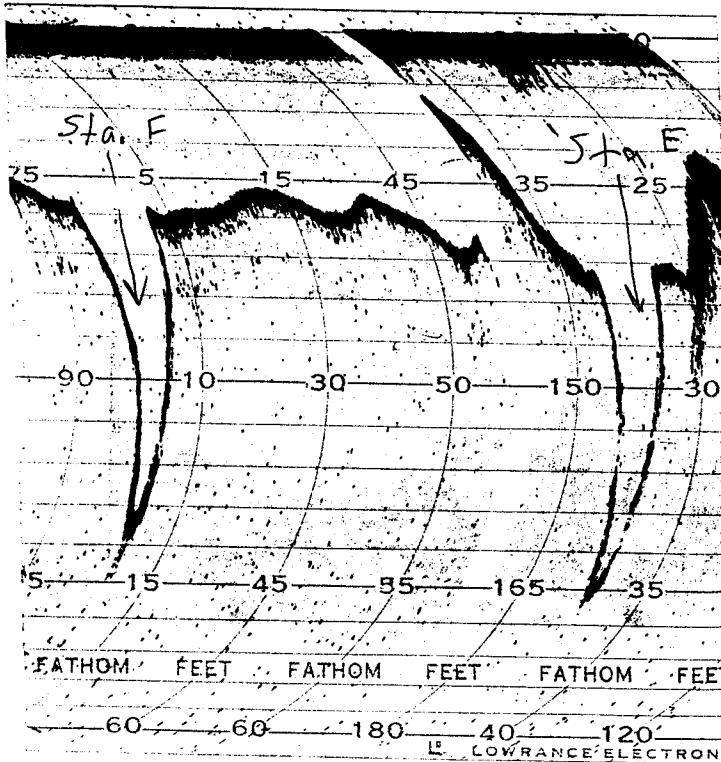
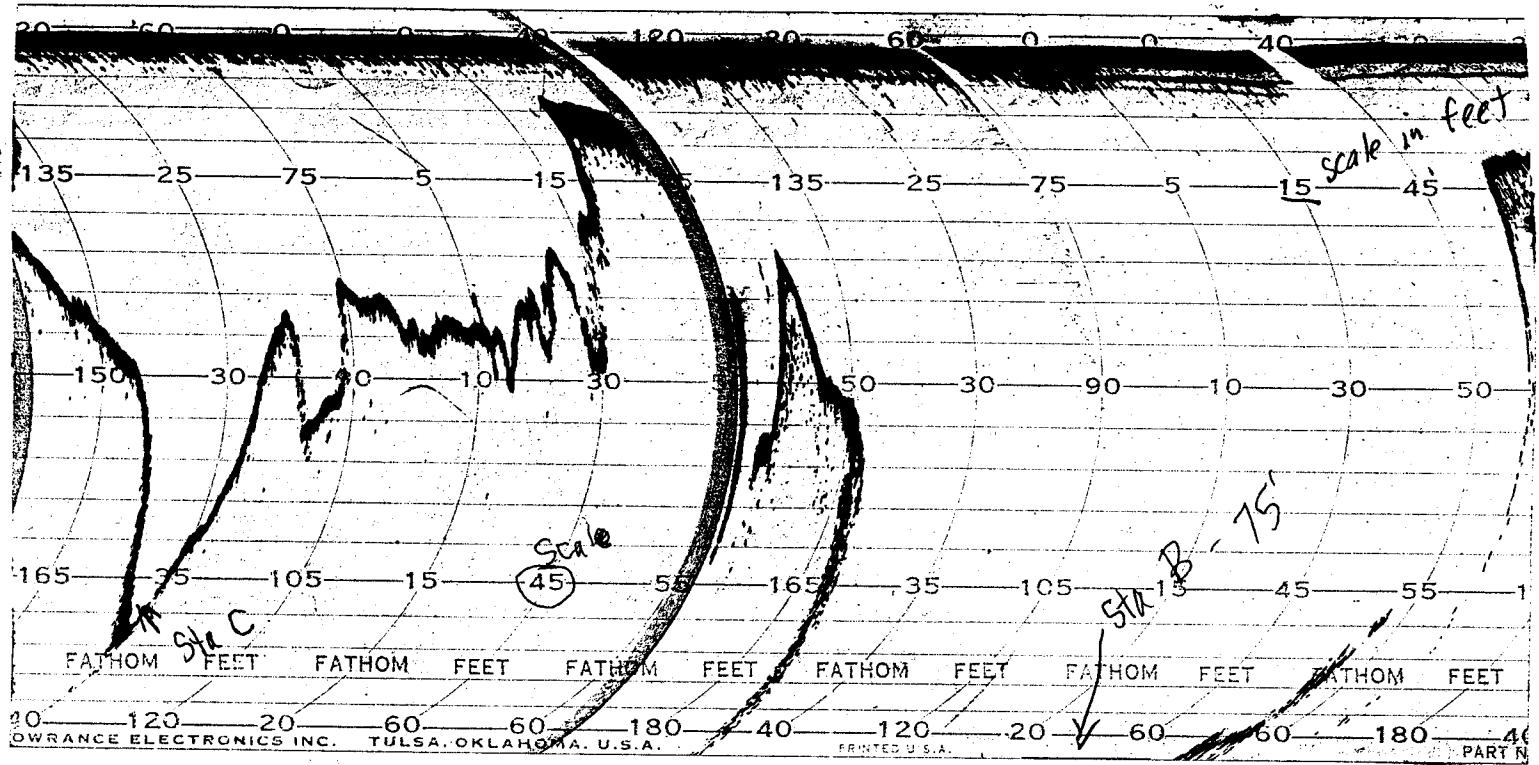


Figure 12. Graph of depth finder readings at each lake station.

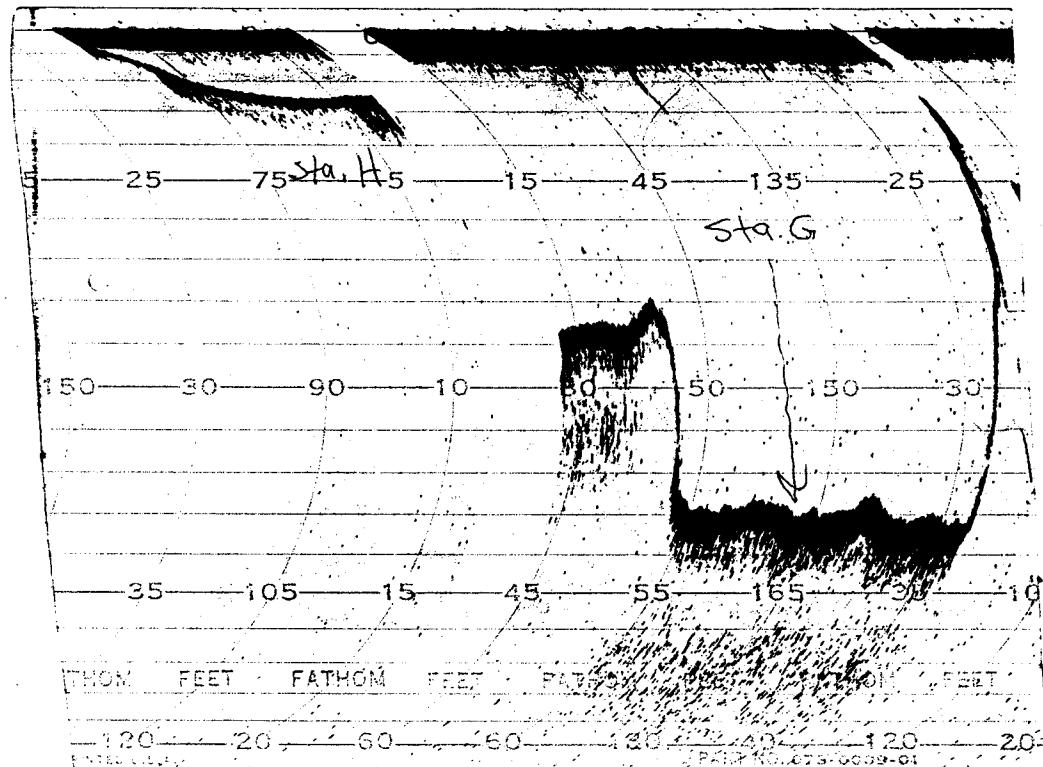


Figure 12 (continued). Graph of depth finder readings at each lake station.

METHODS

Field Collections and Analysis

Water samples for phosphate analyses were collected in acid-washed glass bottles and placed on ice until analyzed in the laboratory. Analyses were performed within 24 hours after collection. Water samples for heavy metals analyses (Fe, Mn and Pb) were collected in polyethylene bottles and acidified with 0.5 ml of concentrated nitric acid in the field. Water samples for mercury analyses were collected in acid-washed glass BOD bottles and acidified with 0.5 ml of concentrated nitric acid. Mercury analyses were performed within 24 hours after collection. Water samples for all other laboratory analyses were collected in polyethylene bottles and placed on ice. Nitrate, nitrite, and alkalinites were analyzed within 24 hours after collection.

Field measurements of dissolved oxygen were performed with either a Hydrolab Surveyor or a YSI oxygen probe. Both units were air calibrated and adjusted for atmospheric pressure and ambient air temperature. Conductivity was measured with either a Hydrolab Surveyor or a YSI salinity-conductivity probe. Both units were calibrated against a standard KCl solution according to APHA Standard Methods. Field measurements of pH were performed with either a Hydrolab Surveyor or a portable Orion Specific Ion Meter. Probes were calibrated against standard buffers of 7.00 and 9.16 pH. Depth of water was recorded with a Lowrance recording depth finder. Subsurface water samples were pumped from desired depths with a nylon impeller 12-volt bilge pump through polyethylene hoses. A backup subsurface Van Dorn water sampler was used to supplement the pump system.

Laboratory Analyses

Metals: The cold flameless atomic absorption method was used to analyze samples for concentration of mercury (Hatch and Ott 1968). Total iron and manganese were analyzed by flame atomic absorption. Samples were digested in accordance with EPA procedures (EPA 1974). Total lead in the digested samples was analyzed by heated graphite atomizer accessory for atomic absorption. Organic background was corrected for by subtracting absorbance obtained with a hydrogen lamp from that obtained by normal lead cathode lamp. Matrix interferences were corrected for by methods of standard addition. All other analyses were performed in accordance with APHA Standard Methods.

RESULTS

Water quality conditions at the uppermost Station I in Kaw Lake were below normal on 17 September 1978. Concentration of dissolved oxygen was only 3.4 mg/l at 11:00 A.M. (Figures 13,14 & 15). Normally, algal photosynthetic activity during daylight hours would produce enough oxygen for concentrations to be near saturation. Apparently, biodegradable organic substances were present in the incoming river water and were causing an excessive oxygen demand. Probably the concentration of dissolved oxygen was near zero during the night. A few dead shad were observed in the area.

Overall, water quality in the main body of Kaw Lake on 17 September was similar to previous surveys collected in June, July and August (Tables 1 through 4). In general, the total dissolved solids concentration in Kaw Lake was in excess of maximum permissible criteria of 500 mg/l recommended by USPHS in 1978. The National Academy of Sciences (1972)

did not establish limits upon total dissolved solids but upon individual chemicals such as chlorides. The National Academy of Sciences recommended that the maximum permissible concentration of chlorides in drinking water supplies be limited to less than 250 mg/l. The concentration of chlorides in Kaw Lake were generally less than 250 mg/l. However, the chloride concentration in the main body of Kaw Lake ranged from 120 to 280 mg/l. Therefore, Kaw Lake water would meet maximum allowable concentrations of chlorides most of the time.

Iron and manganese were measured as the total concentration, i.e. dissolved plus suspended. The NAS (1972) and USPHS (1968) maximum permissible criteria were 0.3 mg/l and 0.05 mg/l for soluble iron and manganese, respectively. The total concentration of iron and manganese both exceeded these levels. However, the soluble concentration possibly was less than the recommended maxima. Similarly, total lead concentration in some Kaw Lake samples exceeded the maximum permissible criteria of 0.05 mg/l.

All other chemical parameters were within acceptable levels as recommended by both NAS (1972) and USPHS (1968).

Primary station codes for EPA's STORET water quality database for sampling locations described in this report are as follows:

<u>Sampling Location</u>	<u>Primary Station Code</u>
A	OKN0131
B	OKN0096
C	OKN0097
D	OKN0098
E	OKN0099
F	OKN0100
G	OKN0101
H	OKN0102
I	OKN0103
J	KSS0012
K	KSS0013

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Table 1 Continued. Summary of Field Chemical Analyses
of Kaw Lake.

Station	Date	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
A	24 June	8.2	24.8	7.6	800
	15 July	7.7	26.0	7.6	850
	19 Aug	6.9	22.0	7.6	550
	17 Sep	5.2	25.0	8.3	1000
I	24 June	6.7	30.0	7.8	700
	15 July	7.9	30.5	8.4	1200
	19 Aug	3.0	25.0	8.4	2200
	17 Sep	3.4	27.5	8.8	2300
J	24 June	6.8	28.0	8.6	1200
	15 July	11.4	29.0	9.1	2200
	19 Aug	10.6	22.0	9.0	2100
	17 Sep	9.4	27.0	8.9	2700
K	24 June	6.8	27.0	7.4	390
	15 July	9.2	32.0	8.2	1100
	19 Aug	4.6	25.0	7.4	1250
	17 Sep	5.8	28.0	7.8	1380

Table 1. Field Chemical Analyses of Kaw Lake, 24 June 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
B	1	7.3	24.5	8.03	700
	3	7.25	24.5	8.0	628
	6	7.20	24.5	8.0	620
	9	7.15	24.5	8.0	620
	12	7.15	24.5	8.0	620
	15	7.15	24.5	8.0	620
	18	7.15	24.5	8.0	625
	21	7.15	24.5	8.0	625
	24	7.10	24.5	8.0	625
	27	7.10	24.5	8.0	630
	30	7.10	24.5	8.0	625
	33	7.05	24.5	8.0	630
	36	6.95	24.5	7.95	630
	39	6.90	24.5	7.95	630
	44	6.7	24.2	7.95	625
	66	4.3	23.25	7.6	650
	69	3.4	23.25	7.6	670
	75	2.0	23.0	7.45	655

Table 1. Field Chemical Analyses of Kaw Lake, 24 June 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
C	1	7.7	25.0	8.0	660
	3	7.7	24.5	8.0	650
	6	7.7	25.0	8.0	650
	9	7.7	25.0	8.0	650
	12	7.7	25.0	8.0	660
	15	7.6	24.0	8.0	660
	18	7.7	25.0	8.0	660
	21	7.6	24.0	8.1	670
	24	7.6	25.0	8.0	660
	27	7.5	25.0	8.0	660
	30	7.5	25.0	8.0	660

Table 1. Field Chemical Analyses of Kaw Lake, 24 June 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
D	1	9.6	26.0	7.7	715
	3	9.5	26.0	7.7	710
	6	9.5	26.0	7.8	710
	9	9.4	26.0	7.8	710
	12	9.4	26.0	7.9	715
	15	9.3	26.0	8.0	715
	18	9.2	26.0	8.2	715
	21	9.3	26.0	8.2	720
	24	9.2	26.0	8.3	720
	27	9.2	26.0	8.3	720
	30	9.1	26.0	8.3	720
	33	9.3	26.0	8.5	720
	46	7.5	26.0	8.8	720

Table 1. Field Chemical Analyses of Kaw Lake, 24 June 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
E	1	7.1	25.5	8.0	630
	3	7.0	25.5	7.9	620
	6	6.9	26.0	7.9	620
	9	6.9	25.7	7.9	620
	12	6.9	25.5	7.9	620
	15	6.7	25.2	7.9	610
	18	6.6	25.2	7.9	600
	21	6.3	25.0	7.8	590
	24	6.1	24.5	7.8	580
	27	6.0	25.0	7.8	580
	30	6.0	25.0	7.8	580
	33	6.0	25.0	7.8	580
	45	5.1	24.5	7.8	570

Table 1. Field Chemical Analyses of Kaw Lake, 24 June 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
F	1	7.8	26.5	8.7	595
	3	7.8	26.5	8.7	595
	6	7.8	26.5	8.7	590
	9	7.8	26.5	8.7	590
	12	7.7	26.5	8.8	595
H	1	9.3	26.0	9.5	750

Table 1. Field Chemical Analyses of Kaw Lake, 24 June 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
G	1	7.7	26.0	8.8	760
	3	7.5	26.0	8.8	760
	6	7.6	25.5	8.9	760
	9	7.1	25.0	8.9	760
	12	7.3	25.0	9.0	760
	15	7.2	25.0	8.9	760
	18	7.1	25.0	9.0	760
	21	6.8	25.5	9.1	750
	24	6.5	25.0	9.1	730
	27	6.3	24.5	9.2	720
	30	6.4	24.5	9.2	710
	23	6.3	24.5	9.6	680
	40	5.7	24.5	9.5	680

Table 1. Field Chemical Analyses of Kaw Lake, 15 July 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
B	0	7.7	28.5	8.1	920
	3	7.3	28.0	8.2	920
	6	6.8	28.0	8.3	930
	9	5.9	27.5	8.3	930
	12	5.6	26.5	8.3	930
	15	5.7	26.5	8.3	930
	30	5.2	26.5	8.2	910
	33	5.2	26.5	7.9	910
	45	2.2	25.5	7.9	910
	66	1.5	25.0	7.9	910
	75	1.5	24.5	7.9	780

Table 1. Field Chemical Analyses of Kaw Lake, 15 July 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
C	0	8.2	29.5	8.4	905
	3	6.4	28.5	8.4	905
	6	6.0	28.5	8.4	905
	9	6.0	28.3	8.4	905
	12	5.9	28.3	8.4	905
	15	5.9	28.5	8.4	905
	18	5.9	28.3	8.4	910
	33	4.1	28.0	8.3	910
	45	3.1	26.5	8.2	895

Table 1. Field Chemical Analyses of Kaw Lake, 15 July 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
D	0	8.3	29.5	8.3	905
	3	7.7	28.5	8.4	905
	6	6.5	27.5	8.4	905
	9	6.1	28.0	8.4	910
	12	6.0	27.5	8.4	910
	15	5.9	28.0	8.4	910
	18	5.7	27.0	8.4	910
	33	5.4	28.0	8.3	915
	45	3.0	26.5	8.1	895

Table 1. Field Chemical Analyses of Kaw Lake, 15 July 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
E	0	9.5	31.0	7.8	800
	3	6.4	28.0	7.5	800
	9	5.7	28.0	7.5	800
	12	4.6	28.0	7.5	800
	15	4.1	28.0	7.5	800
	18	3.9	28.0	7.5	800
	39	2.6	27.0	7.5	800

Table 1. Field Chemical Analyses of Kaw Lake, 15 July 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
F	3	7.5	29.5	7.6	700
	6	7.3	29.5	7.6	750
	9	7.1	29.5	7.5	650
	12	6.9	29.5	7.5	650
	15	6.4	28.0	7.5	750
	18	5.3	28.0	7.5	700
	30	0.6	26.0	7.5	600
H	0	7.5	29.5	8.1	1100
	3	6.9	29.5	8.1	1100
	6	6.7	28.5	8.1	1100
	9	6.6	28.5	8.0	1100
	12	6.6	28.5	8.2	1100
	15	6.5	28.5	8.2	1100

Table 1. Field Chemical Analyses of Kaw Lake, 15 July 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
G	0	6.7	30.5	8.1	1100
	3	5.4	30.0	7.8	1000
	6	5.2	29.0	7.8	1000
	9	4.8	29.0	7.8	1000
	12	4.2	28.0	7.8	900
	15	3.9	28.0	8.1	900
	18	3.9	27.0	7.8	900
	33	3.5	26.0	8.0	900

Table 1. Field Chemical Analyses of Kaw Lake, 19 Aug 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
B	1	7.1	25.5	7.7	920
	3	7.2	25.5	7.7	920
	6	7.1	25.5	7.8	920
	9	7.2	26.0	7.8	920
	12	7.3	26.0	7.8	920
	15	7.2	26.0	7.8	920
	18	7.3	26.5	7.8	930
	21	7.3	26.5	7.8	930
	24	7.2	26.0	7.8	920
	27	7.2	26.0	7.8	930
	30	7.2	26.0	7.7	920
	33	7.3	26.0	7.8	920
	45	7.5	26.0	7.8	930
	55	6.8	25.5	7.7	870
	66	6.7	25.5	7.7	920
	75	6.8	25.0	7.6	910

Table 1. Field Chemical Analyses of Kaw Lake, 19 Aug 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
C	1	8.6	26.5	7.8	990
	3	7.7	26.0	7.8	980
	6	7.8	26.5	7.7	980
	9	7.8	26.5	7.8	970
	12	7.8	26.5	7.8	970
	15	7.8	26.5	7.8	960
	18	7.8	26.5	7.8	960
	21	7.8	26.5	7.7	950
	24	7.9	26.5	7.8	950
	27	7.9	26.5	7.8	950
	30	7.8	26.5	7.8	940
	33	7.8	26.5	7.8	940
	45	7.6	26.5	7.8	870

Table 1. Field Chemical Analyses of Kaw Lake, 19 Aug 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
D	1	8.4	26.5	7.8	900
	3	8.2	26.5	7.8	900
	6	8.1	26.5	7.7	900
	9	7.9	26.5	7.8	900
	12	7.8	26.5	7.8	900
	15	7.9	26.5	7.8	900
	18	7.8	27.0	7.8	890
	21	7.8	26.5	7.8	900
	24	7.9	26.5	7.8	890
	27	7.9	27.0	7.7	900
	30	7.8	26.5	7.8	900
	33	7.7	27.0	7.8	890
	45	7.7	27.0	7.7	900

Table 1. Field Chemical Analyses of Kaw Lake, 19 Aug 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
E	1	8.7	27.0	7.8	820
	3	8.2	26.5	7.8	870
	6	7.9	26.5	7.8	870
	9	7.8	26.5	7.8	870
	12	7.6	26.5	7.8	870
	15	7.6	26.0	7.5	870
	18	7.5	26.0	7.6	900
	21	7.5	25.5	7.8	900
	24	7.6	26.5	7.8	900
	27	7.4	26.0	7.8	900
	30	7.5	26.0	7.8	910
	33	7.4	27.0	7.8	910
	45	7.1	26.0	7.8	910

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Table 1. Field Chemical Analyses of Kaw Lake, 19 Aug 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
F	1	9.4	26.5	7.8	780
	3	8.3			790
	6	8.2			790
	9	8.2			800
12	12	7.9	26.5	7.8	800
15	15	7.9	26.5	7.8	810
	18	7.7			810
	21	7.7			820
	24	7.8			820
	27	7.6	26.0	7.8	820
	30	7.6	26.0	7.8	840
	33	7.6	25.5	7.8	850

Table 1. Field Chemical Analyses of Kaw Lake, 19 Aug 1978.

Station	Depth Feet	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
G	1	9.4	27.0	7.8	970
	3	8.7	26.5	7.8	970
	6	8.5	27.0	7.8	970
	9	8.3	27.0	7.8	970
	12	7.5	27.0	7.8	950
	15	6.7	26.5	7.8	950
	18	6.8	26.5	7.8	960
	21	7.0	26.5	7.8	960
	24	7.0	26.5	7.8	960
	27	7.0	26.0	7.8	970
	30	7.0	26.0	7.8	970
	33	6.8	26.0	7.8	980
H	1	11.8	25.0	7.8	770
	3	11.0	25.0	7.8	810
	6	10.2	25.0	7.8	840

Table 1. Field Chemical Analyses of Kaw Lake, 17 Sep 1978.

Station	Depth Meters	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
B	1	8.1	25.0	7.8	930
	2	7.4	25.0	7.8	930
	3	7.2	25.0	7.8	930
	4	6.8	25.5	7.8	930
	5	7.0	25.0	7.8	930
5	8	6.8	25.0	7.8	930
5	11	6.8	25.0	7.8	930
	14	5.5	25.5	7.8	930
	17	4.9	25.0	7.8	930
	20	4.9	25.5	7.8	930
	23	4.9	24.5	7.8	930
	24	4.6	24.5	7.8	930

Table 1. Field Chemical Analyses of Kaw Lake, 17 Sep 1978.

Station	Depth Meters	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
C	1	8.2	26.0	7.8	940
	2	8.0	26.0	7.8	940
	3	8.0	26.0	7.8	940
	4	8.0	25.5	7.8	940
	5	8.0	25.5	7.8	940
	8	8.0	25.5	7.8	940
	11	8.0	25.5	7.8	940
D	1	9.0	26.5	7.7	1000
	2	8.9	26.5	7.7	1000
	3	8.6	26.5	7.7	1000
	4	8.1	26.0	7.7	1000
	5	8.1	26.0	7.7	1000
	8	8.5	26.0	7.7	1000
	11	8.5	26.0	7.7	1000

Table 1. Field Chemical Analyses of Kaw Lake, 17 Sep 1978.

Station	Depth Meters	Dissolved Oxygen mg/l	Temp. °C	pH	Conductance micromhos
G	1	8.4	27.5	7.6	1000
	2	7.8	26.5	7.6	1000
	3	7.8	27.5	7.6	1000
	4	7.2	26.5	7.6	1000
	5	6.9	27.0	7.6	1000
	8	5.6	25.5	7.6	1000

Table 2. Summary of Laboratory Chemical Analyses of Kaw Lake Water Samples.

STATION A

Date	CaCO_3 Hardness mg/l	Turbidity Units JTU	Cl^- mg/l	$\text{SO}_4^{=}$ mg/l	Bicarbonate Alkalinity mg/l
24 June	204	68	150	74	149
15 July	196	61	150	68	136
19 Aug	230	42	230	68	153
17 Sep	226	39	177	41	144
\bar{x}	214	52	177	63	146
SD	16	14	38	15	7

Table 2 (continued). STATION A OKNO 31

Date	$\text{PO}_4^{2-}\text{-P}$ mg/l	NO_2^- -N mg/l	NO_3^- -N mg/l	Total Dissolved Solids		Suspended Solids mg/l
				6.0	6.5	
24 June	.186	.006	.969	556	556	30
15 July	.180	.006	.813	777	777	26
19 Aug	.124	.015	.635	626	626	13
17 Sep	.033	.005	.216	588	588	15
\bar{x}	.131	.008	.658	637	637	21
SD	.007	.0004	.325	98	98	8

Table 2. Summary of Laboratory Chemical Analyses of Kaw Lake Water Samples.

STATION B

OKN0096

	Date	CaCO_3 Hardness mg/l_{eq}	Turbidity Units JTU_{70}	Cl^- mg/l_{940}	$\text{SO}_4^{=}$ mg/l_{945}	Bicarbonate Alkalinity $\text{mg/l}_{\text{4/0}}$
B1:						
24 June		200	50	155	60	138
15 July		207	47	195	70	146
19 Aug		210	32	177	42	146
17 Sep						
\bar{x}		206	43	176	57	143
SD		5	10	20	14	5
B33:						
24 June		204	55	155	76	131
15 July		196	47	150	67	139
19 Aug		211	49	190	68	145
17 Sep		210	41	177	41	140
\bar{x}		205	48	168	63	139
SD		7	6	19	15	6
B66:						
24 June		200	85	160	68	137
15 July		196	68	140	65	139
19 Aug		211	59	190	73	144
17 Sep		210	47	187	43	142
\bar{x}		204	65	169	62	140
SD		7	16	24	13	3
B75:						
24 June		212	258	162	68	158
15 July		200	61	67	67	142
19 Aug		214	106	190	70	151
17 Sep		206	68	177	43	144
\bar{x}		208	123	176	47	149
SD		6	92	14	30	7

Table 2 (Continued). STATION B OKN 0096

	Date	PO ₄ ^{-P} mg/l <i>6.60</i>	NO ₂ -N mg/l <i>6.15</i>	NO ₃ -N mg/l <i>6.20</i>	Total Dissolved Solids mg/l <i>70304</i>	Suspended Solids mg/l
						70299
B1:	24 June					
	15 July	.136	.015	.692	490	8
	19 Aug	.158	.006	1.043	532	11
	17 Sep	.065	.003	.393	575	11
	\bar{x}					
	SD	.049	.008	.709	532	10
				.325	42	2
B33:	24 June					
	15 July	.030	.007	.800	477	15
	19 Aug	.140	.015	.706	457	4
	17 Sep	.144	.007	.898	516	13
	\bar{x}			.368	588	10
	SD					
				.693	510	10
				.230	58	5
B66:	24 June					
	15 July	.045	.016	.849	479	
	19 Aug	.002	.011	.887	493	11
	17 Sep	.184	.008	.655	496	52
	\bar{x}			.003	564	13
	SD					
				.010	508	24
				.005	38	19
				.194		
B75:	24 June					
	15 July	.088	.032	.814	502	115
	19 Aug	.247	.013	.875	501	12
	17 Sep	.173	.008	.657	540	7
	\bar{x}			.004	560	18
	SD					
				.014	526	38
				.012	209	52
					29	

KAWA
1953
STATION C

Table 2. Summary of Laboratory Chemical Analyses of Kaw Lake Water Samples.

STATION C
OKANDO 17

	Date	Caco ₃ Hardness mg/1 700	Turbidity Units JTU 70	Cl ⁻ mg/l 940	SO ₄ ⁼ mg/l 945	Bicarbonate Alkalinity mg/l 410
Cl':	24 June	208	68	165	74	140
	15 July	200	36	148	67	142
	19 Aug	207	56	185	70	145
	17 Sep	210	32	198	44	142
	\bar{x}	206	48	174	64	142
	SD	4	17	22	13	2
C33':	24 June	204	47	150	76	135
	15 July	200	49	145	68	140
	19 Aug	211	54	195	67	148
	17 Sep	206	46	198	43	142
	\bar{x}	205	49	172	64	141
	SD	4	4	28	14	5
C45:	24 June	204	96	143	66	142
	15 July	207	47	190	70	146
	19 Aug	214	112	187	43	144
	17 Sep					
	\bar{x}	208	85	173	60	144
	SD	5	34	26	14	2

Table 2 (Continued). STATION C

OK Nov 97

Date	PO ₄ ^{-P} mg/l 660	NO ₂ -N mg/l 630	NO ₃ -N mg/l 630	Total Dissolved Solids mg/l 70304		Suspended Solids mg/l 70299
				Cl ¹ :	C33 ¹ :	
24 June	.159	.004	.841	.841	.264	.476
15 July	.109	.009	.546	.546	.797	.484
19 Aug	.195	.022	.494	.494	.513	.484
17 Sep	.033	.004	.357	.357	.322	.574
\bar{x}	.124	.010	.560	.560	.474	.12
SD	.070	.008	.204	.204	.240	.10
						19
						25
						12
						59
						38
						16
						24

Table 2. Summary of Laboratory Chemical Analyses of Kaw Lake Water Samples.

567
15.00^a
STATION D
OKNOO98

		CaCO ₃ Hardness mg/1	Turbidity Units JTU	Cl ⁻ mg/1	Bicarbonate Alkalinity mg/1 4/0
	Date	700	70	740	745
D1:	24 June	220	101	170	77
	15 July	200	42	139	64
	19 Aug	207	71	190	70
	17 Sep	214	47	208	44
	\bar{x}	210	65	177	64
	SD	9	27	30	14
D33':	24 June	208	91	170	68
	15 July	204	47	190	60
	19 Aug	207	77	218	68
	17 Sep	214	61	218	43
	\bar{x}	208	69	193	60
	SD	4	19	24	12
D45':	24 June	208	102	160	68
	15 July	188	92	138	67
	19 Aug	211	75	195	68
	17 Sep	222	113	218	41
	\bar{x}	207	96	178	61
	SD	14	16	36	13
					2

Table 2 (Continued). STATION D *oak Acetate*

Date	PO ₄ -P mg/l	NO ₂ -N mg/l	NO ₃ -N mg/l	Total Dissolved Solids mg/l		Suspended Solids mg/l
				6.60	6.20	
D1':						
24 June	.020	.004	.812	502	20	
15 July	.150	.006	.574	525	6	
19 Aug	.139	.067	.398	501	15	
17 Sep	.015	.003	.343	599	15	
\bar{x}	.081	.020	.532	532	14	
SD	.075	.031	.211	46	6	
D33':						
24 June	.222	.004	.970	498	18	
15 July	.180	.008	.762	490	25	
19 Aug	.152	.080	.441	508	14	
17 Sep	.048	.004	.343	615	20	
\bar{x}	.151	.024	.629	528	19	
SD	.074	.037	.289	59	5	
D45':						
24 June	.252	.006	.824	498	28	
15 July	.018	.011	.715	479	24	
19 Aug	.165	.079	.448	481	21	
17 Sep	.106	.007	.332	632	48	
\bar{x}	.135	.026	.580	522	30	
SD	.098	.036	.228	73	12	

Table 2. Summary of Laboratory Chemical Analyses of Kaw Lake Water Samples.

STATION E
OKN 0097

	Date	CaCO ₃ mg/l	Turbidity Units JFU	Cl ⁻ mg/l	SO ₄ ²⁻ mg/l	Bicarbonate Alkalinity mg/l g/o
E1':	24 June	204	73	135	74	143
	15 July	184	65	126	59	132
	19 Aug	211	59	185	63	136
	17 Sep					
	\bar{x}	200	66	149	65	137
	SD	14	7	32	8	6
E33':	24 June	196	109	120	41	150
	15 July	200	95	136	59	146
	19 Aug	199	56	180	67	135
	17 Sep					
	\bar{x}	198	87	145	56	144
	SD	2	27	31	13	8
E45':	24 June	192	123	115	44	142
	15 July					
	19 Aug					
	17 Sep					
	\bar{x}					
	SD					

Table 2 (Continued). STATION E Okanogan

	Date	$\text{PO}_4^{2-}\text{-P}$ mg/l \bar{x}	$\text{NO}_2\text{-N}$ mg/l \bar{x}	$\text{NO}_3\text{-N}$ mg/l \bar{x}	Total Dissolved Solids mg/l \bar{x}	Suspended Solids mg/l \bar{x}
E1':	24 June	.008	.018	.772	447	17
	15 July	.038	.012	.124	441	18
	19 Aug	.097	.045	.130	471	17
	17 Sep					
	\bar{x}	.048	.025	.342	453	17
	SD	.045	.018	.372	16	0.5
E33':	24 June	.101	.052	.642	420	36
	15 July	.109	.020	.414	406	27
	19 Aug	.052	.046	.095	446	16
	17 Sep					
	\bar{x}	.087	.039	.384	424	26
	SD	.031	.017	.2755	20	10
E45':	24 June					
	15 July					
	19 Aug					
	17 Sep					
	\bar{x}	.020	.053	.603	412	79
	SD					

Table 2. Summary of Laboratory Chemical Analyses of Raw Lake Water Samples.

STATIONS F AND H

	Date	CaCO ₃ mg/l 900	Turbidity Units JTU 70	Cl ⁻ mg/l 940	SO ₄ ²⁻ mg/l 945	Bicarbonate Alkalinity mg/l 4/0
F1':	24 June	196	93	117	37	145
DKP0100	15 July	212	64	120	60	134
	19 Aug	211	64	180	73	132
	17 Sep					
	\bar{x}	206	74	139	57	137
	SD	9	17	36	18	7
F30':	24 June	204	99	118	48	144
DKP0100	15 July	188	155 ^b	100	18	146
	19 Aug	199	65	185	73	134
	17 Sep					
	\bar{x}	197	106	134	46	141
	SD	8	45	45	28	6
H1':	24 June	216	137	175	77	147
DKP0100	15 July	220	115	193	76	154
	19 Aug	230	80	280	82	148
	17 Sep					
	\bar{x}	222	111	216	78	150
	SD	7	29	56	3	4
H15':	24 June			185		159
	15 July			228		74
	19 Aug					
	17 Sep					
	\bar{x}					
	SD					

Table 2 (Continued), STATIONS F AND H

	Date	$\text{PO}_4^-\text{-P}$ mg/l \bar{x} SD	$\text{NO}_2^-\text{-N}$ mg/l \bar{x} SD	$\text{NO}_3^-\text{-N}$ mg/l \bar{x} SD	Total Dissolved Solids mg/l \bar{x} SD	Suspended Solids mg/l \bar{x} SD
F1':						
24 June	.068	.072	.506	410	40	
15 July	.048	.008	.094	447	18	
19 Aug	.040	.029	.067	452	20	
17 Sep						
\bar{x}	.052	.036	.222	436	26	
SD	.014	.033	.246	23	12	
F30':						
24 June	.048	.069	.559	422	36	
15 July	.034	.021	.197	321	38	
19 Aug	.095	.029	.076	472	19	
17 Sep						
\bar{x}	.059	.040	.277	405	31	
SD	.032	.026	.251	77	10	
H1':						
24 June	.023	.015	.836	521	53	
15 July	.259	.058	.576	615	41	
19 Aug	.173	.034	.134	631	29	
17 Sep						
\bar{x}	.152	.036	.517	589	41	
SD	.119	.022	.352	59	12	
H15':						
24 June						
15 July	.142					
19 Aug						
17 Sep						
\bar{x}						
SD						

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Table 2. Summary of Laboratory Chemical Analyses of Kaw Lake Water Samples.

STATION G

o_{KNO₃O}

		CaCO ₃ Hardness mg/1 900	Turbidity Units JTUL 70	Cl ⁻ mg/1 740	SO ₄ ⁼ mg/1 945	Bicarbonate Alkalinity mg/1 440
G1':	24 June	212	88	165	74	145
	15 July	208	71	170	82	143
	19 Aug	211	56	220	73	144
	17 Sep	222	51	228	43	146
	\bar{x}	213	67	196	68	144
	SD	6	17	33	17	1.3
G33':	24 June	208	168	150	76	142
	15 July	212	86	152	70	145
	19 Aug	211	80	210	73	142
	17 Sep	222	75	239	44	146
	\bar{x}	213	102	188	66	144
	SD	6	44	44	15	2
G45':	24 June	196	193	150	76	137
	15 July					
	19 Aug					
	17 Sep					
	\bar{x}	207	59	228	45	144
	SD	16	95	126	61	141
					55	5
					22	

Table 2 (Continued). STATION C
OK 10101

	Date	PO ₄ ⁻ -P mg/l	NO ₂ -N mg/l	NO ₃ -N mg/l	Total Dissolved Solids mg/l		Suspended Solids mg/l
					6/15	7/05/04	70299
G1':							
24	June	.156	.005	.950		513	23
15	July	.221	.074	.677		471	11
19	Aug	.141	.100	.213		554	13
17	Sep	.069	.002	.282		620	14
\bar{x}		.148	.045	.531		540	15
SD		.062	.049	.346		63	5
G33':							
24	June	.000	.030	.753		492	50
15	July	.164	.048	.600		621	28
19	Aug	.184	.117	.206		526	26
17	Sep	.098	.076	.265		658	26
\bar{x}		.112	.068	.456		574	32
SD		.083	.038	.263		78	12
G45':							
24	June	.063	.031	.751		471	56
15	July						
19	Aug						
17	Sep						
\bar{x}							
SD							

Table 2. Summary of Laboratory Chemical Analyses of Kaw Lake Water Samples.

STATIONS I, J, K

	Date	Caco ₃ Hardness mg/1 700	Turbidity Units JTU 70	Cl ⁻ mg/1 740	SO ₄ ⁼ mg/1 745	Bicarbonate Alkalinity mg/1 4/0
I:	24 June	169	>395	115	66	140
OKNO012	15 July	227	217	210	81	152
	19 Aug	329	131	560	102	160
	17 Sep	361	150	586	75	204
	\bar{x}	272	223	368	81	164
	SD	89	120	240	15	28
J:	24 June	208	>395	260	77	150
KSS0012	15 July	290	145	450	95	147
	19 Aug	333	99	640	111	139
	17 Sep	373	101	729	78	190
	\bar{x}	301	185	520	90	156
	SD	71	142	209	16	23
K:	24 June	180	>395	44	<10	149
KSS0013	15 July	321	68	117	98	150
	19 Aug	303	59	230	108	196
	17 Sep	397	104	239	65	190
	\bar{x}	300	156	158	68	171
	SD	90	160	94	49	25

Table 2 (Continued), STATIONS I, J, K

	Date	$\text{PO}_4^{2-}\text{-P}$ mg/l	$\text{NO}_2^{-}\text{-N}$ mg/l \bar{x}_{15}	$\text{NO}_3^{-}\text{-N}$ mg/l \bar{x}_{20}	Total Dissolved Solids mg/l \bar{x}_{304}	Suspended Solids mg/l \bar{x}_{305}
<i>I:</i> <i>OKN0102</i>	24 June	.045	.027	.777	397	332
	15 July	.091	.040	.350	1170	108
	19 Aug	.163	.004	.054	1108	282
	17 Sep	.506	.005	.030	1259	92
	\bar{x}	.201	.019	.303	984	154
	SD	.209	.018	.348	396	119
<i>J:</i> <i>KSS0012</i>	24 June	.328	.016	.968	572	345
	15 July	.407	.003	.028	593	140
	19 Aug	1.096	.004	.033	1166	83
	17 Sep	1.098	.114	.165	1402	77
	\bar{x}	.732	.034	.298	798	161
	SD	.042	.005	.045	607	126
<i>K:</i> <i>KSS0013</i>	24 June	.033	.025	.938	268	482
	15 July	.136	<.001	.028	574	68
	19 Aug	.110	.004	.037	658	41
	17 Sep	.029	.004	.029	810	63
	\bar{x}	.077	.008	.258	578	164
	SD	.005	.001	.045	228	213

KAW7

6575 (OK)

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Table 3. Concentration of Heavy Metals in Kaw Lake Water Samples
Collected 24 June 1978.

Station	Fe mg/l <i>1045</i>	Mn mg/l <i>1055</i>	Pb µg/l <i>1051</i>	Hg µg/l <i>71900</i>
A-1' OKN0131	1.01	0.10	<5.0	<0.5
B-1'				
B-33' OKN0096	0.45	0.08	<5.0	<0.5
B-66'	1.12	0.19	<5.0	<0.5
B-75'	5.72	0.56	<5.0	<0.5
C-1'				
C-33' OKN0097	0.56	0.06	<5.0	<0.5
C-33' OKN0098	0.39	0.07	<5.0	<0.5
D-1'				
D-33' OKN0098	0.56	0.10	<5.0	<0.5
D-46'	0.67	0.08	<5.0	<0.5
D-46'	1.46	0.12	<5.0	<0.5
E-1'				
E-33' OKN0099	0.90	0.08	<5.0	<0.5
E-45'	1.68	0.14	<5.0	<0.5
E-45'	1.68	0.17	<5.0	<0.5
F-1'				
F-12' OKN0100	1.07	0.10	<5.0	<0.5
F-12'	1.40	0.12	<5.0	<0.5
G-1'				
G-33' OKN0101	0.95	0.03	<5.0	<0.5
G-40'	2.35	0.08	<5.0	<0.5
G-40'	3.48	0.10	<5.0	<0.5
H-1' OKN0102	2.02	0.19	<5.0	<0.5
I-1' OKN0103	10.88	0.34	<5.0	<0.5
J-1' KSS0012	12.01	0.34	<5.0	<0.5
K-1' KSS0013	23.89	0.43	<5.0	<0.5
EPA Standard	0.42	0.45	298.0	4.5
This Lab.	0.35	0.15	249.0	6.5

Table 4. Concentration of Heavy Metals in Kaw Lake Water Samples
Collected 15 July 1978.

Station	Fe mg/l <i>(10⁻⁴)</i>	Mn mg/l <i>(10⁻⁵)</i>	Pb ug/l <i>(10⁻³)</i>	Hg ug/l <i>(10⁻⁶)</i>
A-1' OKN0131	0.50	<0.05	<5.0	<0.5
B-1'	0.05	<0.05	<5.0	<0.5
B-33' OKN0096	0.23	<0.05	<5.0	<0.5
B-66'	0.50	0.19	<5.0	<0.5
B-75'	0.54	0.36	<5.0	<0.5
C-1'	0.14	<0.05	<5.0	<0.5
C-33' OKN0097	0.50	0.07	<5.0	<0.5
C-45'	1.81	0.19	<5.0	<0.5
D-1'	0.23	<0.05	<5.0	<0.5
D-33' OKN0098	0.45	<0.05	<5.0	<0.5
D-45'	6.87	0.36	<5.0	<0.5
E-1'	0.45	<0.05	<5.0	<0.5
E-33' OKN0099	1.27	0.07	<5.0	<0.5
F-1'	0.50	<0.05	<5.0	<0.5
F-30' OKN0100	2.40	0.07	<5.0	<0.5
G-1'	0.63	<0.05	<5.0	<0.5
G-33' OKN0101	0.77	0.19	<5.0	<0.5
H-1'	Lost	Lost	<5.0	<0.5
H-15'	6.73	0.36	<5.0	<0.5
I-1' OKN0103	3.74	0.13	<5.0	<0.5
J-1' KSS0012	2.04	0.19	<5.0	<0.5
K-1' KSS0015	0.95	0.25	<5.0	<0.5
EPA Standard	0.42	0.45	298.0	4.5
This Lab.	0.35	0.15	233.0	5.9

Table 5. Concentration of Heavy Metals in Kaw Lake Water Samples
Collected 19 August 1978.

Station		Fe mg/l 1045	Mn mg/l 1055	Pb 1g/l 1051	Hg 1g/l 10900
A	OKN013)	.54	.09	<5.0	<0.5
B-1'		.62	.11	<5.0	<0.5
B-33'	OKN0096	.54	.11	<5.0	<0.5
B-66'		.46	.06	<5.0	<0.5
B-75'		2.63	.16	<5.0	<0.5
C-1'		.46	.06	<5.0	<0.5
C-33'	OKN0097	.54	.11	<5.0	<0.5
C-45'		1.60	.11	<5.0	<0.5
D-1'		.78	.06	<5.0	<0.5
D-33'	OKN0098	.94	.09	<5.0	<0.5
D-45'		1.02	.06	,38	<0.5
E-1'	OKN0099	.62	<.05	<5.0	<0.5
E-33'		2.55	.11	<5.0	<0.5
F-1'	OKN0100	.62	.09	<5.0	<0.5
F-33'		.62	.06	<5.0	<0.5
G-1'		.62	.09	<5.0	<0.5
G-33'	OKN0101	1.10	.06	<5.0	<0.5
H-1'	OKN0102	.86	<.05	<5.0	<0.5
I	OKN0103	1.74	.26	<5.0	<0.5
J	KSS0012	.54	.21	<5.0	<0.5
K	KSS0013	1.51	.26	<5.0	<0.5
EPA Standard		416 µg/l	45 µg/l	298	4.5
This Lab.		383	61	243	5.9

Kaw No 1560 # 1564

Table 6. Concentration of Heavy Metals in Kaw Lake Water Samples
Collected 17 September 1978.

Station	Fe mg/l 1045	Mn mg/l 1055	Pb μg/l 1051	Hg μg/l 71900
A-1 OKN0131	2.97	.1	<5.0	<.5
B-1	.22	<.05	<5.0	<.5
B-33 OKN0096	.31	<.05	<5.0	<.5
B-60	.49	<.05	<5.0	<.5
B-75	.80	.14	<5.0	<.5
C-1	.36	<.05	<5.0	<.5
C-33 OKN0097	.67	<.05	<5.0	<.5
C-45	1.20	<.05	<5.0	<.5
D-1	.44	<.05	0.2	<.5
D-33 OKN0098	.75	<.05	<5.0	<.5
D-45	1.64	.06	<5.0	<.5
G-1	.58	<.05	<5.0	<.5
G-33 OKN0101	1.06	.06	<5.0	<.5
G-45	.67	<.05	<5.0	<.5
I-1 OKN0102	2.42	.30	<5.0	<.5
J-1 KSS0012	1.02	.14	<5.0	<.5
K-1 KSS0013	1.95	.26	<5.0	<.5
Epa Standard (μg/l)	417		298	4.5
This Lab. (μg/l)	416		199	6.5