WATER QUALITY ASSESSMENT

Black Lake, Kootenai County

Study plan and design by Dwight Hagihara; sampling performed by Dwight Hagihara and other staff of the Coeur d'Alene Field Office.

Report compiled by Mike A. Beckwith, Coeur d'Alene Field Office

September 1985

Idaho Dept of Health and Welfare
Division of Environment
Water Quality Bureau
Statehouse
Boise ID 83702

TABLE OF CONTENTS

List of Tables

List of Figures

PURPOSE AND NEED

The purpose of the water quality assessment of Black Lake was to characterize lake water quality and the toxic blooms of nuisance blue-green algae which have occurred during the fall in two of the last four years (1981 and 1982).

According to ID Dept. of Fish & Game & Bureau of Land Management (water ways of the lower Coeur d'Alene River) the size of the lake is 330 Acres

DESCRIPTION OF STUDY AREA

Black Lake is located in southern Kootenai County, Idaho (Section 12, T47N, R3W, Boise Meridian). It is one of several lateral lakes adjacent to the Coeur d'Alene River between Cataldo and the river mouth at Harrison, Idaho. The lake has an approximate surface area of 400 acres (161.9 ha) and a volume of 6000 acre-feet (7.4 million cubic meters). It has a maximum depth of about 25 feet (7.6 m) and a mean depth of 15 feet (4.57 m).

Black Lake has four main tributary streams and an outlet to the Coeur d'Alene River. Black and Lamb Creeks are the two major tributaries; they are perennial streams. The level of Black Lake fluctuates with that of Lake Coeur d'Alene and stage of the Coeur d'Alene River, particularly during the spring. Agricultural land adjacent to the northwest and southwest shores of the lake are for at least part of the year below lake level depending on Coeur d'Alene Lake level and Coeur d'Alene River stage. Pumps remove the standing water and discharge it to Black Lake through dikes. These lands are primarily hay fields and serve as pasture for cattle during the fall and winter.

BACKGROUND

This study was initiated in response to toxic blooms of nuisance blue-green algae occurring in the fall of 1981 and 1982. The first recorded incident of animal poisoning from drinking Black Lake water during an algae bloom was reported by the ID Dept. of Fish and Game in September, 1972. Dog and livestock deaths were also reported in the two most recent bloom periods resulting in the posting of signs around the lake warning of the health hazard. The poisonings probably were caused by a toxin produced by the blue-green algae Nostoc sp. (Anabaena sp.); they were similar in nature to those reported in the literature in other eutrophic lakes throughout North America.

METHODS

Water samples were collected by Kemmerer or Van Dorn sampler at six points in the lake in 1983 (Figure 1). Composite samples of the euphotic zone (defined as 2.5 times Secchi disk transparency) were collected for analysis of the parameters listed in Table 1. Physical/chemical parameters of dissolved oxygen, conductivity and temperature were measured in situ with a Yellow Springs Instrument dissolved oxygen meter and a combination specific conductivity/temperature meter equipped with 10m probe cables. Chemical analyses were performed by the ID Bureau of Laboratories in Coeur d'Alene and Boise according to American APHA/AWWA and EPA Standard Methods.

In 1984, composite lake samples taken at 1m and 3m were collected at two locations corresponding to 1983 Stations 13 and 14 by University of Idaho staff and analyzed for total phosphorus and nitrogen by the State Bureau of Laboratories. Bio-assays of the algal growth potential of Black Lake waters were also performed on samples taken at these locations by the U.S. EPA Corvallis (OR) Environmental Research Laboratory.

Stream sampling sites are also shown on Figure 1. Their locations are described in detail in Table 2. Stream flow was measured with Price AA or pygmy flow meters according to methods approximating those described by the U.S. Geological Survey. Midstream grab samples were taken for analysis of the parameters listed in Table 3. Nutrient loads carried to the lake by the tributaries and drainage pumps were calculated by the U.S. EPA STORET computer system.

RESULTS

Thermal Stratification

Black Lake has a maximum depth of about 8m. During the summer of 1983 it exhibited stratification (Table 4). The maximum difference in temperature between surface and bottom waters was 5.4 ^{0} C with a fairly

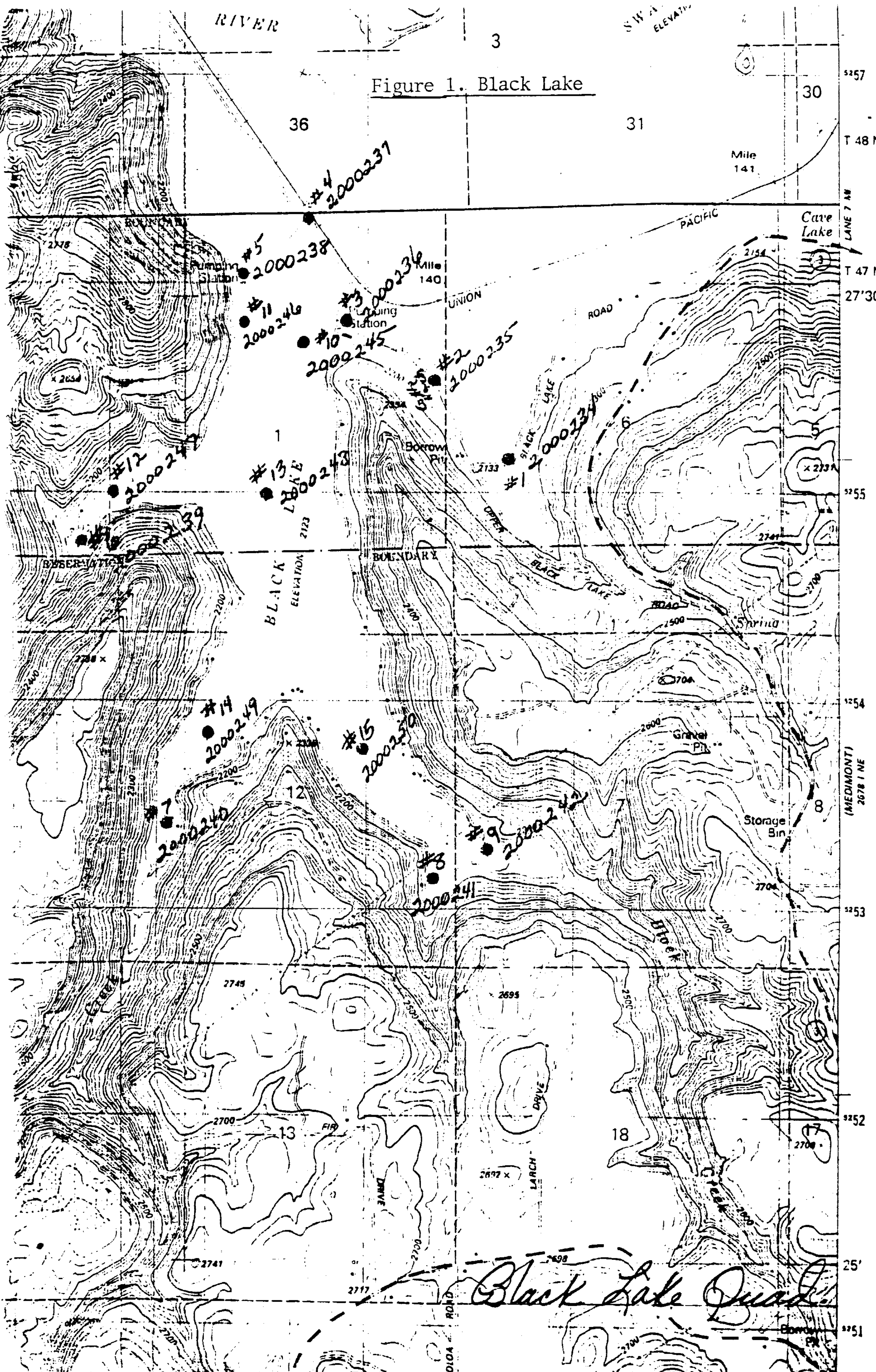


Figure 1. Black Lake

TABLE 1

LAKE SAMPLING STATION ANALYSIS PARAMETERS

Temperature

pH

Total Alkalinity

Dissolved Oxygen

Conductivity

Total Phosphorus

Dissolved Ortho Phosphorus

NO_2 + NO_3 - Nitrogen

NH_3 - Ammonia

Kjeldahl Nitrogen

Transparency - Secchi Disc

Table 2. SURVEY STATIONS - BLACK LAKE STUDY

STATION #		LATITUDE/LONGITUDE	RIVER MILE	ELEVATION	STORET #
1	Unnamed Cr cross Blk Lk Rd ab junct-Upper Blk Lk	47°27'05"/116°38'45"	643.0/139.4/.4/.75	2,133'	2000234
2	Drainage from Cattle Ranch @ Black Lk Rd	47°27'15"/116°39'05"	643.0/139.4/.4/.4	2,133'	2000235
3	Marshall Slough Nr East Pumphouse Inlet	47°27'25"/116°39'25"	643.0/139.4/.4/.05	2,133'	2000236
4	Black Lk Outlet @ Railroad Bridge	47°27'37"/116°39'37"	643.0/139.4/.1	2,123'	2000237
5	Black Lk Nr West Pumphouse Inlet	47°27'30"/116°39'47"	643.0/139.4/.35/.1	2,133'	2000238
6	Unnamed Cr ab Mouth @ end of Rd on W side Blk Lk	47°26'57"/116°37'53"	643.0/139.4/.8/.7	2,140'	2000239
7	Lamb Cr @ Culvert under Black Lk Rd	47°26'08"/116°40'04"	643.0/139.4/1.2/.8	2,140'	2000240
8	Unnamed Cr (WF Black Cr) Bl Br on Black Lk Rd	47°26'00"/116°39'05"	643.0/139.4/2.0/.1	2,140'	2000241
9	Black Cr at Br on Black Lk Rd	47°26'05"/116°38'50"	643.0/139.4/2.10	2,140'	2000242
10	Black Lk 50M offshore from E Pumphouse Discharge	47°27'23"/116°39'35"	None	2,123'	2000245
11	Black Lk 50M offshore from W Pumphouse Discharge	47°27'25"/116°39'45"	None	2,123'	2000246
12	Black Lk midbay 150M offshore from Trib Mouth	47°27'00"/116°40'15"	None	2,123'	2000247
13	Black Lake-Mid Lake	47°27'00"/116°39'47"	None	2,123'	2000248
14	Black Lk-Midbay 200M offshore-Mouth of Lamb Cr	47°26'23"/116°39'55"	None	2,123'	2000249
15	Black Lk-Midbay 200M offshore-Black Lk Resort	47°26'20"/116°39'20"	None	2,123'	2000250

TABLE 3

STREAM SAMPLING STATION ANALYSIS PARAMETERS

Temperature

pH

Total Alkalinity

Dissolved Oxygen

Conductivity

Total Phosphorus

Dissolved Ortho Phosphorus

NO_2 + NO_3 - Nitrogen

NH_3 - Ammonia

Kjeldahl Nitrogen

Sediment

TABLE 4.

STATION NO. 13 (mid-lake) TEMPERATURE, DISSOLVED OXYGEN PROFILES, 1983

	6/21/83		7/19/83		8/30/83		9/27/83		10/17/83		10/26/83		11/22/83	
Depth (m)	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO
0	17.5	9.0	-	-	21.0	8.4	-	-	10.0	8.2	10.5	8.1	7.0	9.0
1	17.0	9.0	22.0	9.6	21.0	8.4	15.0	9.3			10.4	8.0	-	-
2	16.0	9.0	21.0	9.7	20.5	8.5	15.0	9.2			10.2	7.8	-	-
3	16.0	8.7	18.5	8.7	20.0	8.5	15.0	9.3			10.0	7.5	7.0	8.0
4	16.0	8.7	18.0	8.0	20.0	8.5	15.0	9.3			10.0	7.3	-	-
5	15.0	8.0	17.5	5.8	19.0	4.0	14.5	7.5			10.0	7.4	-	-
6	12.1	0.4	18.0	5.0	17.0	0.8	14.0	2.5			10.0	5.2	7.0	7.9

well defined thermocline, (zone of greatest temperature change with depth) existing between 5m and 6m on June 21. Weaker stratification was observed on July 19 and August 30 with a temperature difference between surface and bottom waters of 4.0 ^{0} C with no well defined thermocline.

Dissolved Oxygen

Probably because the lake's shallow depth and absence of strong and sustained thermal stratification allows for mixing throughout its volume by occasional summer winds or storms, anoxic conditions near the bottom were approached on only two occasions, June 21 and September 27, with dissolved oxygen concentrations at 6m of 0.4 and 2.5 mg/l respectively (Table 4). Dissolved oxygen concentrations of about 4 mg/l are generally considered necessary to support "rough" fish, and considerably higher (~6 mg/l) to support game fish species.

Lake Nutrient Concentrations

Table 5 presents averages of the nutrient concentrations found at all lake stations; Figures 2 and 3 graphically depict the average of nutrient (total phosphorus and nitrogen) concentrations found at the six lake sampling stations. Table 6 presents results of total nitrogen and phosphorus analyses performed on samples collected by U of I staff in summer and fall of 1984. Appendix A presents the results of nutrient analyses on samples collected from the 6 lake stations.

Lake Nutrient Loads from Tributaries

Figures 4 - 6 illustrate the relative difference of flow and nutrient loads carried to the lake by natural tributaries and pumps draining adjacent agricultural lands. Appendix B presents the flow and loads of total phosphorus and nitrogen entering Black Lake from each tributary on each sampling date.

Lake Phytoplankton

Algal species present in composite samples of the Black Lake euphotic zone are described in Tables 7 and 8. Appendix C graphically illustrates phytoplankton present in Black Lake samples by taxonomic class. Unfortunately, due to problems with study continuity, no meaningful sampling was conducted during bloom conditions. Likewise, all chlorophyll data was judged to be unreliable due to problems with sampling procedure, preservation and timely analysis and is therefore not presented.

TABLE 5.

LAKE NUTRIENTS (mg/1) (average of stations), 1983

	NH_3-H	Kjeldahl-N	NO_2+NO_3-N	Total-N	Total-P
6/21/83	0.034	0.45	0.008	0.458	0.021
7/19/83	0.028	0.45	0.007	0.457	0.004
8/30/83	0.040	0.45	0.006	0.456	<0.010*
9/27/83	0.156	0.77	0.001	0.771	0.057
10/17/83	0.081	0.63	0.026	0.656	0.068
10/26/83	0.141	0.65	0.015	0.665	0.030
11/22/83	0.138	0.63	0.563	1.193	0.043
Mean	0.088	0.58	0.089	0.67	0.032
Min	0.028	0.45	0.001	0.456	<0.010
Max	0.156	0.77	0.563	1.193	0.068

*Below detection limit of analysis; figured as 0 in calculation of mean

Figure 2.

1983 Total Phosphorus - Average of Lake Stations #10-15

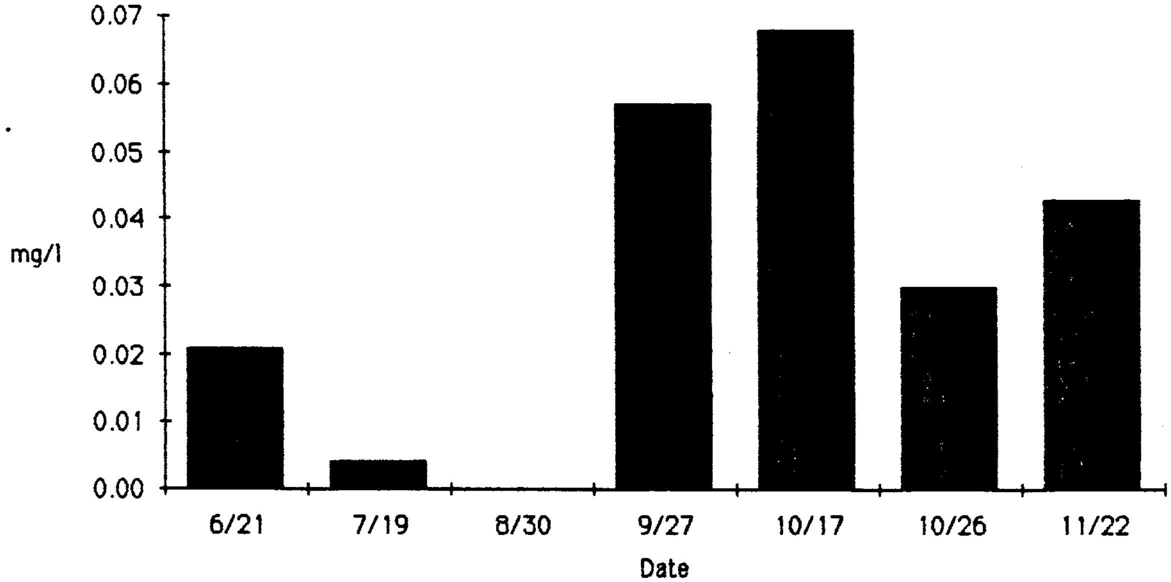


Figure 3.

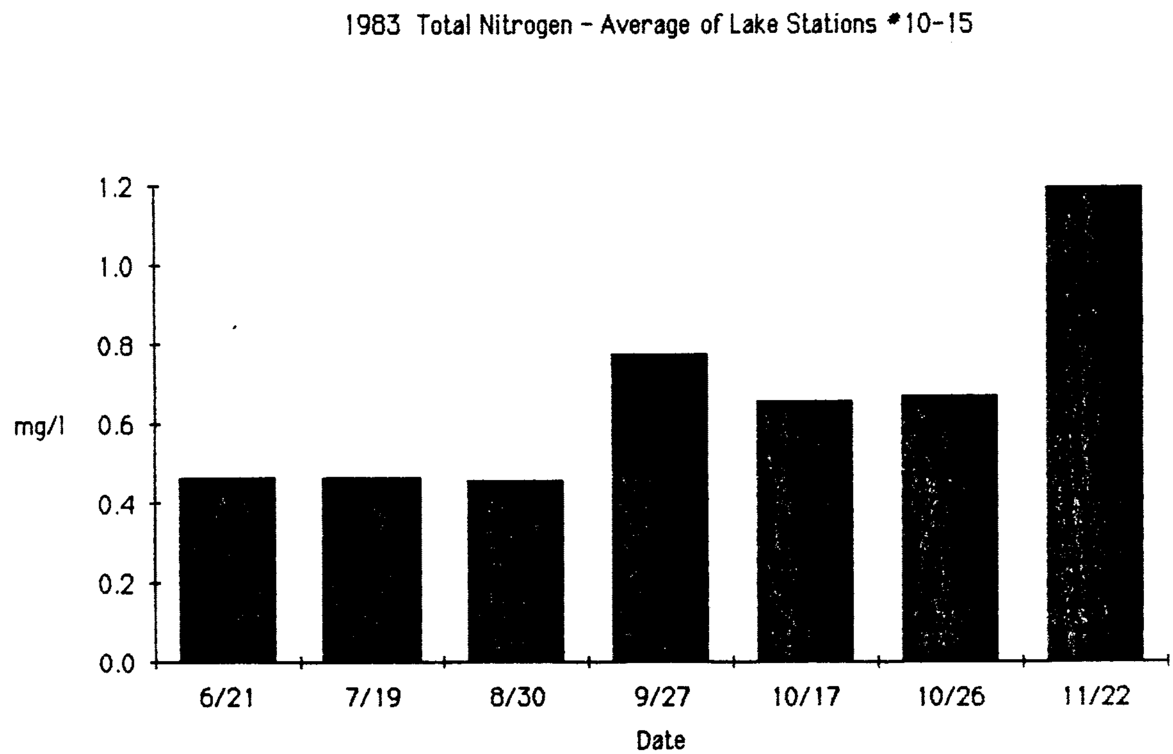

1983 Total Nitrogen - Average of Lake Stations #10-15
mg/l
1.2
1.0
0.8
0.6
0.4
0.2
0.0
6/21
7/19
8/30
9/27
10/17
10/26
11/22
Date

TABLE 6.

BLACK LAKE MID-LAKE STATION, 1984 (Composite; 3 point transect; 1 & 3 m)

Date	NO_2+NO_3	Kjeldahl-N	Total N	Total P
6-29-84	0.014	0.45	0.464	0.04
8-4-84	0.011	0.37	0.381	0.01
9-8-84	0.018	0.047	0.058	0.03
9-22-84	-	-	-	-
10-6-84	0.028	0.048	0.076	0.04
10-13-84	-	-	-	-
10-27-84	0.098	0.48	0.578	0.05
11-10-84				
11-25-84				

Figure 4.

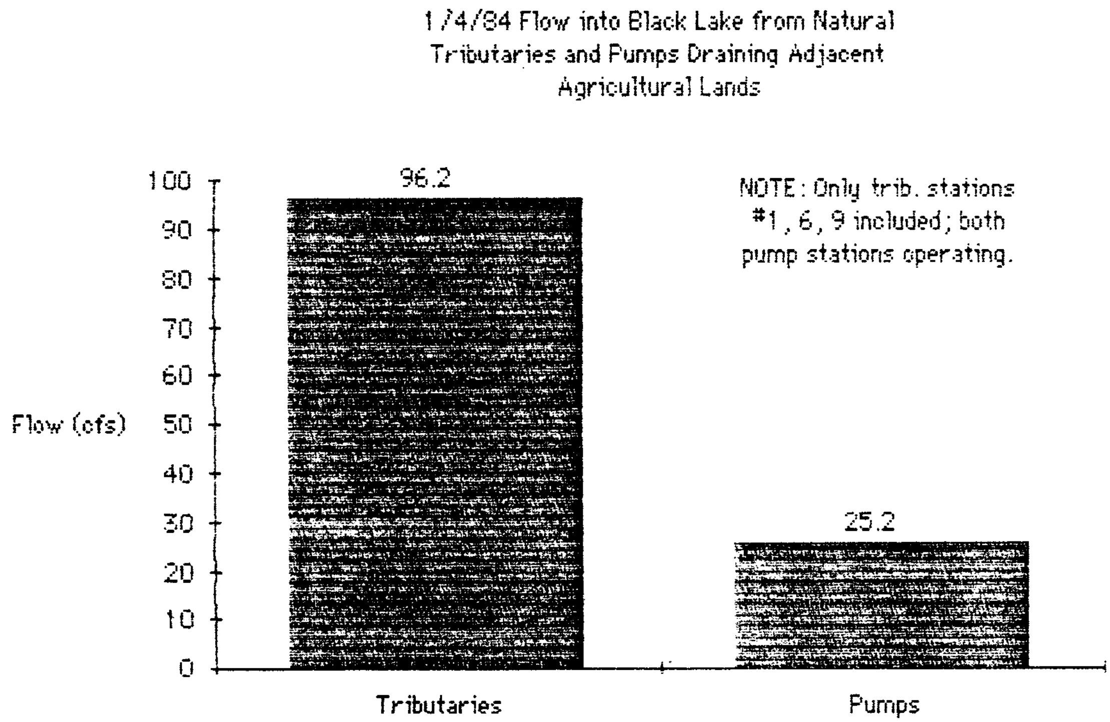

1/4/84 Flow into Black Lake from Natural Tributaries and Pumps Draining Adjacent Agricultural Lands
Flow (cfs)
100
90
80
70
60
50
40
30
20
10
0
96.2
25.2
NOTE: Only trib. stations #1, 6, 9 included; both pump stations operating.
Tributaries
Pumps

Figure 5.

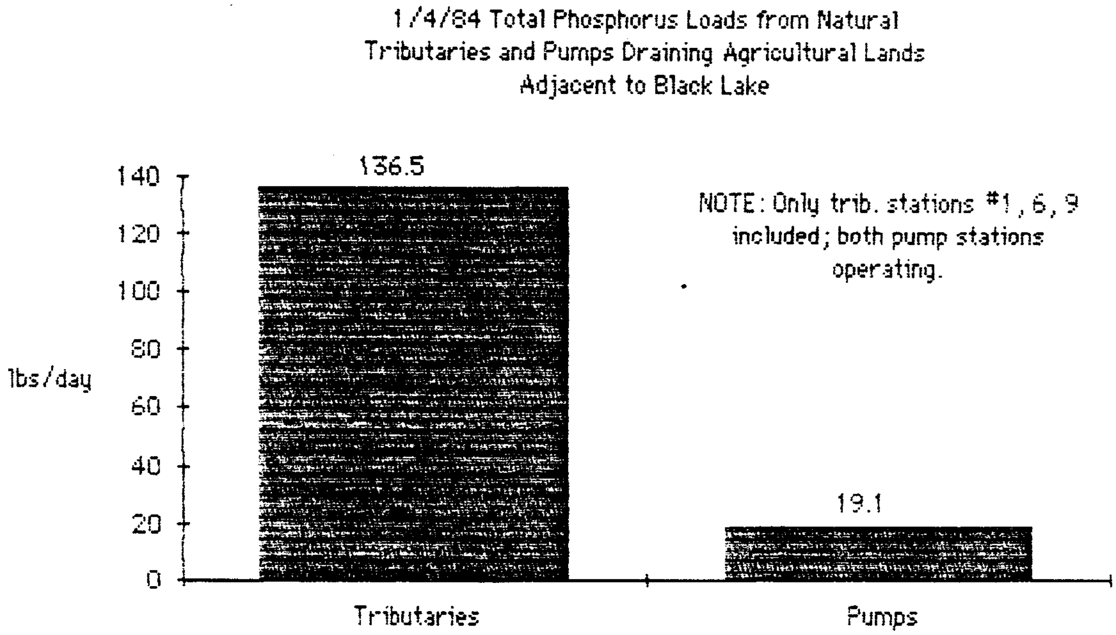

1/4/84 Total Phosphorus Loads from Natural
Tributaries and Pumps Draining Agricultural Lands
Adjacent to Black Lake
140
120
100
80
60
40
20
0
lbs/day
136.5
19.1
NOTE: Only trib. stations #1, 6, 9
included; both pump stations
operating.
Tributaries
Pumps

Figure 6.

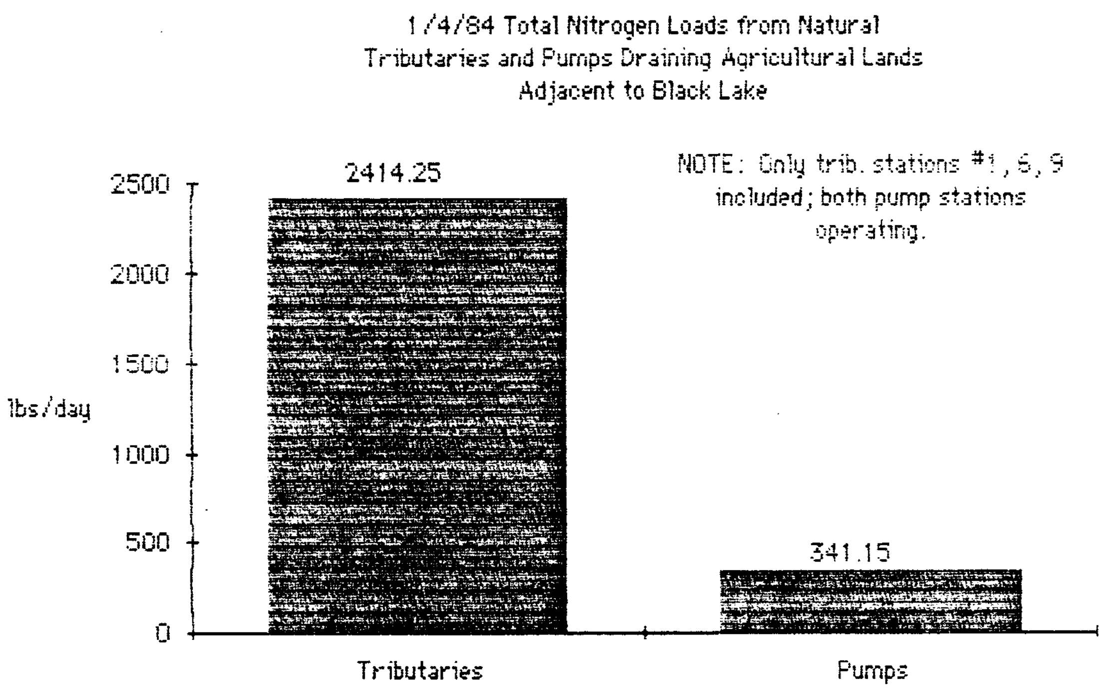

1/4/84 Total Nitrogen Loads from Natural
Tributaries and Pumps Draining Agricultural Lands
Adjacent to Black Lake
NOTE: Only trib. stations #1, 6, 9
included; both pump stations
operating.
2414.25
341.15
2500
2000
1500
1000
500
0
lbs/day
Tributaries
Pumps

Table 7. Phytoplankton Taxa Identified in Samples Collected from Black Lake ID during 1983 Field Season.

BACILLARIOPHYCEAE
Amphora sp.
Asterionella sp.
Cocconies sp.
Cymbella sp.
Epithemia sp.
Eunotia sp.
Fragillaria crotonensis
Gomphonema sp.
Melosira sp.
Melosira italica
Navicula sp.
Neidium sp.
Rhapolodia sp.
Surirella sp.
Synedra sp.
Tabellaria sp.
Tabellaria fenestrata

CYANOPHYCEAE
Coccochloris sp.
Nostoc communae
Nostoc spumigena
unidentified Blue-green chains

CHLOROPHYCEAE
Staurastrum sp.
Dictyosphaerium sp.
Dimorphococcis sp.
Cosmarium sp.

EUGLENOPHYCEAE
Trachelomonas sp.

XANTHOPHYCEAE
Ceratium hirundella

Table 8. Rank of Phytoplankton Taxa Identified in Samples Collected From Black Lake ID According to Frequency of Occurrence

1) *Melosira* sp.
   Trachelomonas sp.

2) *Fragillaria* sp.

3) *Tabellaria* sp.
   Nostoc communae

4) *Navicula* sp.

5) *Fragillaria crotonensis*

6) *Synedra* sp.

7) *Cocconeis* sp.
   Cymbella sp.
   Epithemia sp.
   unidentified blue-green chains

8) *Amphora* sp.
   Eunotia sp.
   Tabellaria fenestrata
   Staurastrum sp.

Bacteriological Water Quality

Coliform bacteria were often detected in samples collected from Black Lake and its tributaries. Temporal and spatial certainty and reliability is lacking in the data collected during this study. However, coliform bacteria were either generally absent or in low concentrations in lake samples and higher in tributary samples. Samples of the pumped discharges from adjacent agricultural lands showed the highest concentrations. Results of the bacteriological water quality analyses are presented in Appendix C.

Algal Bio-assay

Assays of algal growth potential of Black Lake waters collected in summer and fall of 1984 were conducted by the U.S. EPA (Corvallis OR) Environmental Research Laboratory. Appendix E reports the results of algal assays performed by CERL.

To summarize the results, algal bioassay revealed no growth inhibition by metals of the test alga, Selenastrum capricornutum. In fact, yields of the test alga grown in culture were higher than what might be expected form the resùlts of nutrient analyses. Phosphorus was the nutrient limiting to growth of the test organism through most of the summer of 1984 with nitrogen becoming the limiting nutrient in late fall. Yields of the test alga indicate Black Lake waters were moderately high to high in productivity according to the productivity group classification developed by CERL.

CONCLUSIONS

From the presently available data, it can be concluded that Black Lake is a eutrophic lake, that is, it is well supplied with or contains sufficient algal nutrients to be highly productive and exhibit characteristics associated with such lakes. The fact that it supports blooms of nuisance blue-green algae often associated with eutrophic conditions supports this conclusion.

No real conclusions can be drawn from the data produced by this study regarding the cause of, or possible control measures for the toxic blooms of Nostoc which have on occasion occurred in Black lake and other area lakes. Toxic algae blooms have been reported somewhat frequently in the literature. It appears that the algae produces a toxin which is released when the cells lyse (disrupt) upon death and decomposition. Wind and wave action often concentrate algal cells (and hence the toxin) along lee shores.

Poisoning occurs when animals and livestock drink from water containing large amounts of algae. Such water is usually so unappealing for human use, both for recreation and consumption that human poisoning seems unlikely. However, it is conceivable that a small child could ingest enough water to result in poisoning if it were to fall in. Hence, the primary danger posed by water containing toxic algae is to animals and livestock. It is not known what effect the algal toxin has on fish. It is suspected that it is toxic to fish and it has been speculated that summer fish kills in eutrophic lakes originally attributed to lack of oxygen or exposure to dissolved toxic gases produced from anaerobic decomposition in the bottom waters of dead algal biomass may in fact have been caused by toxins associated with blooms of nuisance blue-green algae. Much pure research must yet occur to fully understand the mechanisms of toxin production, its effects in the environment, and the conditions which stimulate a ubiquitous and usually non-toxic blue-green algae (Nostoc) to suddenly begin producing it.

Though Black Lake is quite eutrophic, its eutrophic condition is not unique. All lakes progress toward this condition with time as they gradually fill with sediment and associated nutrients, ultimately becoming marshes and dry land. Nutrients are supplied by erosion and weathering of the rocks and soils of the surrounding watershed. Generally, the older a lake is, the more nutrients available for growth of algae and aquatic plants.

Though eutrophication is a natural, progressive, and ultimately irreversible process, the effects of man's activities can greatly accelerate and aggravate its effects. Disturbance in the surrounding watershed can accelerate erosion and hence sediment and nutrient delivery to the lake.

The impact of man's activities on the eutrophication of Black Lake can not be determined from the data gathered in this study. Nor can the results of this study show that the current activities of man contribute significantly to Black Lake's eutrophic condition or whether that condition will significantly change as a result of changes in land use or other factors in the watershed. More study would be necessary to determine nutrient budgets and annual nutrient loads from various sources and tributaries. More and better data would be necessary to answer the questions of whether Black Lake's eutrophic condition can be altered or whether such alteration should even be attempted or explored further. Additional study, it is assumed, would allow for the identification of potentially adverse and controllable effects of man's activities on Black Lake and for the development of management strategies to reduce those effects. The decision of whether Black Lake warrants such further investigation lies outside the scope of this study.

Though no attempt was made in this study to determine a nutrient budget or to quantify annual nutrient loads, an indication of nutrient load contribubutions from the various tributaries can be obtained. Figures 4 - 6 contrast instantaneous flow and nutrient loads to the lake of the natural tributaries with those of the pumps draining adjacent agricultural lands on a given date (1/4/84). Pumped discharge accounted for 20.7% of the flow, 12.3% of the total phosphorus, and 12.4% of the total nitrogen entering the lake on that date. Inspection of the data presented in Appendix B indicate that Black Creek (Station #9) is the largest contributor of flow, nutrients and probably sediment. Lamb Creek (Station #7) is the next largest.

That Black and Lamb Creeks appear to be the largest contributors of nutrients to the lake is also supported by the generally higher nutrient concentrations in the southwest and southeast bays during periods of higher flow (corresponding to lake sampling stations #14 and #15 as shown in data presented in Appendix A). These creeks appeared to have the ability to noticeably increase nutrient concentrations in the vicinity of their mouths while the pump discharges generally did not. It would appear that the pumped discharges have much less impact on lake nutrient concentrations in the near vicinity of their outfalls than do the major creeks. This is perhaps due to dilution of the relatively small volume of pumped discharge (compared to lake volume and flow of the major creeks) or that water from the pump discharges moves rather quickly toward the outlet with current patterns prevailing in the lake.

The foregoing statements do not represent rigorous analysis of a data base sufficiently large or of high enough quality to make definitive conclusions; they simply represent observations from the available data.

SUMMARY

1) Black Lake is eutrophic.

2) Black Lake contains a blue-green algae species commonly found in eutrophic lakes which can at times during bloom conditions produce substances toxic to animals.

3) The tributaries of Black and Lamb Creeks are the major contributor of nutrients to Black Lake.

APPENDIX A. Nutrient Data from Black Lake Sampling Stations #10 - 15

TABLE A-I

STATION NO. 10 NUTRIENTS (mg/1), 1983

	NH_3-N	Kjeldahl-N	NO_2+NO_3-N	Total-N	Ortho-P	Total-P
6/21/83	0.010	0.30	0.005	0.305	<0.010*	<0.010*
7/19/83	0.021	0.46	0.012	0.472	<0.010*	<0.010*
8/30/83	0.027	0.40	0.005	0.405	<0.010*	<0.010*
9/27/83	0.074	0.60	0.004	0.604	<0.010*	0.016
10/17/83	0.055	0.60	0.008	0.608	<0.010*	0.050
10/26/83	0.121	0.60	0.008	0.608	<0.010*	0.020
11/22/83	0.153	0.57	0.078	0.648	<0.010*	0.010
mean	0.066	0.50	0.017	0.91	-	-
min	0.010	0.3	0.005	0.305	<0.010	<0.010
max	0.153	0.6	0.078	0.648	<0.010	0.050

* Below detection limit of analysis; figured as 0 in calculation of mean

TABLE A-II

STATION NO. 11 NUTRIENTS (mg/1), 1983

	NH_3-N	Kjeldahl-N	NO_2+NO_3-N	Total-N	Ortho-P	Total-P
6/21/83	0.010	0.30	0.006	0.306	<0.010*	<0.010*
7/19/83	0.022	0.46	0.005	0.465	<0.010*	<0.010*
8/30/83	0.020	0.30	0.005	0.305	<0.010*	<0.010*
9/27/83	0.016	0.80	0.003	0.803	<0.010*	0.11
10/17/83	0.065	0.60	0.010	0.610	<0.010*	0.05
10/26/83	0.191	0.60	0.023	0.623	<0.010*	0.030
11/22/83	0.151	0.61	0.072	0.682	<0.010*	0.03
mean	0.046	0.52	0.018	0.54	-	-
min	0.010	0.30	0.003	0.30	<0.010	<0.010
max	0.191	0.80	0.072	0.68	<0.010	0.11

*Below detection limit of analysis; figured as 0 in calculation of mean

TABLE A-III

STATION NO. 12 NUTRIENTS (mg/1), 1983

	NH_3-N	Kjeldahl-N	NO_2+NO_3-N	Total-N	Ortho-P	Total-P
6/21/83	0.013	0.30	0.004	0.304	<0.010*	<0.010*
7/19/83	0.034	0.37	0.003	0.373	0.010	0.013
8/30/83	0.053	0.40	0.005	0.405	<0.010*	<0.010*
9/27/83	0.068	0.50	0.005	0.505	<0.010*	0.036
10/17/83	0.108	0.50	0.031	0.531	0.010	0.030
10/26/83	0.141	0.70	0.011	0.711	<0.010*	0.030
11/22/83	0.149	0.63	0.068	0.698	<0.010*	0.060
mean	0.081	0.49	0.018	0.46	-	-
min	0.013	0.30	0.003	0.040	<0.010	<0.010
max	0.149	0.70	0.068	0.698	0.010	0.060

*Below detection limit of analysis; figured as 0 in calculation of mean

TABLE A-IV

STATION NO. 13 NUTRIENTS (mg/1), 1983

	NH_3-N	Kjeldahl-N	NO_2+NO_3-N	Total-N	Ortho-P	Total-P
6/21/83	0.144	1.40	0.004	1.404	0.010	0.114
7/19/83	0.040	0.45	0.004	0.454	<0.010*	<0.010*
8/30/83	0.056	0.70	0.004	0.704	<0.010*	<0.010*
9/27/83	0.020	0.50	0.003	0.503	<0.010*	<0.010*
10/17/83	0.109	0.70	0.080 ?	0.780	<0.010*	0.070
10/26/83	0.134	0.60	0.016	0.616	0.010	0.020
11/22/83	0.158	0.57	0.049	0.619	-	0.030
mean	0.094	0.50	0.023	0.73	-	-
min	0.020	0.45	0.003	0.454	<0.010	<0.010
max	0.158	1.40	0.080	1.404	0.010	0.114

*Below detection limit of analysis; figured as 0 in calculation of mean

TABLE A-V

STATION NO. 14 NUTRIENTS (mg/l), 1983

	NH_3-N	Kjeldahl-N	NO_2+NO_3-N	Total-N	Ortho-P	Total-P
6/21/83	0.017	0.40	0.008	0.408	<0.010*	<0.010*
7/19/83	0.035	0.48	0.012	0.492	<0.010*	<0.010*
8/30/83	0.058	0.50	0.009	0.509	<0.010*	<0.010*
9/27/83	0.757	0.70	0.023	0.723	<0.010*	<0.010*
10/17/83	0.077	0.60	0.016	0.616	<0.010*	0.150
10/26/83	0.140	0.80	0.019	0.819	0.007	0.04
11/22/83	0.149	0.76	0.141 ?	0.901	0.020	0.030
mean	0.18	0.61	0.033	0.64	-	-
min	0.017	0.40	0.008	0.408	<0.010	<0.010
max	0.757	0.80	0.141	0.901	0.020	0.15

*Below detection limit of analysis; figured as 0 in calculation of mean

TABLE A-VI

STATION NO. 15 NUTRIENTS (mg/1), 1983

	NH_3-N	Kjeldahl-N	NO_2+NO_3-N	Total-N	Ortho-P	Total-P
6/21/83	0.008	0.30	0.016	0.316	<0.010*	0.01
7/19/83	0.018	0.47	0.003	0.473	0.010	0.013
8/30/83	0.026	0.40	-	-	<0.010*	<0.010*
9/27/83	0.310	1.50	0.025	1.525	<0.010*	0.180
10/17/83	0.071	0.80	0.008	0.808	<0.010*	0.060
10/26/83	0.118	0.60	0.012	0.612	<0.010*	0.040
11/22/83	0.065	0.66	2.97 ?	3.63 ?	0.010	0.100
mean	0.09	0.68	0.51 ?	1.23 ?		0.067
min	0.008	0.30	0.012	0.316	<0.010	<0.010
max	0.310	1.50	2.97	3.63	0.010	0.180

*Below detection limit of analysis; figured as 0 in calculation of mean

NOTE: 11/22 NO_2+NO_3 very high: possible lab error

APPENDIX B. Flow and Nutrient Loads of Black Lake Tributaries, Graphically Depicted by Date.

Figure B-I.

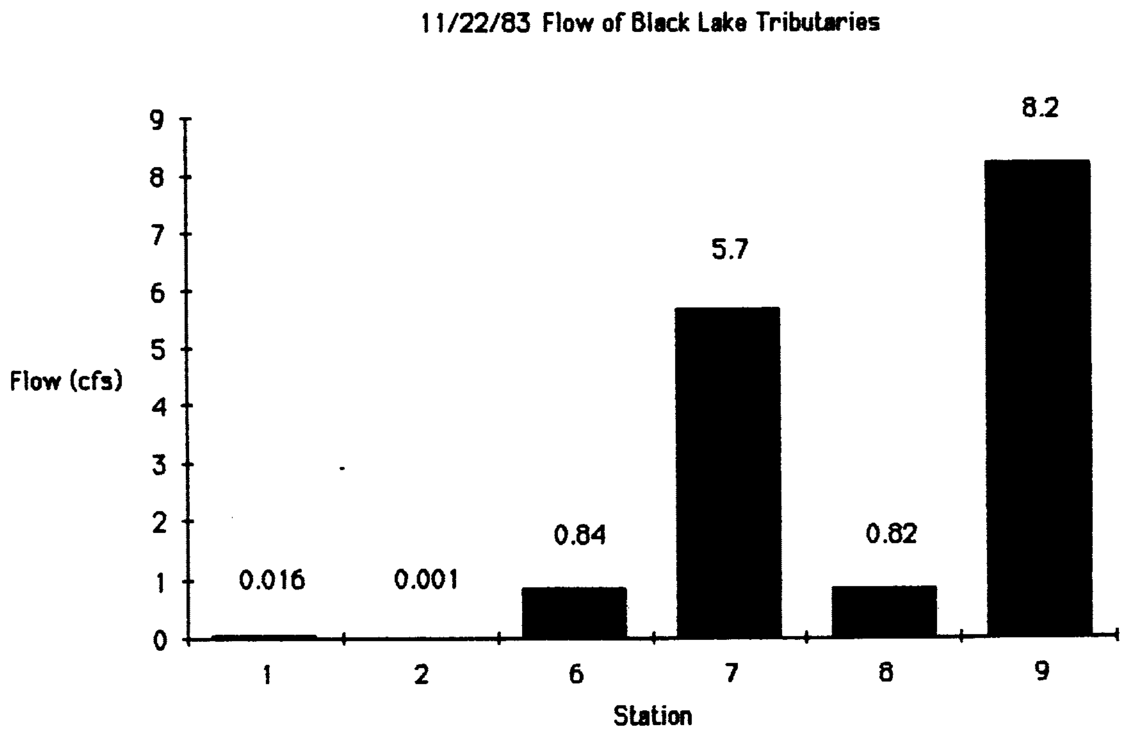

11/22/83 Flow of Black Lake Tributaries
Flow (cfs)
9
8
7
6
5
4
3
2
1
0
0.016
0.001
0.84
5.7
0.82
8.2
1
2
6
7
8
9
Station

Figure B-II

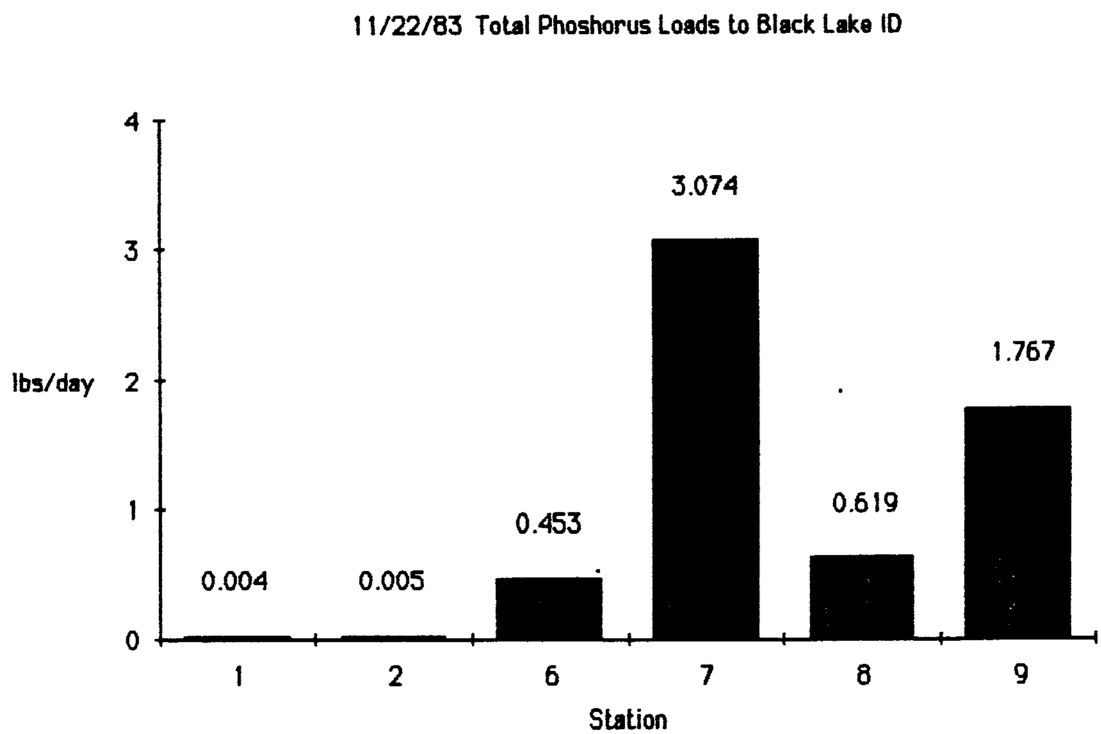

11/22/83 Total Phoshorus Loads to Black Lake ID
lbs/day
4
3
2
1
0
3.074
1.767
0.453
0.619
0.004
0.005
1
2
6
7
8
9
Station

Figure B-III

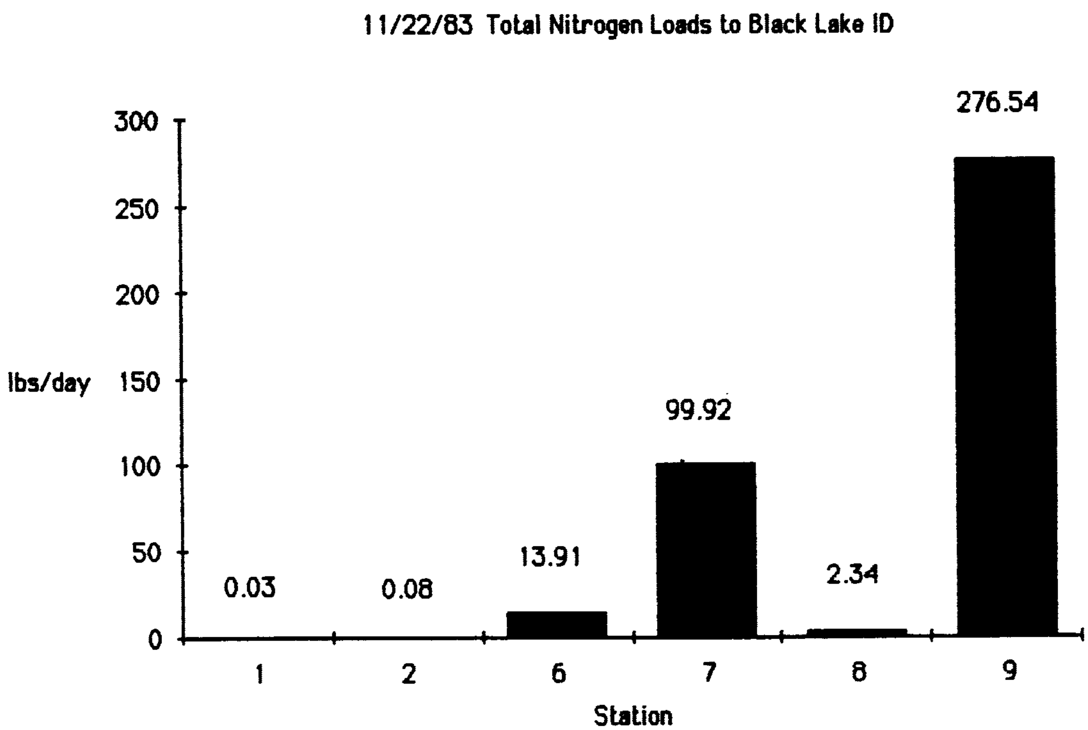

11/22/83 Total Nitrogen Loads to Black Lake ID
lbs/day
300
250
200
150
100
50
0
0.03
0.08
13.91
99.92
2.34
276.54
1
2
6
7
8
9
Station

Figure B-IV

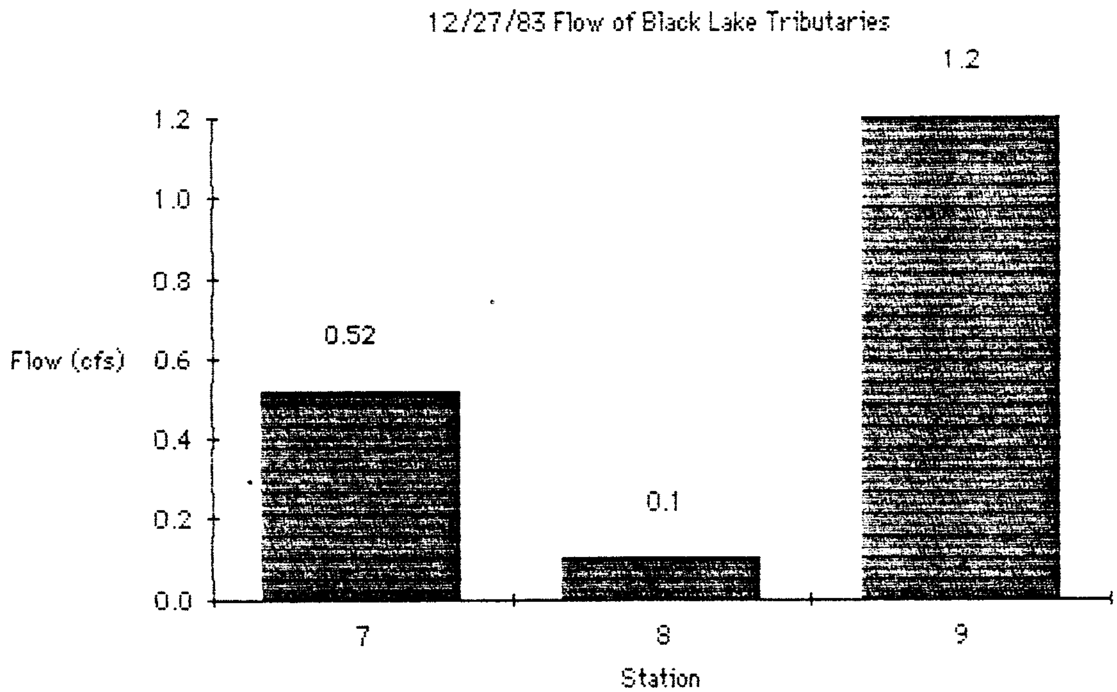

12/27/83 Flow of Black Lake Tributaries
1.2
0.52
0.1
Flow (cfs)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
7
8
9
Station

Figure B-V

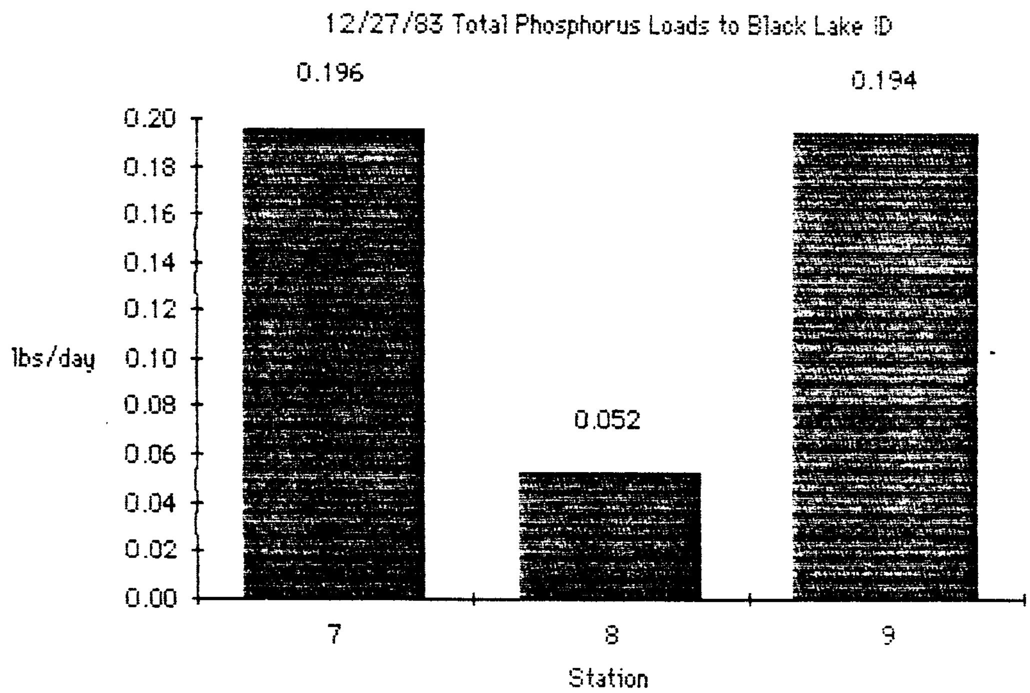

12/27/83 Total Phosphorus Loads to Black Lake ID
0.196
0.194
0.052
0.20
0.18
0.16
0.14
0.12
lbs/day
0.10
0.08
0.06
0.04
0.02
0.00
7
8
9
Station

Figure B-VI

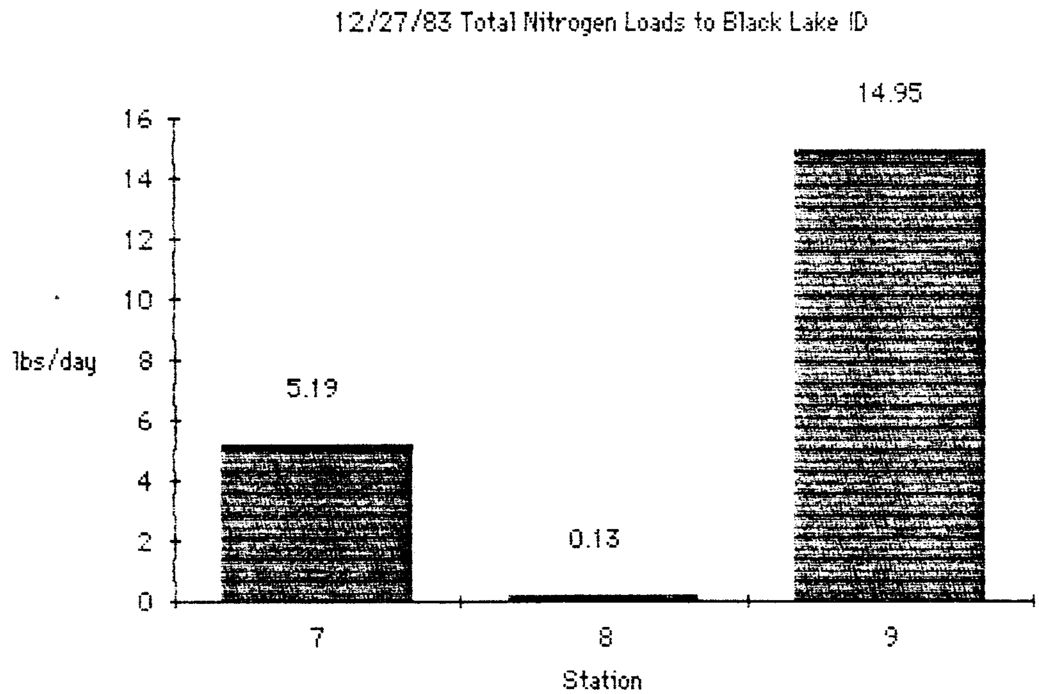

12/27/83 Total Nitrogen Loads to Black Lake ID
lbs/day
0
2
4
6
8
10
12
14
16
5.19
0.13
14.95
7
8
9
Station

Figure B-VII

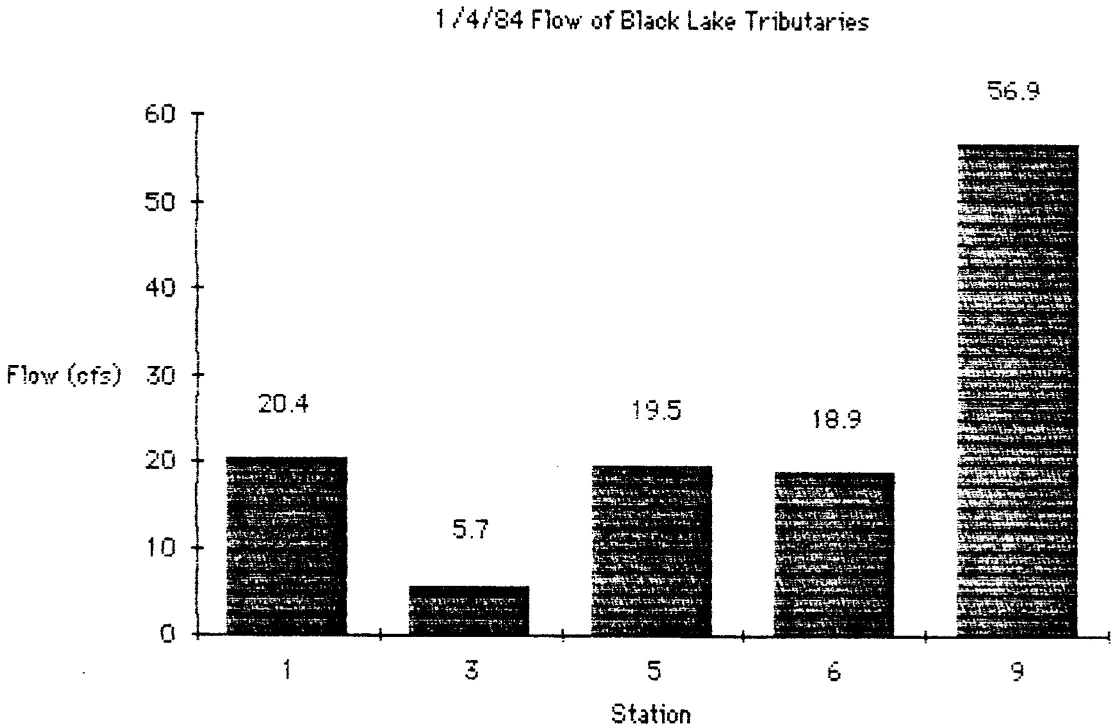

1/4/84 Flow of Black Lake Tributaries
Flow (cfs)
60
50
40
30
20
10
0
20.4
5.7
19.5
18.9
56.9
1
3
5
6
9
Station

Figure B-VIII

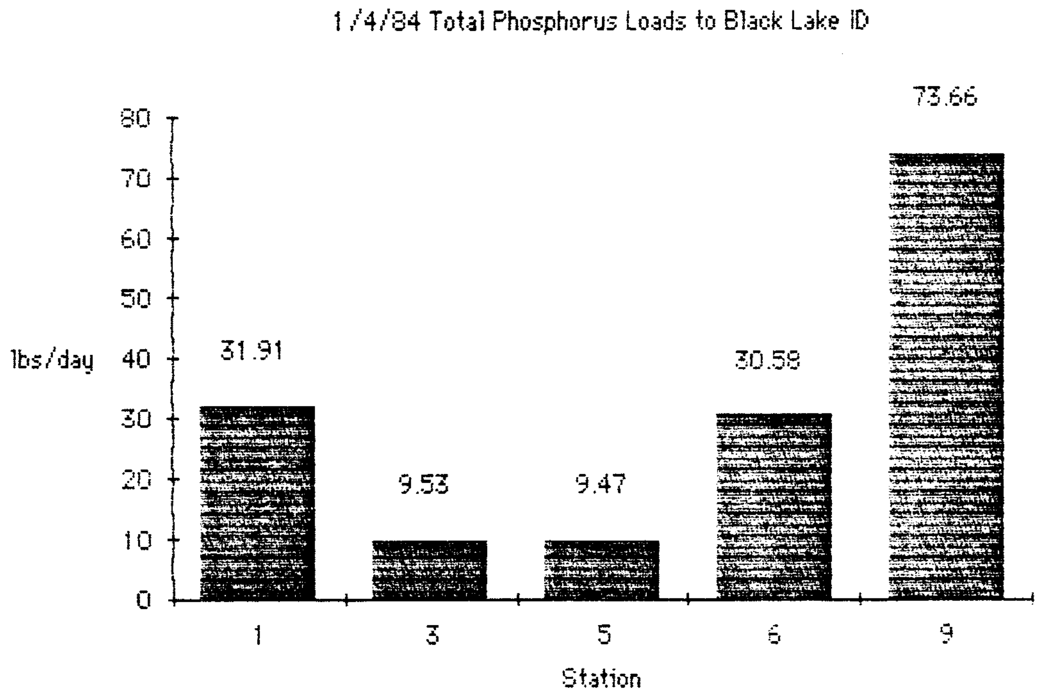


Figure B-IX

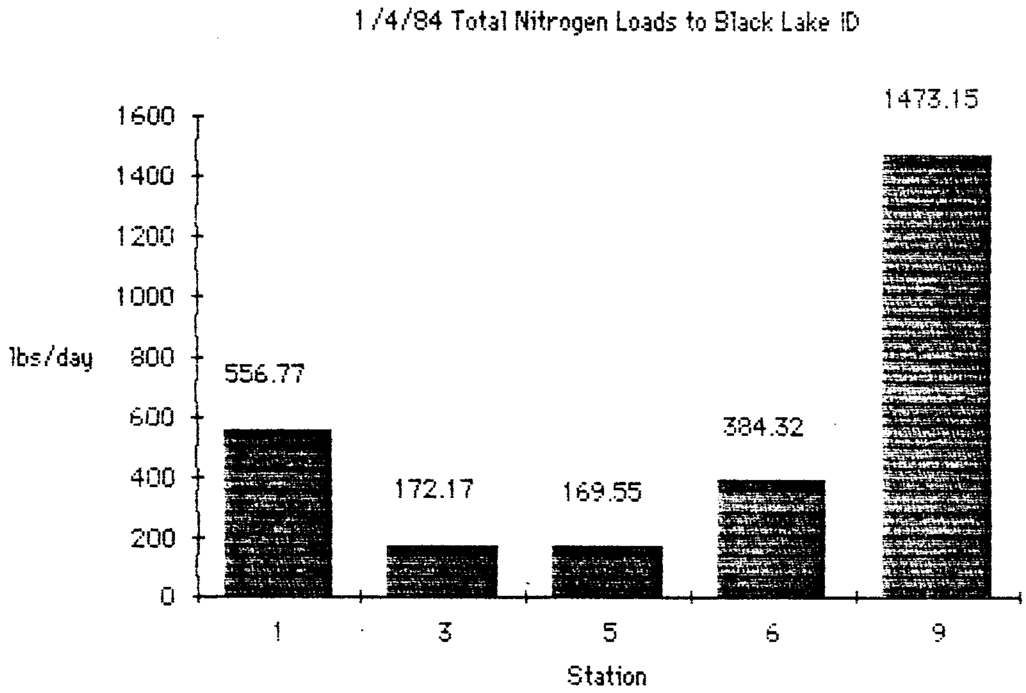

1/4/84 Total Nitrogen Loads to Black Lake ID
1473.15
1600
1400
1200
1000
lbs/day
800
556.77
600
384.32
400
172.17
169.55
200
0
1
3
5
6
9
Station

Figure B-X

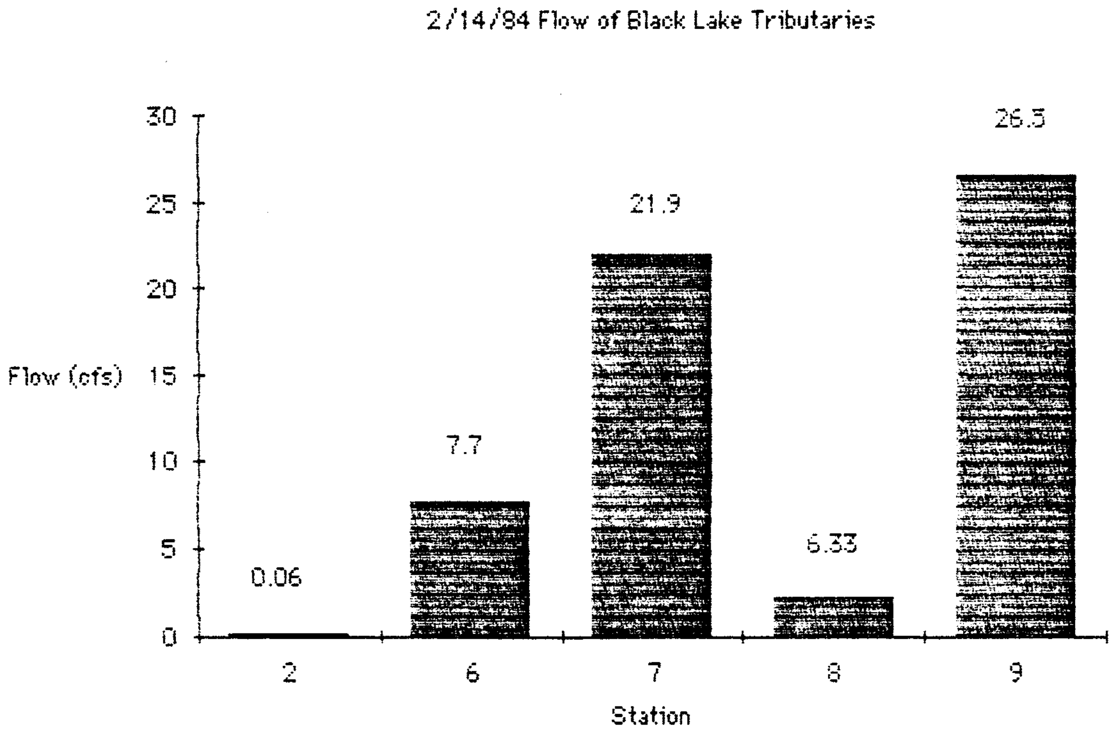

2/14/84 Flow of Black Lake Tributaries
30
25
20
15
10
5
0
Flow (cfs)
0.06
7.7
21.9
6.33
26.5
2
6
7
8
9
Station

Figure B-XI

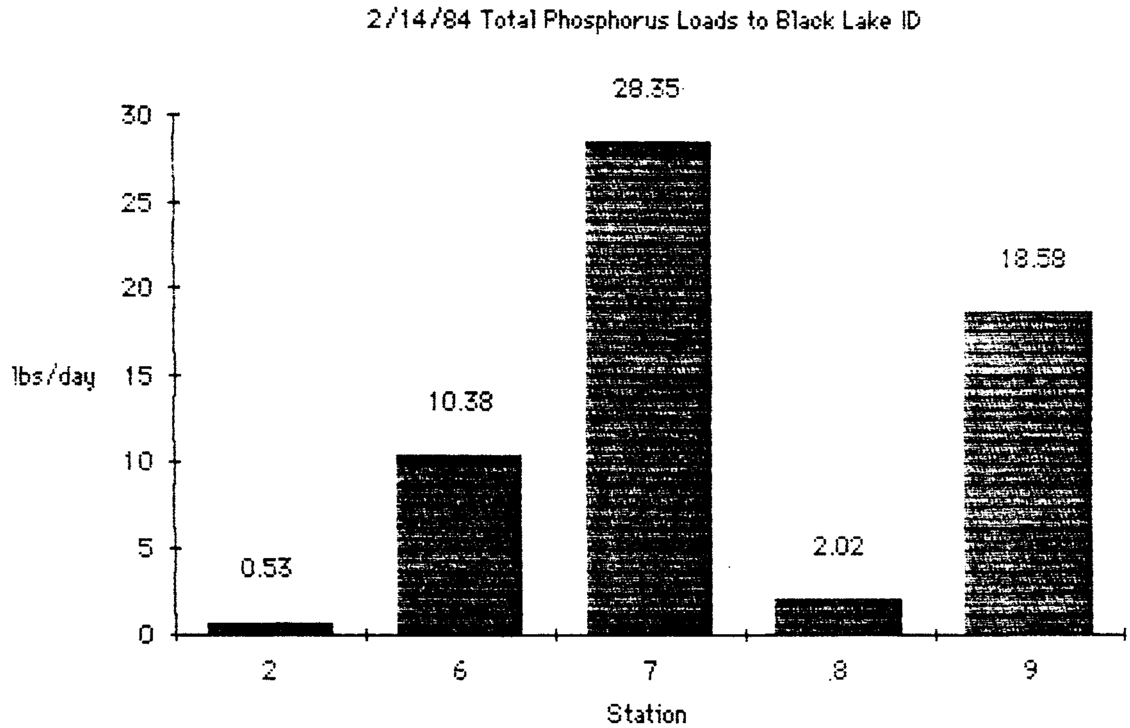
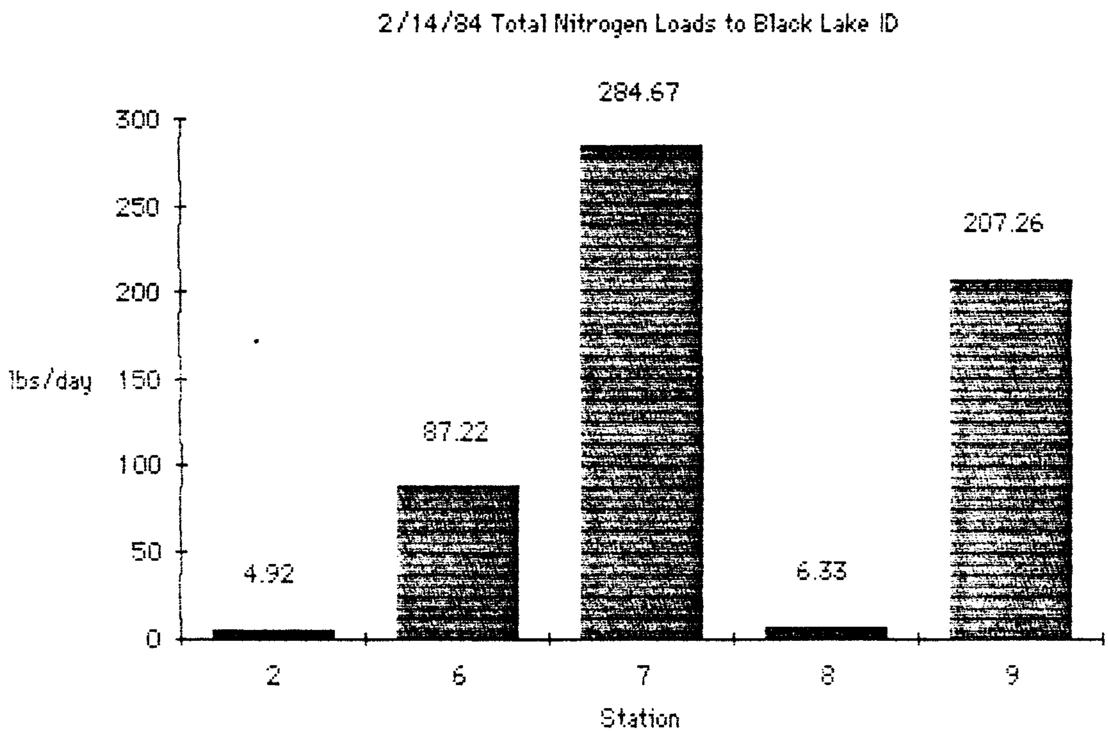
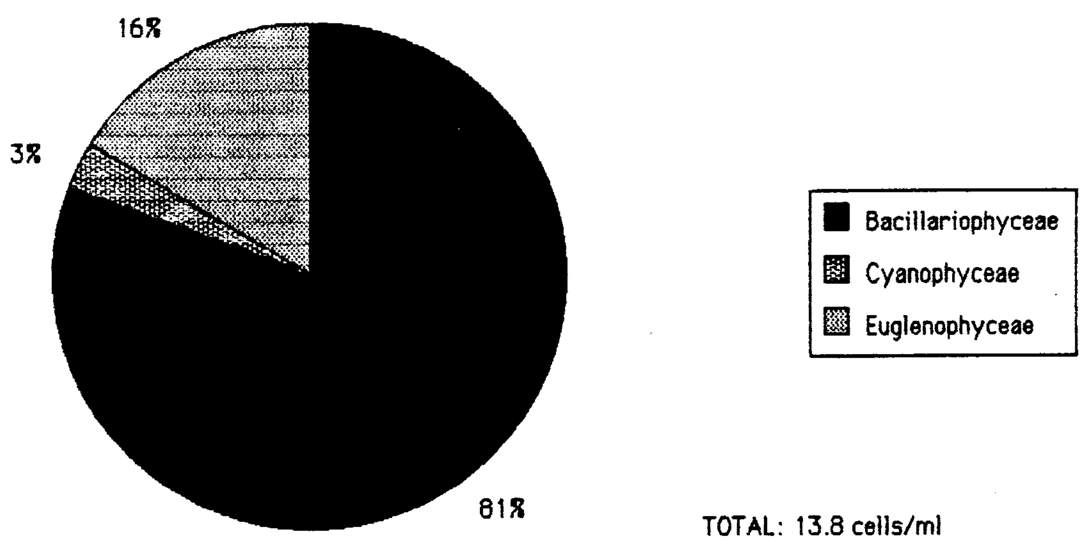

2/14/84 Total Phosphorus Loads to Black Lake ID
lbs/day
30
25
20
15
10
5
0
28.35
18.58
10.38
0.53
2.02
2
6
7
8
9
Station

Figure B-XII

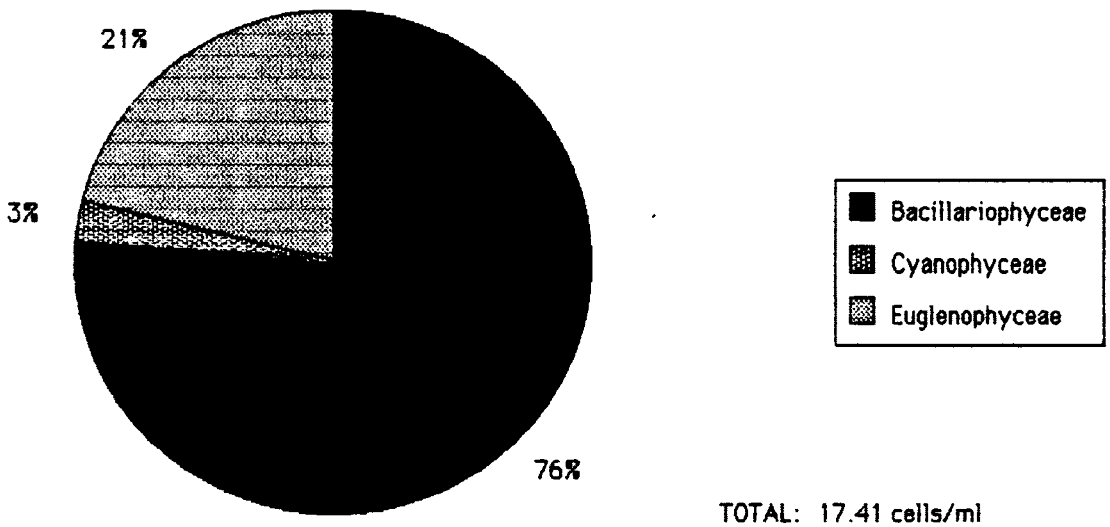

2/14/84 Total Nitrogen Loads to Black Lake ID
lbs/day
300
250
200
150
100
50
0
4.92
87.22
284.67
6.33
207.26
2
6
7
8
9
Station

APPENDIX C. Black Lake Phytoplankton Graphically Depicted By Taxonomic Class (by station and date).

6/22/83 Station 10. Phytoplankton by Class (algal cells/ml)

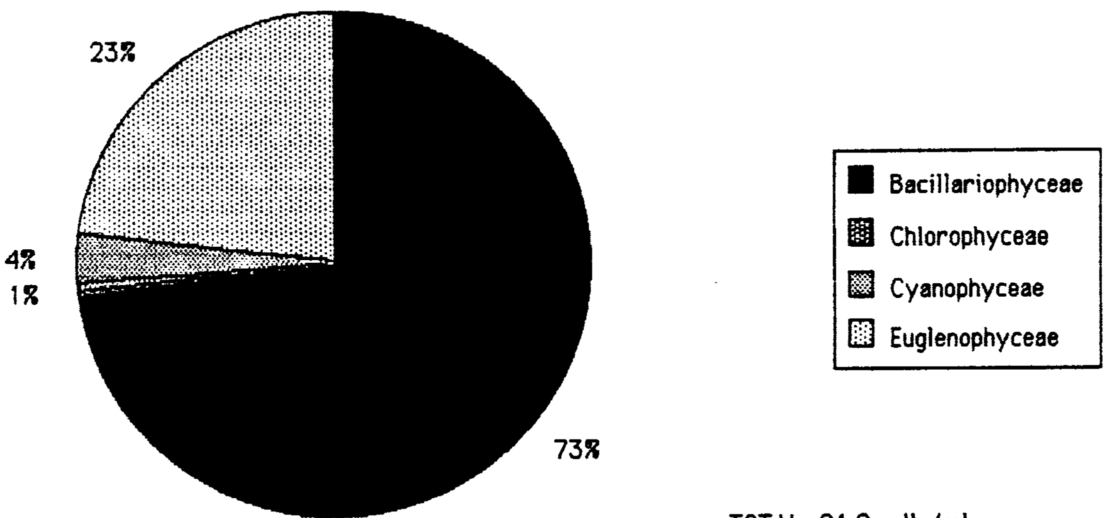


6/22/83 Station 11. Phytoplankton by Class (algal cells/ml)



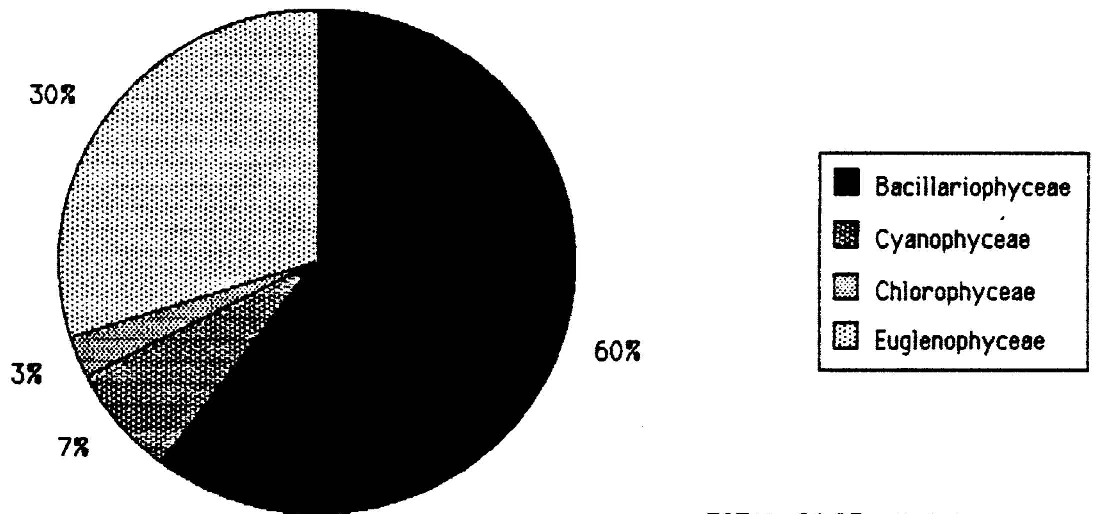
TOTAL: 17.41 cells/ml

6/22/83 Station 12. Phytoplankton by Class (algal cells/ml)



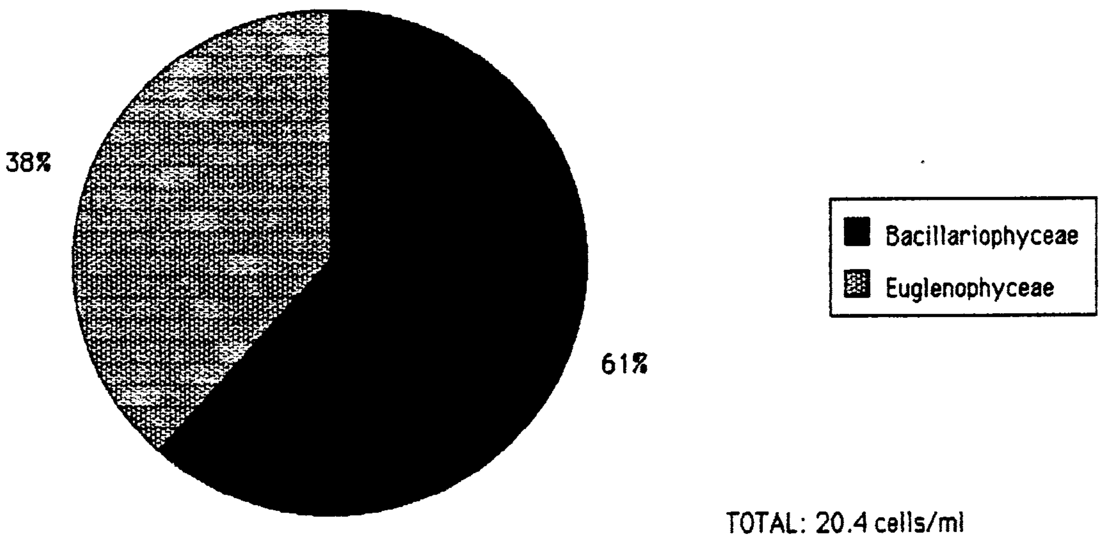
TOTAL: 21.2 cells/ml

6/22/83 Station 13. Phytoplankton by Class (algal cells/ml)

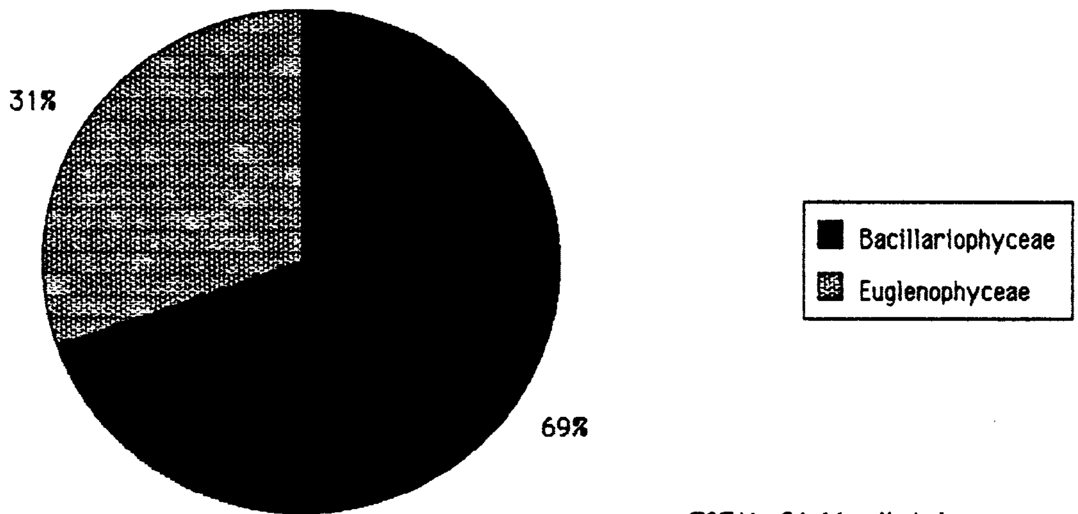


TOTAL: 26.85 cells/ml

6/22/83 Station 14. Phytoplankton by Class (algal cells/ml)

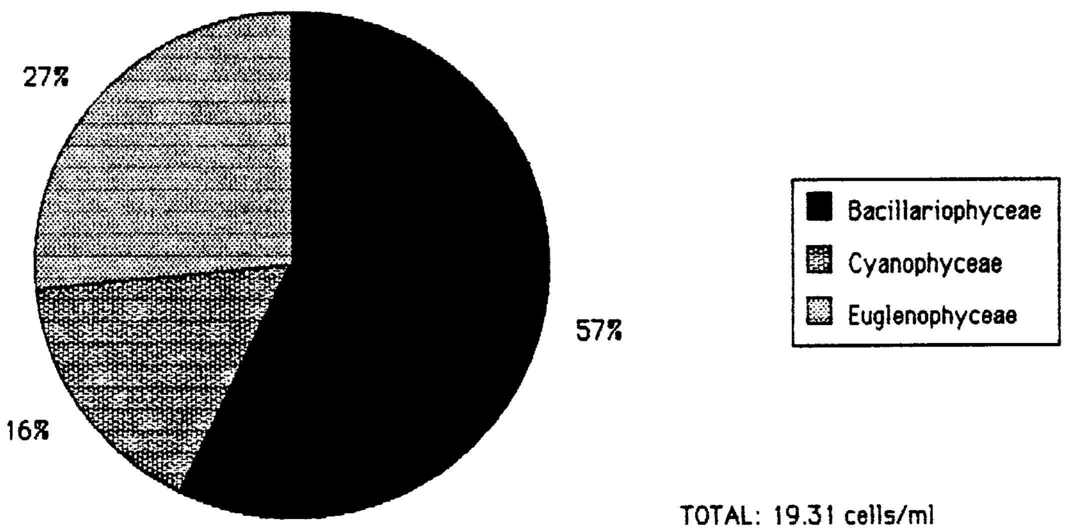


6/22/83 Station 15. Phytoplankton by Class (algal cells/ml)



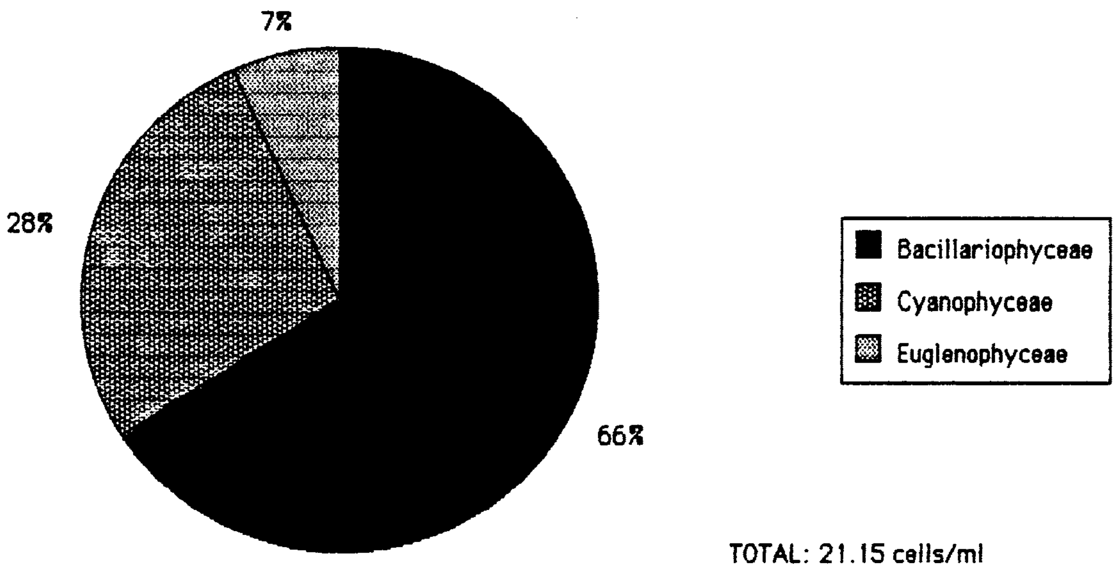
TOTAL: 21.11 cells/ml

7/19/83 Station 10. Phytoplankton by Class (algal cells/ml)

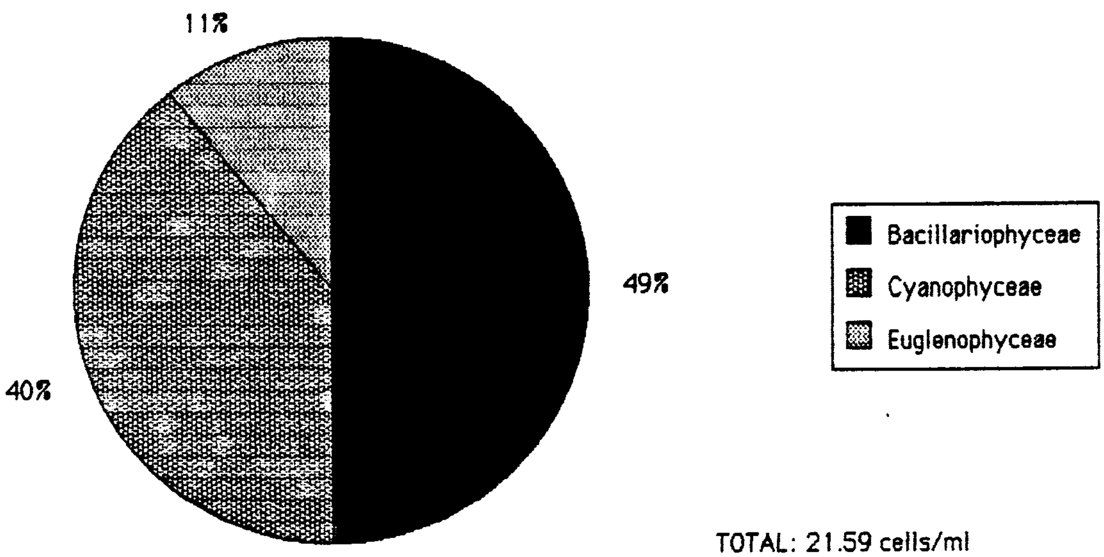


TOTAL: 19.31 cells/ml

7/19/83 Station 11. Phytoplankton by Class (algal cells/ml)

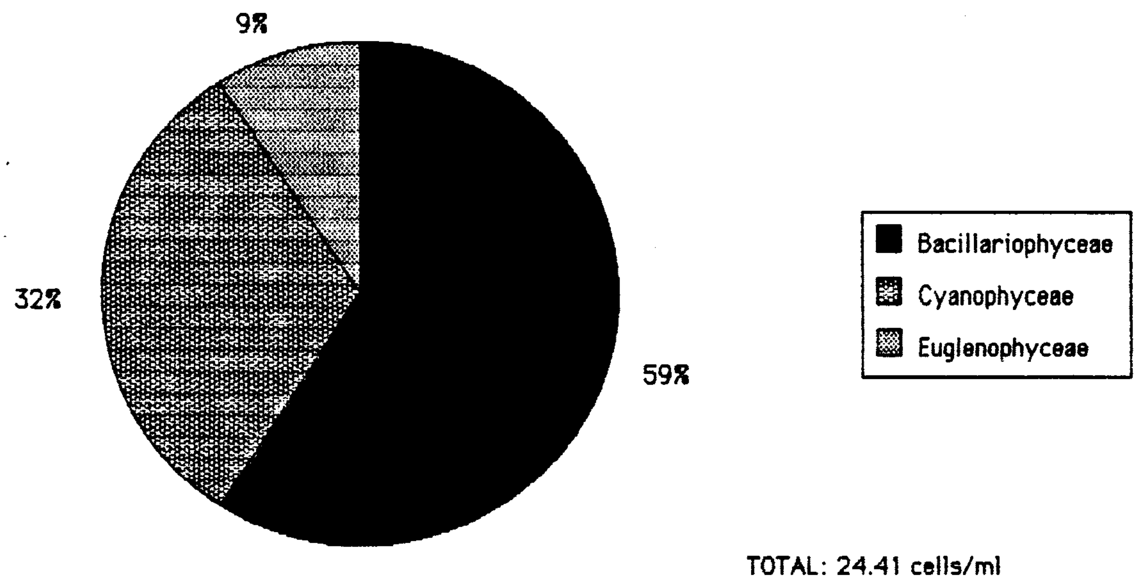


7/19/83 Station 12. Phytoplankton by Class (algal cells/ml)

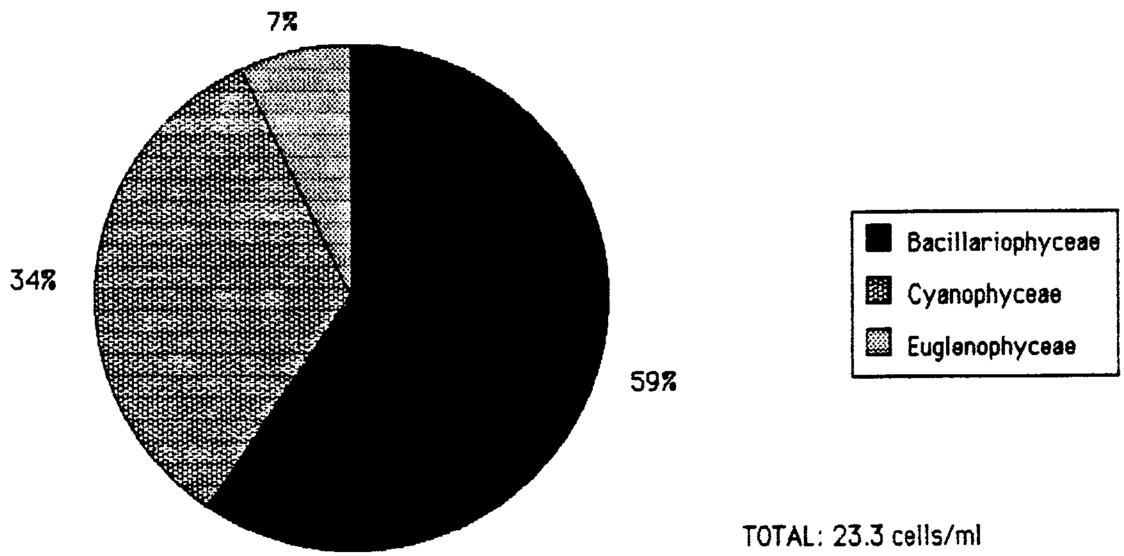


TOTAL: 21.59 cells/ml

7/19/83 Station 13. Phytoplankton by Class (algal cells/ml)

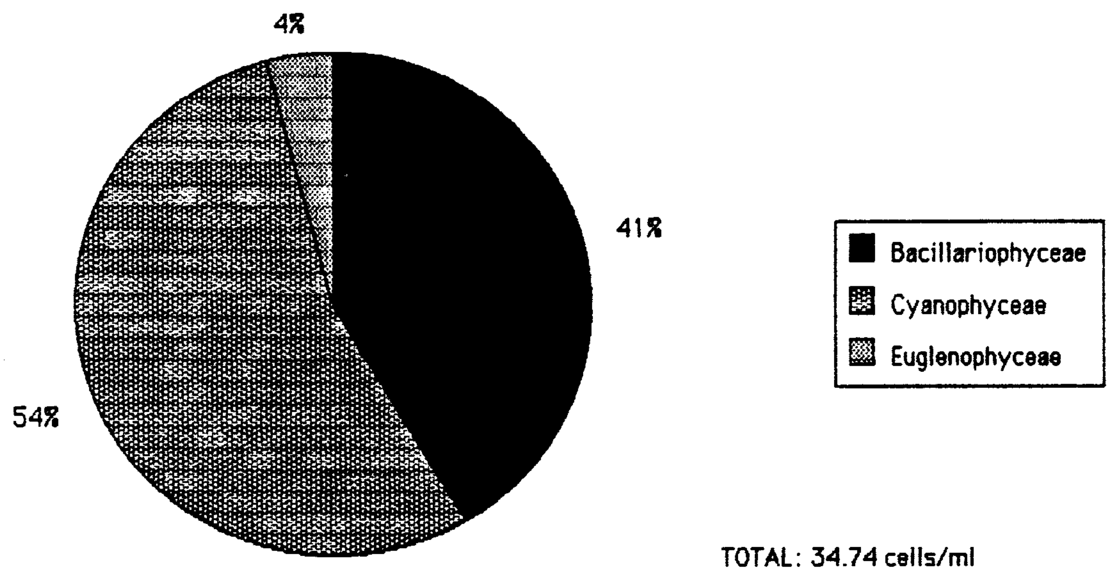


7/19/83 Station 14. Phytoplankton by Class (algal cells/ml)

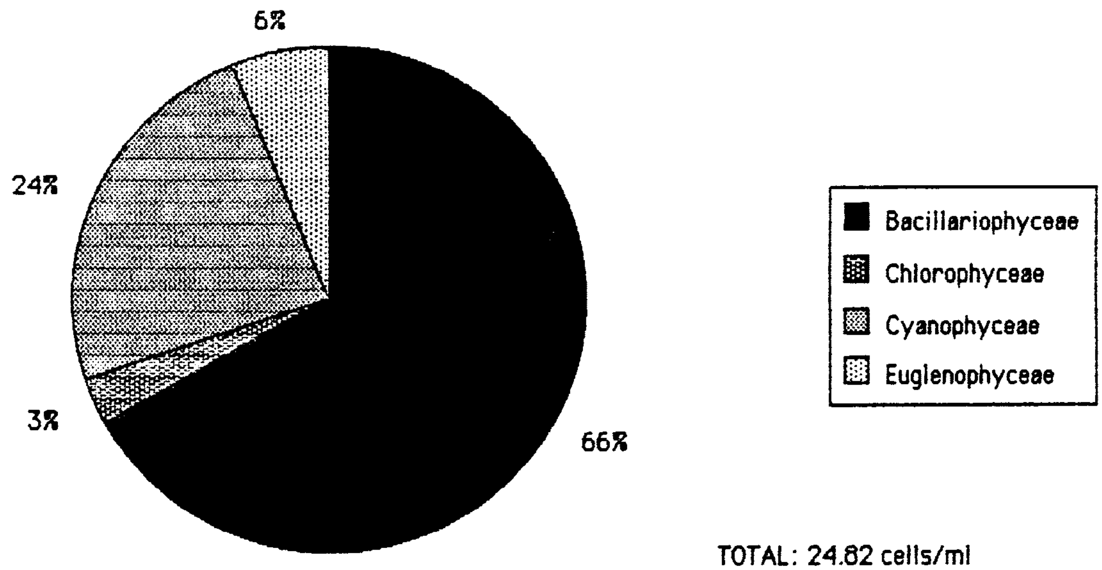


TOTAL: 23.3 cells/ml

7/19/83 Station 15. Phytoplankton by Class (algal cells/ml)

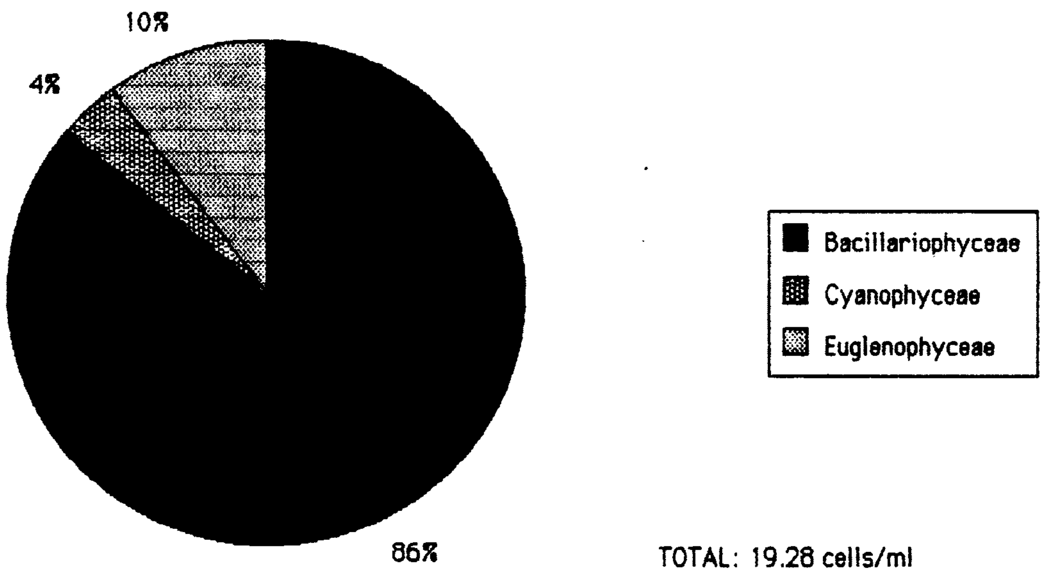


8/31/83 Station 10. Phytoplankton by Class (algal cells/ml)



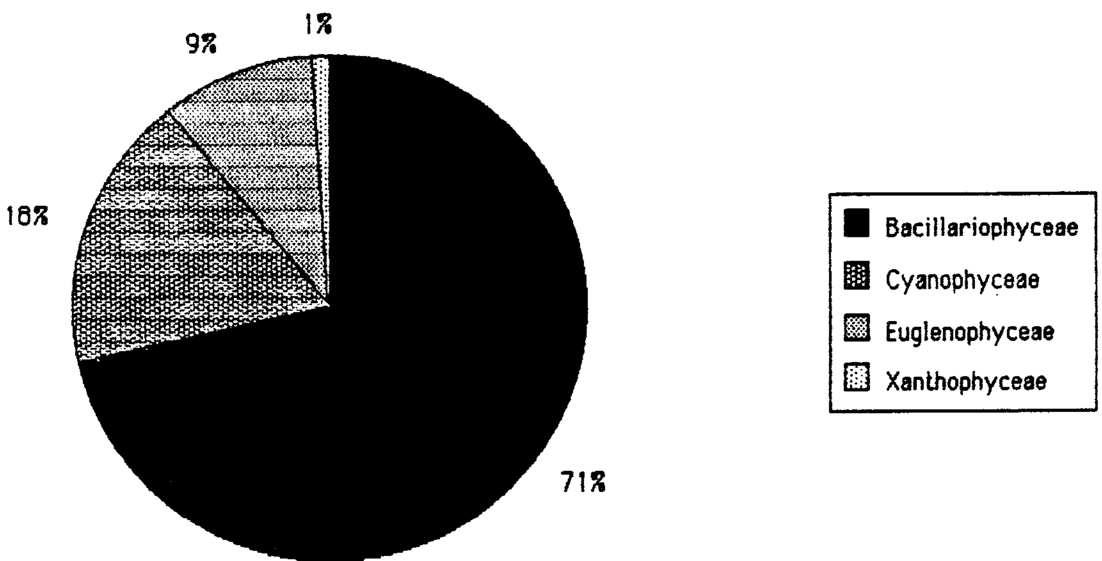
TOTAL: 24.82 cells/ml

8/31/83 Station 11. Phytoplankton by Class (algal cells/ml)



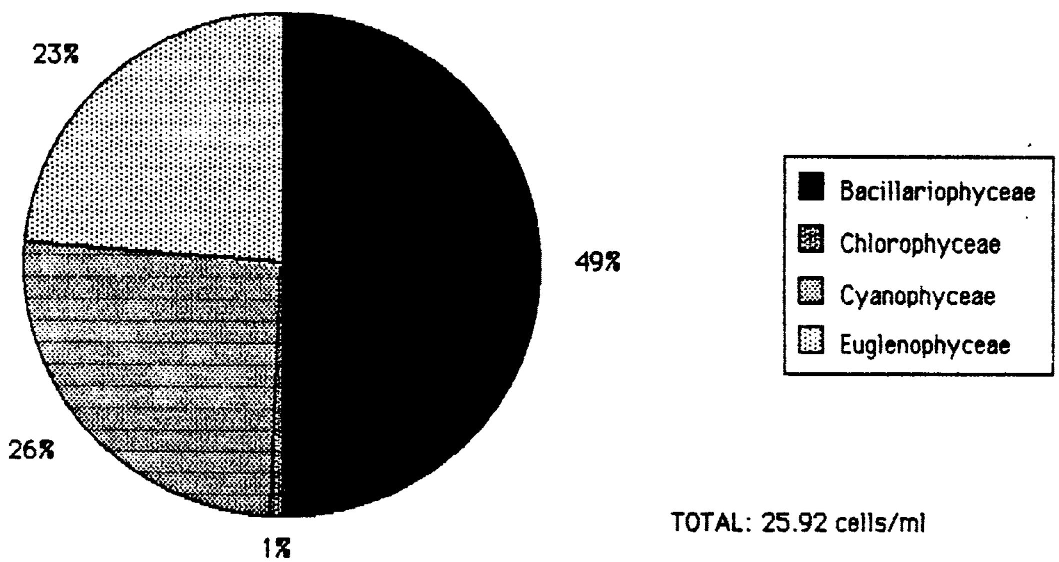
TOTAL: 19.28 cells/ml

8/31/83 Station 12. Phytoplankton by Class (algal cells/ml)

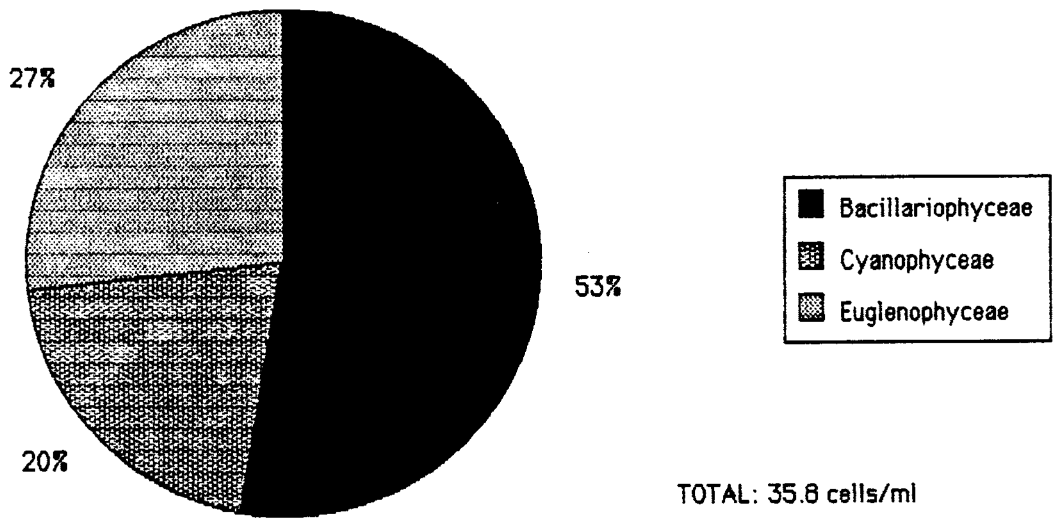


TOTAL: 29.86 cells/ml

8/31/83 Station 13. Phytoplankton by Class (algal cells/ml)

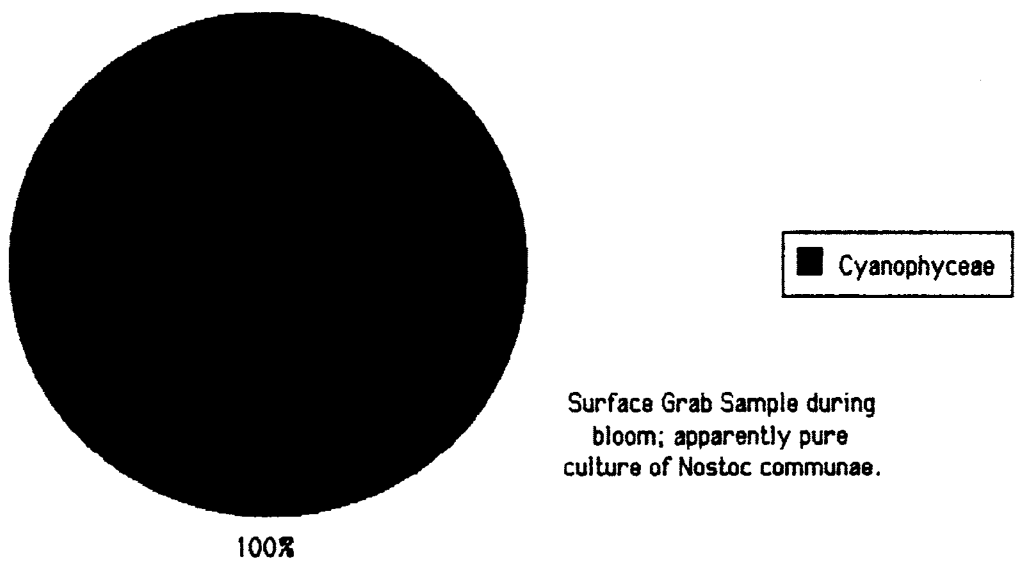


8/31/83 Station 14. Phytoplankton by Class



TOTAL: 35.8 cells/ml

10/26/83 Station 11. Phytoplankton by Class
(algal cells/ml)



Surface Grab Sample during
bloom; apparently pure
culture of Nostoc communae.

APPENDIX D. Black Lake Bacteriological Water Quality Data.

FC - Fecal Coliform
FS - Fecal Strep

BACTERIOLOGICAL RESULTS

Station No.	1		2		3*		4		5	
Bacterial Class -per 100 ml	FC	FS	FC	FS	FC	FS	FC	FS	FC	FS
6/21/83	40	<10			290	<10			730	<10
7/19/83	9	<1			7	<1	<1	<1	<1	<1
8/31/83					70	>100			50	49
9/28/83					<1	18	11	10	2	21
10/17/83					<1	40				
10/27/83					1	4	1	<1	8	1
11/23/83			>80	>80	40	48	8	7		
12/27/83							<1	1		
1/4/84	CG[t]	>100			CG	>100	CG	100	14	15
1/18/84							25	250		
1/26/84					CG	CG	CG	36	CG	79
2/15/85	60	800			130	4000	100	400		

* Samples sometimes taken at pump inlet, when pump not operating

[t] CG - confluent growth

FC - Fecal Coliform
FS - Fecal Strep

BACTERIOLOGICAL RESULTS

Station / Bacterial Class -per 100 ml	6		7		8		9		10	
	FC	FS	FC	FS	FC	FS	FC	FS	FC	FS
6/21/83									<10	<10
7/19/83	230	<1	38	>100	33	>100	7	50	<1	9
8/31/83			>10	>100	-	46	>80	76	<1	98
9/22/83	10	36	15	>80	3	1	7	2	<1	<1
10/17/83									<1	8
10/27/83			25	74	12	18	2	3	<1	1
11/23/83	9	>80	16	42	30	40	60	6	8	10
12/27/83			30	>80	3	>80	20	28		
1/4/84	>60	>100			CG	>100	>60	>100		
1/18/84			30	60	9	600	7	50		
1/26/84										
2/15/84	40	900	10	500	<10	500	50	1500		

FC - Fecal Coliform
FS - Fecal Strep

BACTERIOLOGICAL RESULTS

Station	11		12		13		14		15	
Bacterial Class -per 100 ml	FC	FS	FC	FS	FC	FS	FC	FS	FC	FS
6/21/83	<10	<10								
7/19/83	<1	3	<1	3	<1	5	1	15	<1	2
8/31/83	<1	<1	<1	>100	<1	>100	<1	>100	<1	60
9/28/83	2	55	<1	<1	<1	<1	<1	<1	<1	30
10/17/83	<1	>80	<1	20	7	>80	1	>80	1	45
10/27/83	<1	<1	<1	>80	1	>80	<1	>80		
11/23/83	1	12	2	20	5	12	7	70	46	30
12/27/83										
1/4/84										

APPENDIX E.

Report on the Results of Algal Assays Performed on Waters Collected From Black Lake, Kootenai County, Idaho

by

Joseph C. Greene, Michael A. Long and Cathy Lee Bartels

U.S. Environmental Protection Agency
Corvallis Environmental Research Laboratory
Hazardous Materials Assessment Team
200 S.W. 35th Street
Corvallis, Oregon 97333

Algal assays were performed on Black Lake at the request of representatives of the Division of Environment, Department of Health and Welfare, State of Idaho. Water samples were collected by employees of the Division of Environment or Dr Mike Falter, Dept. Fisheries, University of Idaho at Moscow in autoclavable containers furnished by EPA. Water was collected from 1 and 3 meters at three central points on Black Lake. These 6 subsamples were composites to form a single sample on which algal assays were performed. Samples were shipped by the US Postal Service and were generally received in two to three days.

Algal assays were performed following the methods outlined in The <u>Selenastrum</u> <u>capricornutum</u> Algal Assay Bottle Test (Miller, Greene and Shiroyama, 1978). Samples were autoclaved in their shipping bottles upon arrival. After cooling they were filtered through a 0.45 micrometer pore size millipore filter.

Metals analysis were performed on Black Lake water samples for calcium, magnesium, zinc, copper, chromium, nickel, cadmium, mercury, and sulfur. Only zinc, calcium, magnesium and sulfur results are shown on the enclosed table. All of the other elements measured were below the levels of detection. The zinc concentrations were at background levels and did not inhibit algal growth in these tests.

Nutrient analysis was performed for nitrite, nitrate, ammonia, total phosphorus and ortho phosphorus. The sum of the nitrogen species were used to predict the algal yield under nitrogen limited conditions. The ortho-phosphorus concentrations were used to predict the phosphorus limited algal yields. In every case, where nutrients were present in measureable quantities, the predicted yields were conservative, relative to the actual yields. Chemical analysis under estimated the true algal growth potential in every sample tested.

All samples collected from August 8 to October 14, 1984 were primarily algal growth limited by phosphorus and secondarily limited by nitrogen. From October 27 to November 24, 1984 the order of the limiting nutrients was reversed with nitrogen being the primary and phosphorus being the secondary limiting growth nutrients in Black Lake waters.

According to the productivity group classification of algal biomass defined by Miller, Maloney and Greene (1974) the control yield of 0.62 mg dry weight Selenastrum/liter falls within the **moderate productivity** subgroup of 0.11 to 0.80 mg dry weight/liter. The following samples collected from September 9 to October 14 fell within the **moderately high productivity** subgroup of 0.81 to 6.00 mg dry weight/liter. The three samples collected from October 27 to November 24 were examined more closely because the primary limiting nutrient had shifted to nitrogen. Although two of the control samples fall within the **high productivity** subgroup (=>6.00 mg dry weight/liter), lake growth potential is best defined by studying the yields produced in the nitrogen spiked flasks.

The rationale for this decision is that the dominant nuisance alga in Black Lake is a nitrogen fixing blue-green alga of the genus Nostoc or Anabaena (Personal communication, Mike Beckwith, 1984). Furthermore, the laboratory test alga is a non-nitrogen fixing green alga. By adding nitrogen to the test flasks the green alga's nitrogen requirement is satisfied and it will produce yields similar to what one would expect from the nitrogen fixing alga. Based on these determinations the algal growth potential of Black Lake during the period of October 27 to November 24 ranged between 9.60 to 12.16 mg dry weight/liter rather than the lower control growth potentials of 5.70 to 7.96 mg dry weight/liter.

REFERENCES

Beckwith, Mike. 1984. Senior Water Quality Specialist, State of Idaho, Division of Environment, Coeur d'Alene Field Office, Idaho. Letter dated September 10, 1984.

Miller, W.E., J.C. Greene and T. Shiroyama. 1978. Selenastrum capricornutum Printz Algal Assay Bottle Test: Experimental Design, Application, and Data Interpretation Protocol. U.S. Environmental Protection Agency, Corvallis, Oregon. EPA-600/9-78-018.

Miller W.E., T.E. Maloney and J.C. Greene. 1974. Algal Productivity in 49 lake waters as determined by algal assays. Water Res. 8:667-679.

US EPA, HAZARDOUS MATERIALS ASSESSMENT TEAM - CORVALLIS, OREGON

14-DAY ALGAL GROWTH POTENTIAL TESTS

SITE: BLACK LAKE, KOOTENAI CO., IDAHO
STATION: COMPOSITE OF 3 CENTRAL DEEP POINTS TAKEN FROM 1 AND 3 METERS AT EACH POINT.
STORET NO.: NONE
PRETREATMENT: AUTOCLAVED AND FILTERED

NOTE	SAMPLE DATE	CONTROL	1.00 N	0.05 P	N+P	1.00 E	N+E	P+E	N+P+E	LIMITING FACTORS	CERL ID	ZINC (MG/L)
		NUTRIENT SPIKES (MG/LITER)										
	08/01/84	0.62	0.41	3.26	27.79	1.31	0.45	3.50	25.56	P/N	6334025	-
	09/05/84	3.44	4.23	8.98	34.89	4.23	3.47	9.34	37.40	P/N	6338003	0.008
	10/07/84	4.21	5.25	5.78	37.40	4.17	4.81	5.47	27.23	P/N	6343001	-
	10/14/84	2.47	3.73	2.57	21.47	1.91	2.41	2.90	21.86	P/N	6334001	0.007
	10/27/84	6.97	11.01	7.75	42.19	5.06	5.42	7.03	40.48	N/P	6345003	-
	11/10/84	5.70	9.60	5.88	40.94	5.00	5.44	6.01	35.03	N/P	6347801	0.008
	11/24/84	7.96	12.16	9.25	42.65	7.69	9.68	9.20	46.15	N/P	6349800	0.008

P=PHOSPHORUS; N=NITROGEN; E=EDTA; M=HEAVY METALS INHIBITION.

ICAPES ELEMENTAL CHEMICAL ANALYSIS

SAMPLE DATE	ALGAL TEST CODE	CERL ID	ZN	CA	MG	S
			MG /LITER			
080184	081784	6334025	<	8.892	3.083	-
090584	091484	6338003	0.008	9.549	3.304	-
100784	102684	6343001	<	8.715	3.115	4.459
101484	102684B	6344001	0.007	9.179	3.305	4.695
102784	110984	6345003	<	9.274	3.261	4.675
111084	111684	6347801	0.008	8.901	3.338	4.845
112484	120784	6349800	0.008	8.977	3.182	4.771

TECHNICON

SAMPLE DATE	ALGAL TEST CODE	CERL ID	NO2 + NO3	NH3	TSIN	PREDICT. YIELD	TOTAL PHOS.	ORTHO PHOS>	PREDICT. YIELD
080184	081784	6334006	<0.010	<0.005	-	-	-	<0.005	-
090584	091484	6338003	<0.010	<0.005	-	-	0.019	0.012	5.16
100784	102684	6343001	0.012	0.063	0.075	2.85	0.029	0.007	3.01
101484	102684B	6344001	<0.010	0.017	0.017	<1.00	0.039	<0.005	-
102784	110984	6345003	0.021	0.021	0.041	1.56	0.021	0.012	5.16
111084	111684	6347801	0.032	0.073	0.105	3.99	0.431	0.036	15.48
112484	120784	6349800	0.048	0.093	0.141	5.36	0.036	0.011	4.73

(-) THE ELEMENT WAS NOT ANALYZED.
(<) = ANALYSIS WAS PERFORMED BUT RESULTS FELL BELOW THE LEVEL OF DETECTION.