WATER QUALITY STATUS REPORT • REPORT NO. 61

WINCHESTER LAKE
Lewis County, Idaho
1985

Prepared by
John R. Moeller

Lewiston Field Office
1118 F Street
Lewiston, Idaho 83501

Department of Health & Welfare
Division of Environment
Boise, Idaho

May 1986

Table of Contents

ABSTRACT

Winchester Lake is an 85 acre recreation site located in north-central Idaho, approximately 30 miles southeast of Lewiston. Citizen complaints of poor water clarity, odors, and decline in angler success led to a six-month study of the lake's water quality in 1985.

Winchester Lake exhibits many symptoms of severe eutrophy. Anaerobic conditions and high temperatures were prevalent throughout much of the water column during summer. No direct correlation was seen between secchi disk transparency and suspended sediment.

Mean total phosphate concentrations (with 19 percent as dissolved orthophosphate) in the euphotic zone were 6 times the recommended limits for reservoirs. The ratio of lake depth to hydraulic retention time was over 10 times the rate considered indicative of eutrophic loading. Phosphorus loading rate by the primary tributary was nearly 2 1/2 times the rate suggested as critical. Influent inorganic nitrogen concentrations were between 2 and 28 times critical values.

The mean chlorophyll a concentration was 6-12 times that considered representative of eutrophic conditions. Blue-green algae dominated the phytoplankton community in August comprising 82 percent of the density and 90 percent of algal biovolume. Species diversity declined from 19 to 10 between mid-July and mid-August.

Neither inorganic metals nor organic compounds (herbicides and pesticides) were found to exceed criteria established for water and fish flesh.

Numerous rehabilitation and management options are feasible for Winchester Lake. The recommended actions should consider ongoing nutrient loading from land activities in the watershed. In addition, the stockpile of nutrients already stored in lake sediments must be addressed.

ACKNOWLEDGEMENTS

The assistance of the following individuals and organizations is acknowledged and appreciated: Ray Latham (Idaho Division of Environment) and Rick Lowell (Idaho Department of Fish & Game) for sample collection and data collation; Idaho Department of Fish and Game for background information and paying for sample analysis; Russ Collett, Clearwater Resource Conservation and Development Council Coordinator, for coordinating concerned individuals and agencies; Cecilia Dale for word processing; Idaho Bureau of Laboratories for chemical and bacteriological sample analysis; Jim Sweet, of Aquatic Analysts, EPA Contractor, for phytoplankton identification and analysis.

List of Figures

List of Tables

List of Appendices

INTRODUCTION

Background

Winchester Lake was formed by damming the headwaters of Lapwai Creek in northwest Lewis County, Idaho (Fig.1). It lies within the boundaries of the NezPerce Indian Reservation, one-half mile from the City of Winchester, and 30 miles southeast of Lewiston, and was once called Lapwai Lake.

Construction of Winchester Lake was completed in 1910. It was to serve as a mill pond for the Craig Mountain Lumber Company which was located in the City of Winchester and was the largest sawmill in the area. Several lumber companies utilized the lake until it was drawn down in 1967 in order to recover sinker logs and to install a new spillway and boat ramp. Winchester Lake had been acquired during the previous year by the Idaho Department of Fish and Game from Potlatch Forests, Inc. for $15,000 cash and a land exchange. During the drawdown, rotenone was used to remove undesireable fish species.

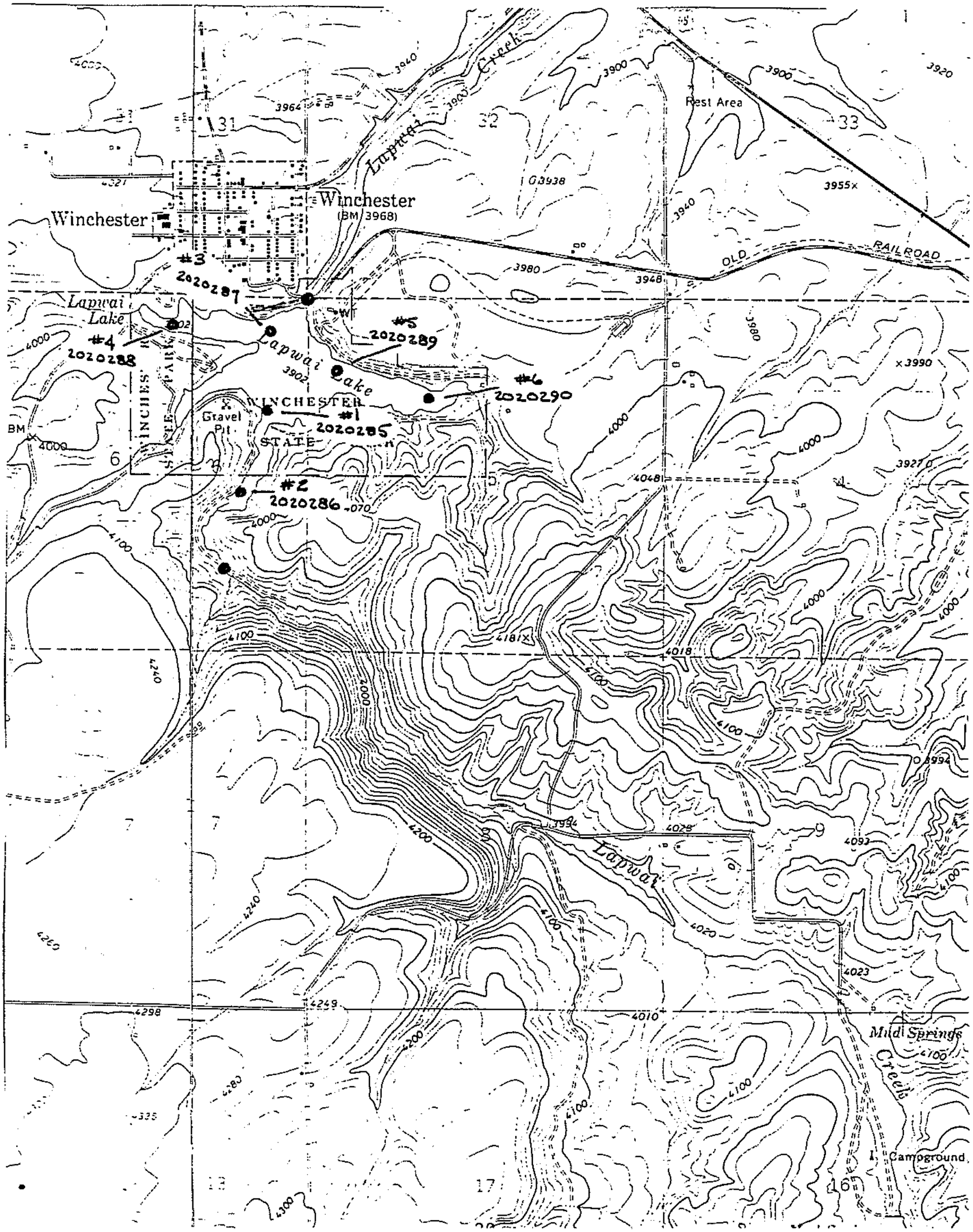
The City of Winchester, which is located on the north shore of the lake, discharged its treated municipal wastes into the lake until the new wastewater facility became operational in 1972. The 85 acre lake presently serves as the focal point of 318 acre Winchester Lake State Park.

The Idaho Department of Fish and Game maintains a trout put-and-take fishery in Winchester Lake. They have stocked the lake annually with an average of 30,000 catchable rainbow trout (from 1969-1985) and 68,000 rainbow trout fry, (from 1969-1982). In addition, an average of 58,000 cutthroat or rainbow-cutthroat hybrid fry were introduced annually from 1969-1977. In spite of the stocking program persistent complaints from the public have centered around poor fishing conditions as well as poor water clarity. Bullhead catfish are abundant, blue-green algal blooms have been frequently reported, and periodic fish kills have fouled the lake banks and air. However, Idaho Department of Fish and Game random creel census data indicate that fishing success, as measured by number of fish caught per hour of angler effort, has not changed radically over the period of record from 1967-1985. It has ranged from 0.47 fish/hour in 1976 to 2.19 fish/hour in 1975; angler success in 1984 and 1985 was 0.55 and 0.56, respectively (IDF&G, pers. comm.).

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FIGURE 1.

Vicinity Map of
Winchester Lake



Land use activities in the upper Lapwai Creek watershed have been recognized as impacting water quality and uses of Lapwai Creek, which is the major tributary to Winchester Lake. The Idaho Division of Environment, Bureau of Water Quality (BWQ) has identified Lapwai Creek as a priority water body due to its intensive use and high public visibility along highway 95, the major north-south roadway in Idaho. Idaho Water Quality Standards protect the headwaters of Lapwai Creek for domestic water supply, agricultural water supply, cold water biota, primary and secondary recreation, and salmonid spawning (IDHW/DOE, 1985).

Lapwai Creek was identified by the Lewis and NezPerce Soil Conservation Districts (SCDs) as being impacted to an unknown extent by agricultural practices. Limited silvicultural activity throughout the basin was also believed to contribute an unknown quantity of pollutants to Lapwai Creek and its tributaries. A planning grant administered by the BWQ through funds provided by the Idaho Water Pollution Control Account was awarded in 1985 to the two SCDs to assess those impacts.

In conjunction with the planning grant, a water quality intensive survey was initiated in early 1985 by the BWQ to assess the existing quality of Lapwai Creek. Numerous physical, chemical, and bacteriological samples were collected from seven sites in the Lapwai Creek watershed. Data obtained from the study will be utilized by the Districts, in consultation with the Soil Conservation Service, to identify those farmed acres where application of Best Management Practices will result in the greatest benefit to water quality.

Early in the planning cycle for Lapwai Creek, Winchester Lake was recognized as deserving additional attention. Winchester Lake is protected for the same uses as Lapwai Creek, with the exception of salmonid spawning. In addition, it has status as a Special Resource Water. Such bodies of water are recognized as needing intensive protection to main current beneficial uses, or to preserve outstanding or unique characteristics (IDHW/DOE, 1985).

An interagency effort was organized to study the problem and to make remedial recommendations. The participants included representatives from Lewis SCD, NezPerce SWCD, City of Winchester, Clearwater Resource Conservation and Development Council, NezPerce Indian Tribe, Idaho Department of Parks and Recreation, Idaho Department of Fish and Game, and the Idaho Bureau of Water Quality.

Description of Project Area

Winchester Lake is located 2 miles west of Highway 95, in the northwest corner of Lewis County. The lake effectively serves as a settling basin for the 7,800 acre watershed. Approximately 3,500 acres are still under forest cover, 860 acres in pasture, and 3,100 acres in dryland crops. The lake was created by impoundment of Lapwai Creek, which is formed by three smaller streams, Big Springs, Scoles Creek, and Johnson Creek. Normal pool level is 3902 feet. The lake is surrounded by forest, including a small virgin stand of ponderosa pine.

Annual precipitation has averaged 25.6 inches over the last 18 years of record, with even monthly distribution. Five percent of the annual total normally falls in July, while 10% of annual total falls in each of December, January, March, April, and May.

Mean annual snowfall for the 1965-1982 period of record was 108.1 inches, ranging from 31.8 inches in 1980-81 to 199 inches in 1971-72. As expected, most of the annual snowfall occurred in December and January (18.7 % and 21.1% of annual). March has typically seen 17.9% of the yearly total snowfall. Mean annual minimum and maximum temperatures between 1977 and 1982 were 31.0 °F and 54.4 °F.

STUDY DESIGN

The Lapwai Creek water quality study included stations immediately upstream and downstream of Winchester Lake. Additional lake stations were established to assess the physical, chemical, and biological dynamics specific to the lake. Therefore, sampling was conducted by the BWQ, in cooperation with the Idaho Department of Fish and Game over a six month period from May through October 1985. Measured parameters were selected to address the decline in water quality and fisheries.

Sample stations for the study were established in order to utilize, if possible, data collected in 1972, 1975, and 1979. Winchester Lake has three prominent bays. Stations 1,3, and 5 were each located in open water and corresponded to those bays; water and sediments were both sampled at those locations (Table 1). Stations 2,4, and 6 were each located in shallow waters at the head of each bay; only sediments were collected from those sites. In addition, inlet and outlet waters of the lake were sampled.

WINCHESTER LAKE STUDY

Station #	Description	Latitude/Longitude	River Mile	Elevation	STORET #
1	Winchester Lk 20' off dock- S Arm 18' depth	46°14'00"/116°37'14"	324.3/139.3/11.8/25.9	3,902'	2020285
2	Winchester Lk-1000' S of #1- S Arm 3' depth	46°13'36"/116°37'20"	324.3/139.3/11.8/26.2	3,902'	2020286
3	Winchester Lk NW Arm entrance 28' depth	46°14'12"/116°37'14"	324.3/139.3/11.8/25.7	3,902'	2020287
4	Winchester Lk NW Arm 1800' from #3-8' depth	46°14'14"/116°37'35"	324.3/139.3/11.8/25.7	3,902'	2020288
5	Winchester Lk E Arm Entrance- 24' depth	46°14'05"/116°37'00"	324.3/139.3/11.8/25.8	3,902'	2020289
6	Winchester Lk 1400' from Sta 5- E Arm 6' depth	46°14'02"/116°36'40"	324.3/139.3/11.8/25.9	3,902'	2020290

TABLE 1. SAMPLE STATION LOCATIONS AND DESCRIPTIONS

MATERIALS AND METHODS

Samples were collected every two weeks between May 7 and October 24, 1985, resulting in a total of 13 sample sets. Temperature, conductivity, and dissolved oxygen concentration profiles were determined at one meter intervals from the surface to lake bottom on each sample date. Secchi disk transparency was measured in order to determine the euphotic zone, i.e. the area of effective light penetration, and region of the majority of primary production. The lower limit of that zone was defined as 2-1/2 times the Secchi disk transparency depth.

Water samples were collected from within the euphotic zone with a Van Dorn sampler, composited in a churn splitter, and then subsampled. Waters near the lake bottom were also obtained with a Van Dorn. All water samples were immediately analyzed for pH.

Water samples were analyzed for physical, chemical, and biological parameters at various frequencies within the general time frame of May through October (Table 2). Only euphotic zone samples were analyzed for chlorophyll a. Phytoplankton were collected four times: preceeding, during, and after the suspected period of maximum growth. Fish were collected with electro-shocking methods on one occasion. Fish flesh from two species was analyzed for heavy metals and a wide spectrum of pesticides and herbicides.

Sediments were collected every other month at the six sites with an Eckman dredge. Those samples were randomly subsampled, as well, for later analysis (Table 3). Samples were placed on ice, and chemically preserved, when appropriate. No attempt was made to classify the sediments according to size composition since organic muck (primarily in the clay fraction) was the dominant component.

In order to assess the direct biological result of increased nutrient loading to the lake, phytoplankton samples were collected four times. Those samples corresponded to periods of initial growth surge, maximum or near-maximum production, and decline of the populations.

Station #1 was randomly singled out for additional analysis. Samples were analyzed for: 1) species richness, i.e. number of algal species; 2) density of each species, i.e. number of individuals per ml; and 3) biovolume of each species, i.e. bulk or volume per ml.

TABLE 2. WATER PARAMETERS

	STORET	FREQUENCY
A. **Physical**		
Conductivity (µmhos/cm)	00094	Biweekly
pH (S.U.)	00400	
Dissolved Oxygen (mg/l)	00300	
Water Temperature(°C)	00010	
Secchi Disk Transparency (m)	00078	
B. **Nutrients-Water column (mg/l)**		
T. Ammonia as N	00610	Biweekly
T. Nitrite as N	00615	
T. Nitrate as N	00620	
Total Kjeldahl Nitrogen as N	00625	
Total Phosphorus as P	00665	
Orthophosphate as P	70507	
Suspended Sediment	00530	
C. **Bacteria-Water column (#/100 ml)**		
Fecal Coliform	31616	Biweekly
Total Coliform	31679	
D. **Minerals**		
Total Alkalinity as $CaCO_3$	00410	Biweekly
Hardness as $CaCO_3$	00900	
Sulphate as SO_4	00945	
E. **Trace Total Metals-Water Column (µg/l)**		
Aluminum	------	Bimonthly
Arsenic	01002	
Boron	01022	
Cadmium	01027	
Chromium	01034	
Copper	01042	
Lead	01051	
Manganese	01055	
Mercury	71900	
Nickel	01067	
Silver	01077	
Zinc	01092	
F. **Trace Total Metals (µg/g) - Fish Tissues**		Once
G. **Pesticide/Herbicide (µg/g) - Fish Tissues**		Once
H. **Photosynthetic Activity in Euphotic Zone**		
Phytoplankton Standing Crop (Chl.a)	32217	Biweekly
Phytoplankton Ident., Biomass, & Diversity		Four Times

TABLE 3 - SEDIMENT PARAMETERS

A. **Nutrients-Sediments (mg/kg)**	**STORET**	**FREQUENCY**
T. Ammonia as N		Bimonthly
T. Nitrite as N		
T. Nitrate as N		
Total Kjeldahl Nitrogen as N		
Total Phosphorus as P		
B. **Trace Total Metals-Sediments (µg/g)**		
Aluminum		Bimonthly
Arsenic		
Boron		
Cadmium		
Chromium		
Copper		
Lead		
Manganese		
Mercury		
Nickel		
Silver		
Zinc		

All collection and preservation procedures conformed to Standard Methods (APHA, 1985) or EPA Methods for Chemical Analysis of Water and Wastes (EPA, 1979). Dissolved oxygen was determined with a YSI Model 54 meter; electrical conductivity with a YSI Model 33 SCT meter; pH with a Corning Model M-103 meter; water depth with a Lowrance depth finder. Samples were submitted to the Idaho Bureau of Laboratories in Boise and Lewiston for analysis.

RESULTS

Physical Parameters

Transparency

Secchi disk transparency varied at each station only minimally on each sample date (Fig.2). Apparently the lake is small enough that no large differences in turbidity were evident between the three stations on any particular date. The mean Secchi disk transparency (mean=1.0m) was identical for each station over the thirteen sample dates.

Periods of lesser Secchi disk transparency (reflecting increased turbidity) were in early May, late June, and August. The low early May reading was probably a function of rain and gusting winds which made it difficult to view the disk through the choppy surface. The low transparency of the three August samples were a function of very high concentrations of algae. However, no correlation was evident between observed transparency and concentrations of suspended sediment (Fig.3).

Dissolved Oxygen and Water Temperature

In general, dissolved oxygen concentration and temperature profiles at Stations 1, 3, and 5 showed good comparability. Therefore, all data at given depths throughout the lake were combined in order to produce a mean oxygen vs depth curve, and a corresponding water temperature vs depth curve (Fig. 4). Over the 26 week period of this study, the mean concentration of dissolved oxygen below three meters (10 ft) was below State and EPA standards of 6.0 mg/l.

Fig. 2 - Secchi Disk Transparency

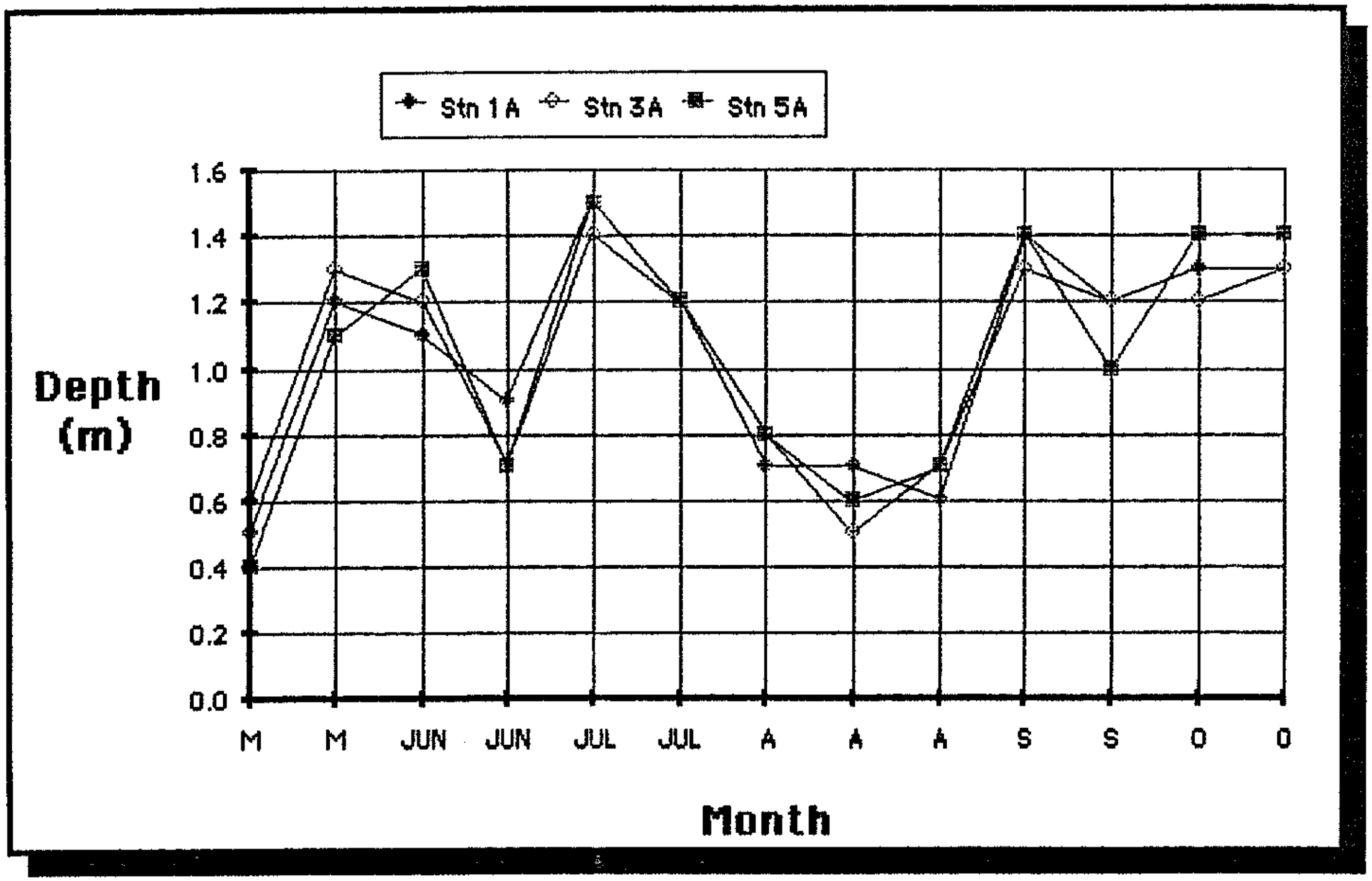


Fig. 3 - Secchi Disk Transparency vs. Suspended Sediment Concentrations

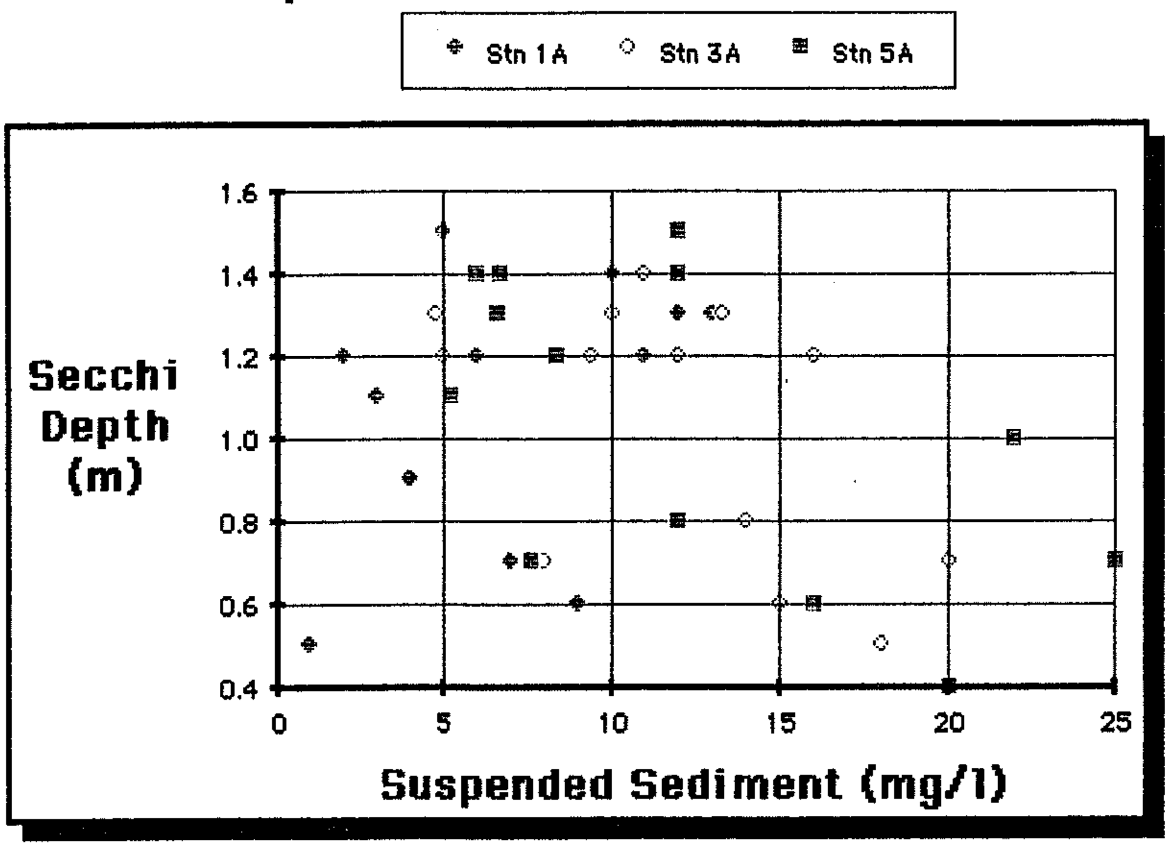
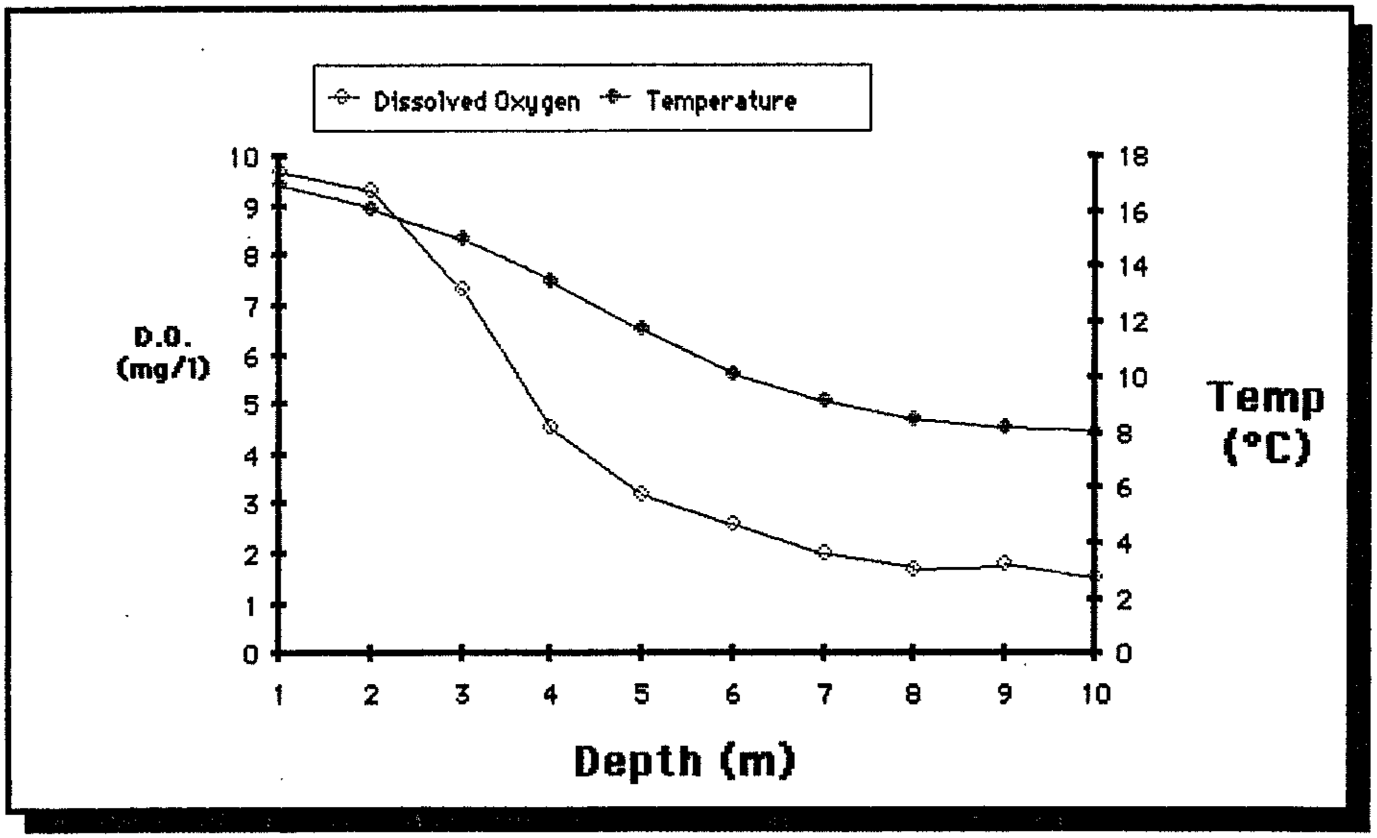


Fig. 4 - Mean Dissolved Oxygen Concentrations & Mean Temperatures Through Water Column



Three different dates at Station #3 serve to illustrate the dramatic decrease in dissolved oxygen through the water column. Sufficient oxygen was available only in the uppermost two meters of the lake on June 5 (Fig. 5A). Dissolved oxygen concentrations were essentially zero from 5 meters down to the lake sediments. Water temperatures were satisfactory throughout the water column, ranged from 6° to 7°C.

By July 17, dissolved oxygen concentrations were nearly zero from three meters below the surface down to the lake sediments; sufficient dissolved oxygen concentrations for salmonid fish were available only in the uppermost two meters (Fig. 5B). However, within that layer temperatures approached 24° C, a value also likely to preclude fish survival. In addition, pH was 9.0, which may also be of concern from a fisheries standpoint.

During fall mixing, lake stratification was eliminated. Both dissolved oxygen and temperature were nearly constant throughout the water column (Fig. 5C), and suitable for cold water biota.

Electrical Conductivity and pH

Electrical conductivity is typically positively correlated with concentration of total dissolved solids. Conductivity ranged from 119-224, µmhos/cm at Station #1; 117-185 at Station #3; and 120-205 at Station #5 (all in the euphotic zone). The mean conductivity at each station differed by only 5 units (Appendix 1).

Electrical conductivity near the lake bottom was approximately 20% higher than in the upper layers. This is indicative of higher concentrations of dissolved solids and perhaps some adsorption processes in lower waters. No correlation between electrical conductivity and time of year was determined.

Waters in the euphotic zone exhibited mean pH values which were over one S.U. greater than those in bottom waters (Appendix 1). Minimum values of approximately 6.2 were seen throughout the lake. However, while waters near lake bottom never exceeded pH of 7.3, those in the euphotic zone were determined to range up to 9.5. The difference reflects the impact of phytoplankton production in upper waters where temperatures and light penetration are favorable to growth.

Fig. 5A - Depth Profiles of Dissolved Oxygen & Temperatures at Stn. #3 on June 5, 1985

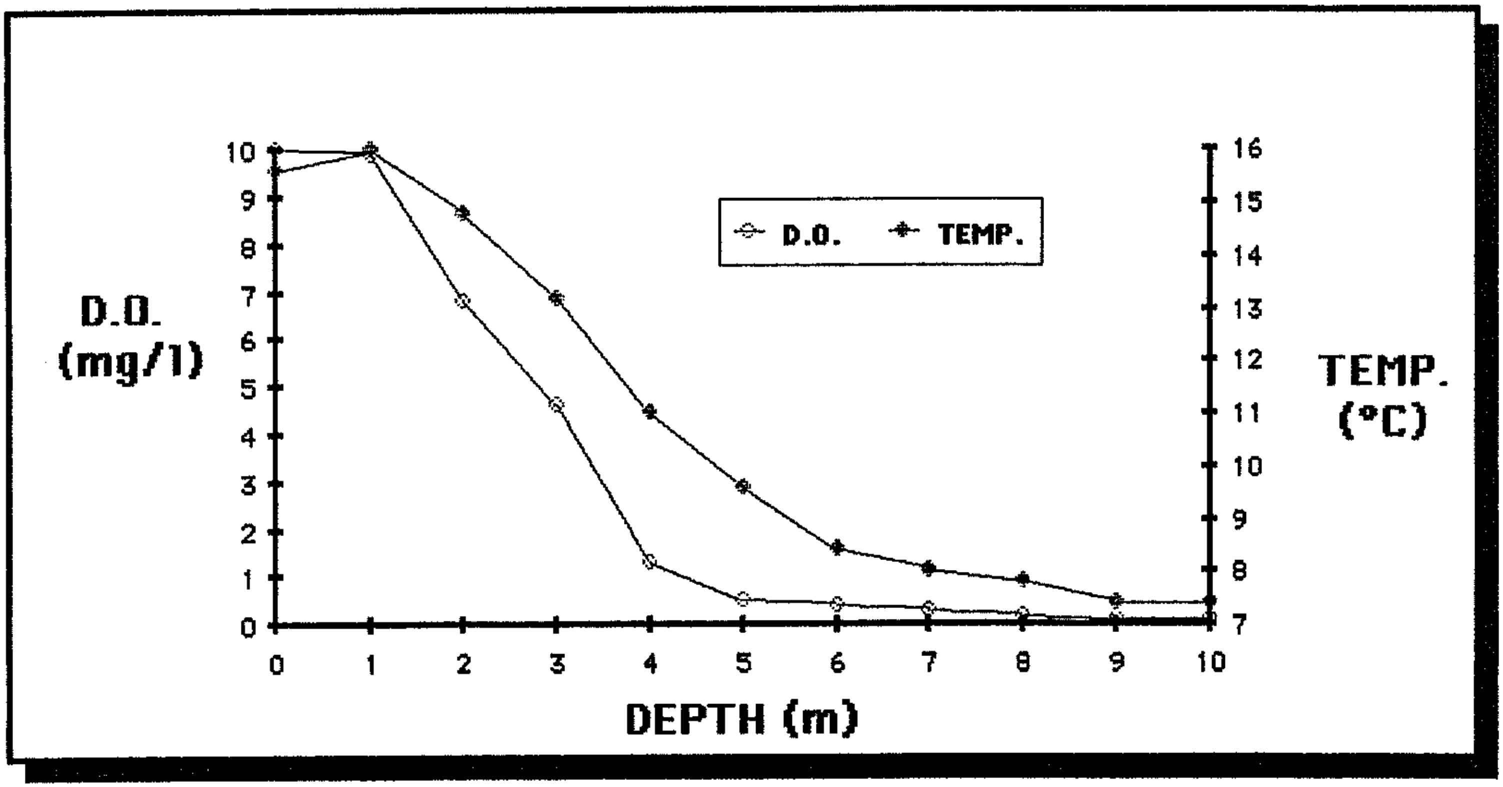


Fig. 5B - Depth Profiles of Dissolved Oxygen & Temperatures at Stn. #3 on July 17, 1986

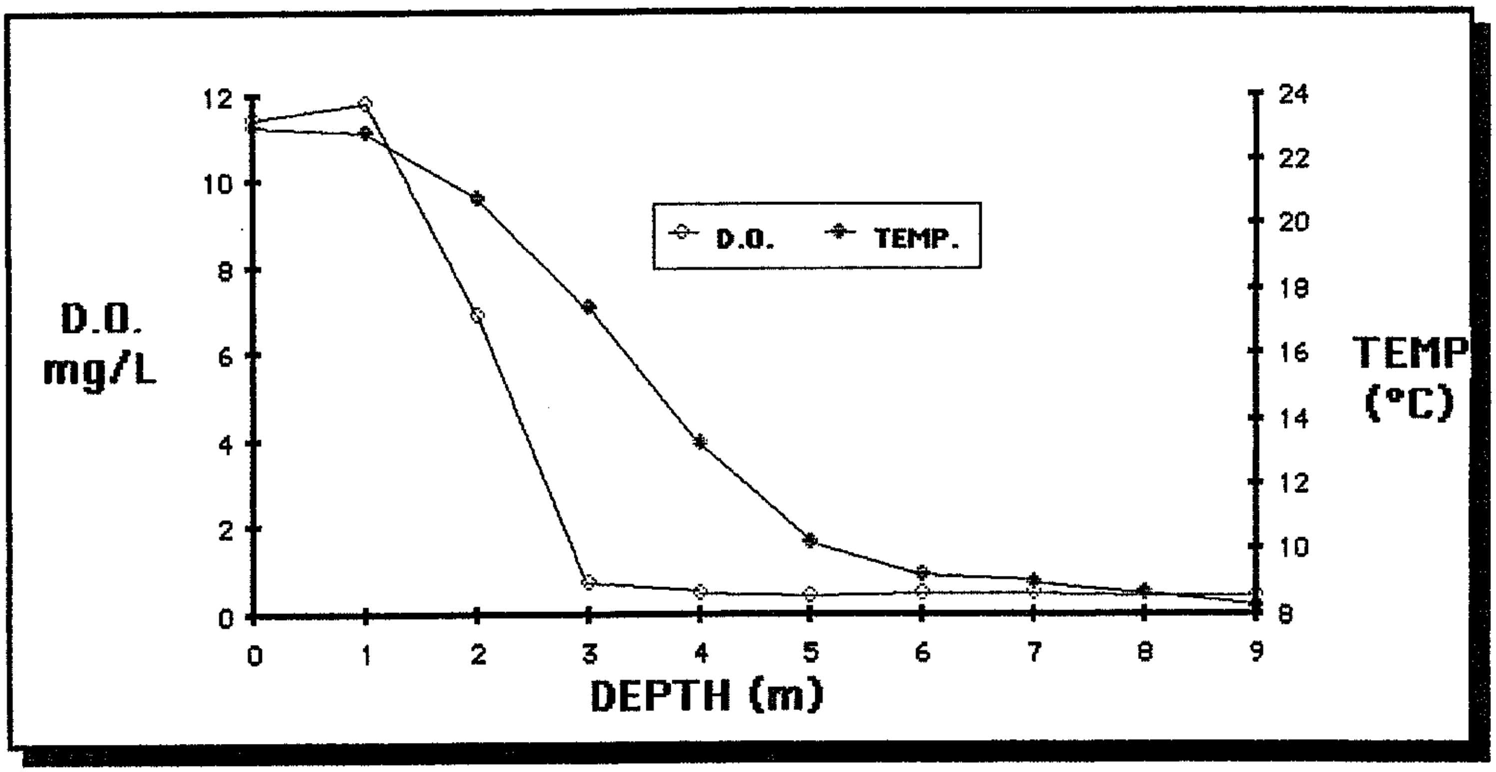
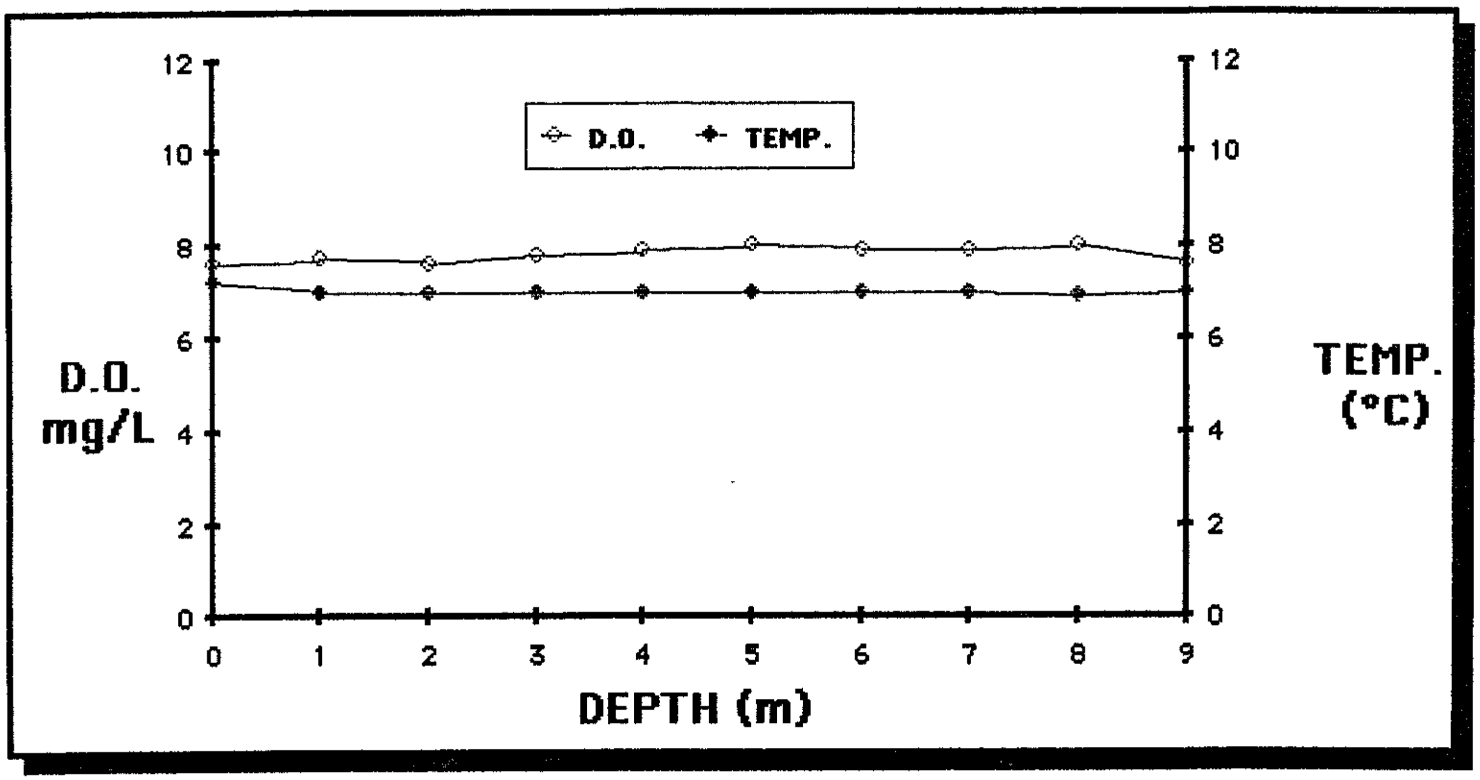


Fig. 5C - Depth Profiles of Dissolved Oxygen & Temperatures at Stn. #3 on October 24, 1985



Chemical Parameters
Phosphorus

Total phosphorus in the euphotic zone of Winchester Lake ranged from 0.06 to 0.60 mg/l with a mean of 0.14 mg/l-P (Fig. 6A). Most of the samples collected over the six months of this study showed good comparability between stations and between sample collections. However, a very high concentration was noted on June 19 at Station 1 (0.6 mg/l). It is conceivable that a large pulse of phosphorus entered the lake from the upper Lapwai Creek drainage, near the time of sampling. Laboratory or sampling errors are also possible.

Approximately 19% of the total phosphorus in the euphotic zone was in the dissolved orthophosphate form (Fig. 6 B). That is very high when compared to the small percentage of orthophosphate normally found in natural waters. The mean dissolved orthophosphate concentration of 0.027 mg/l was greatly influenced by high concentrations detected in September and October. During those months, the percentage of dissolved orthophosphate averaged 45% of total phosphorus, and ranged between 31 and 93%.

Typically, particles of phosphorus adhere to suspended sediments. Thus, a positive correlation is often seen between increased sediments in suspension and the concentration of total phosphorus. Some correlation was seen between these parameters in the surface waters of Winchester Lake (Fig. 7).

Phosphorus in Sediments and Overlying Waters

Total phosphorus in the sediments of Winchester Lake ranged from 255 to 2212 mg/Kg (ppm) with a mean of 1108 ppm (Table 4). Those values, all expressed as dry weight, are two to three orders of magnitude greater than those in the upper water column, and are typical of lake sediments.

Waters lying directly over the sediments showed a mean concentration of total phosphorus of 0.33 mg/l, with values ranging from 0.12 to 1.02 mg/l (Fig. 8A), and which was approximately twice those total phosphorus concentrations found in the euphotic zone. Concentrations of total phosphorus generally increased in these bottom waters throughout the study period until October.

Fig. 6A - Total Phosphorus Concentration in Euphotic Zone (mean= 0.14 mg/l)

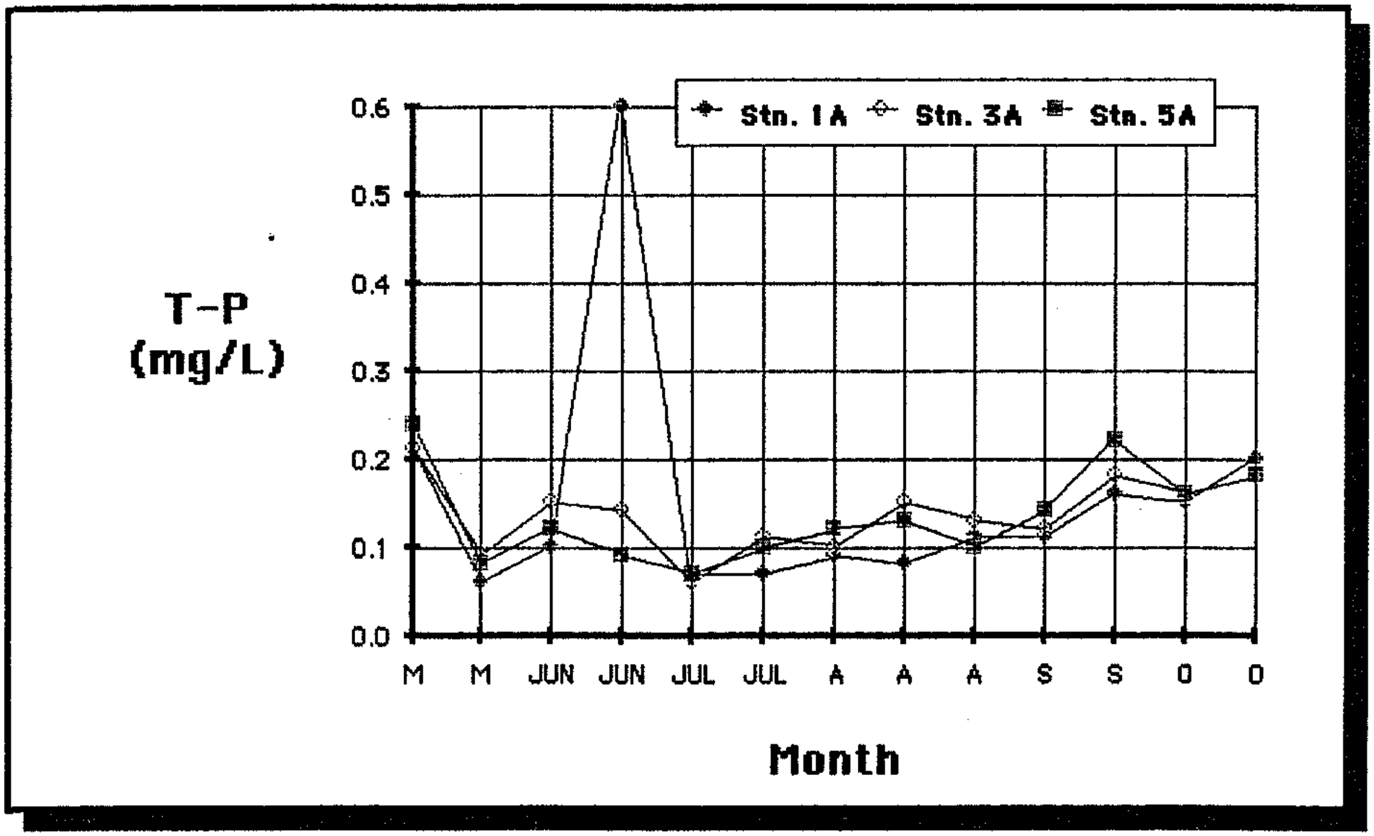


Fig. 6B - Dissolved Orthophosphate Concentrations in Euphotic Zone (mean= 0.027 mg/L)

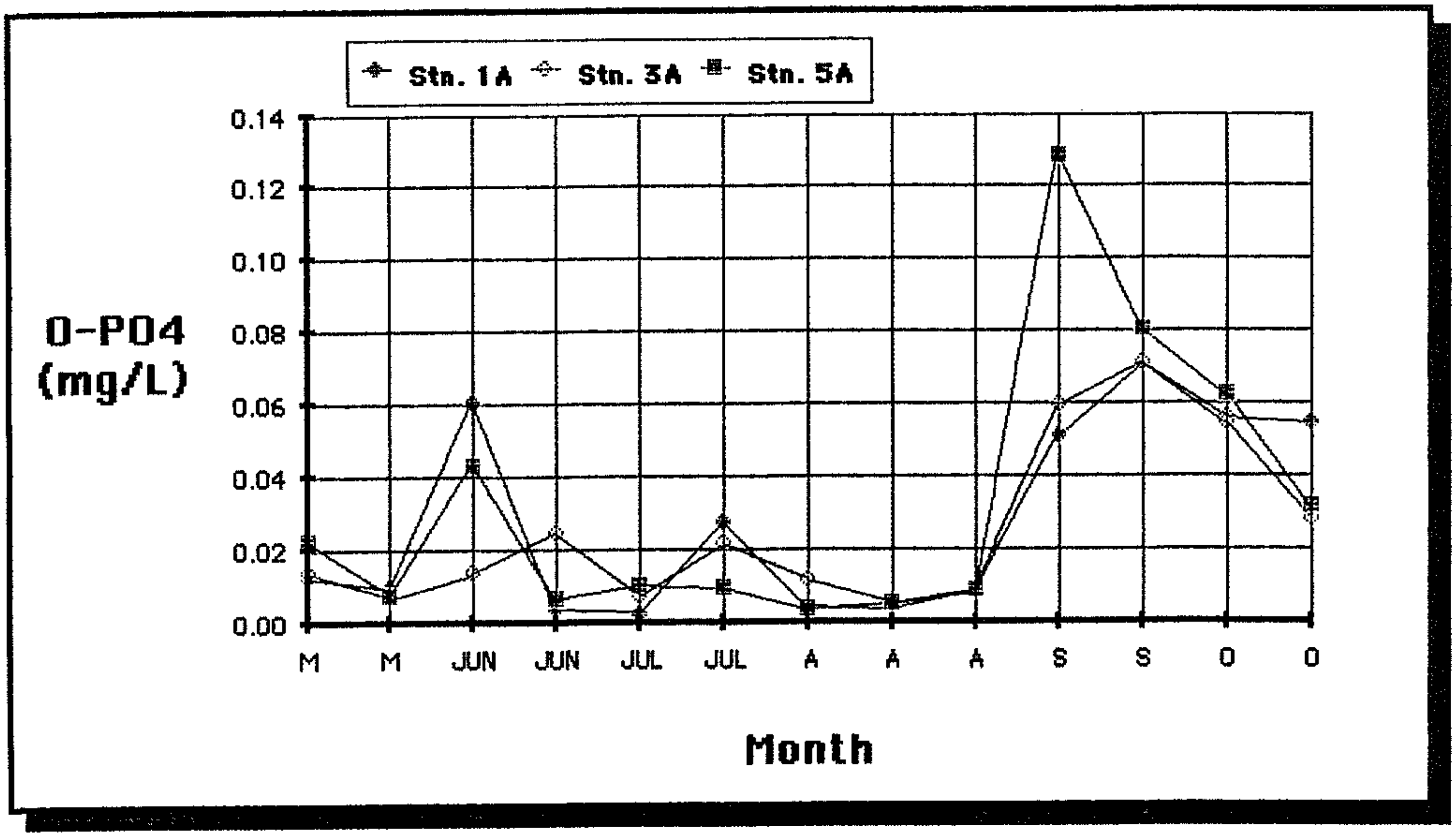


Fig. 7 - Total Phosphorus vs. Suspended Sediment for All Stations (log-log plot)

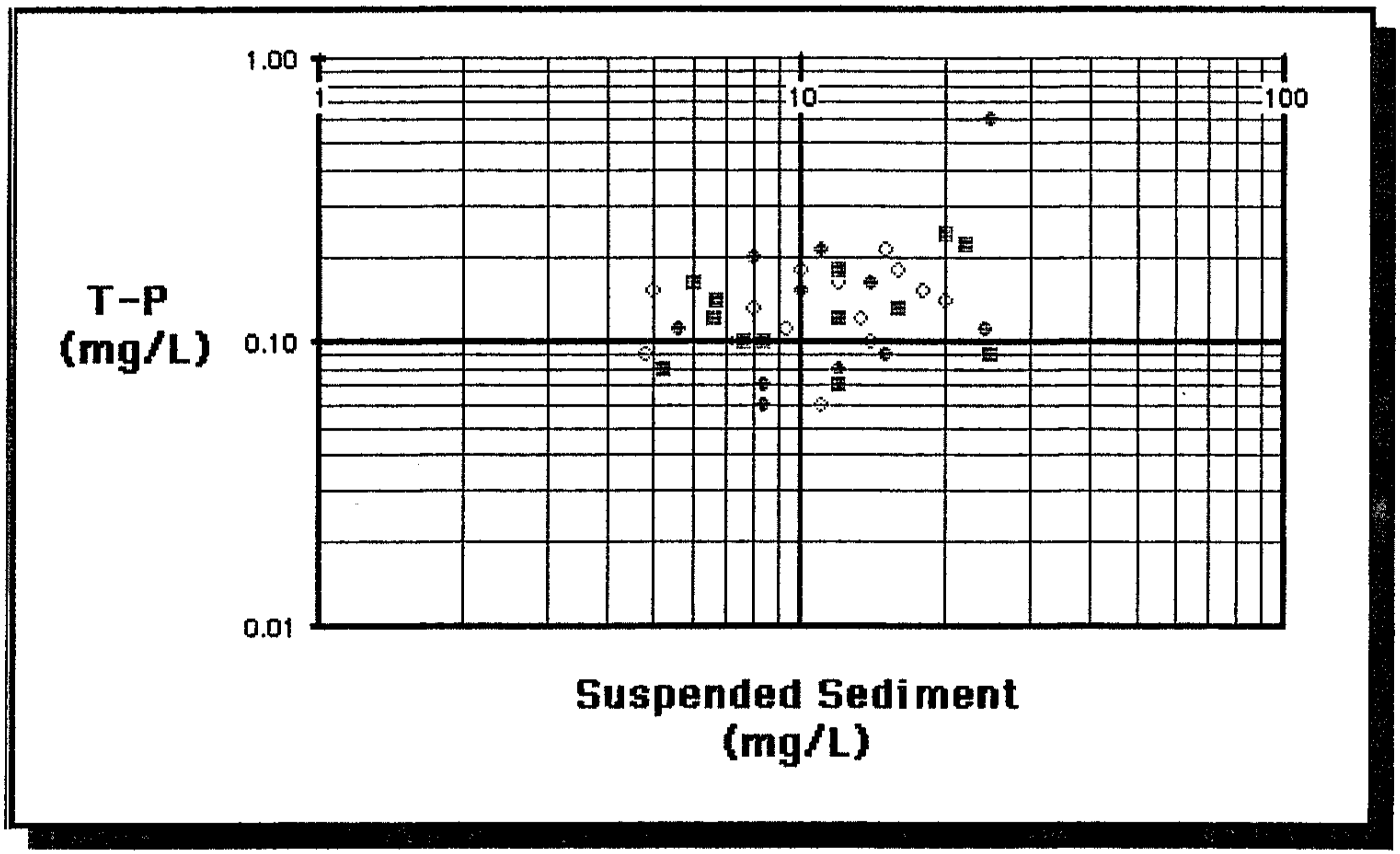
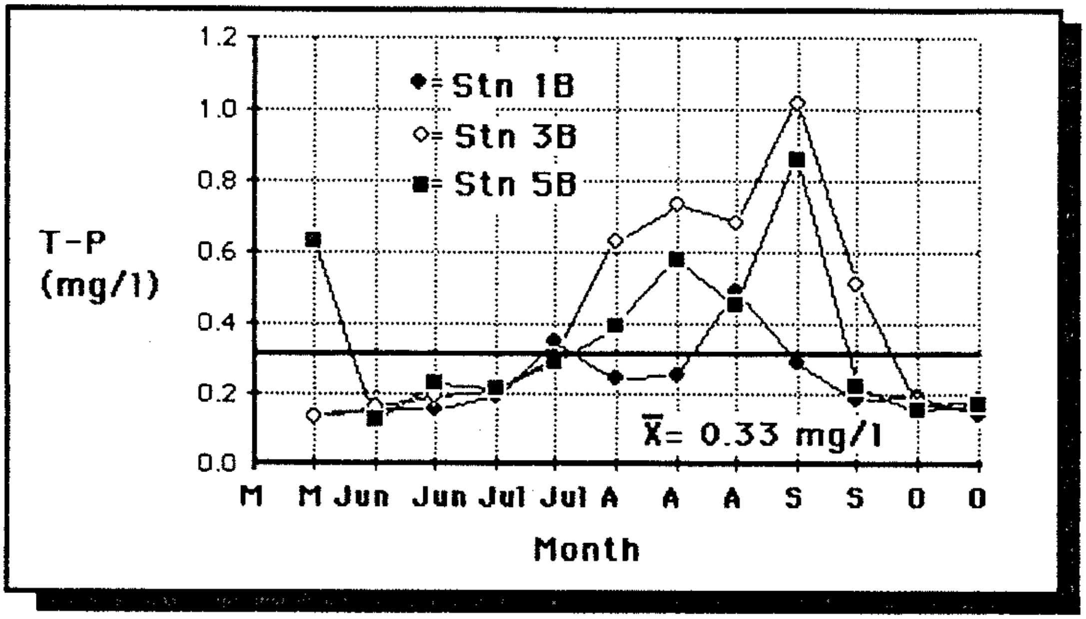


Table 4. Nutrient and Heavy Metal Concentrations in Winchester Lake Sediments, 1985.

St#	Date	NO2+ NO3 mg/Kg	TKN mg/Kg	Total P mg/Kg	Al µg/L	As µg/L	B µg/L	Cd µg/L	Cr µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Hg µg/L	Ni µg/L	Ag µg/L	Zn µg/L
1	05/07/85	1.6	4989	1547	28801	1.16	AAA	<.5	18.4	28.0	15.5	402	<0.25	23.2	<0.5	81.2
1	07/17/85	47.1	2654	647	37449	1.30	1460	<.5	21.0	39.1	17.0	409	<0.25	25.0	<0.1	97.3
2	05/07/85	7.9	5458	1830	36810	1.65	AAA	<.5	18.5	36.9	18.5	497	<0.25	25.3	<0.5	103.5
2	07/17/85	40.8	1751	255	17142	<1.0	1240	<.5	13.0	19.9	8.97	419	<0.25	14.0	<0.1	55.4
3	05/07/85	36.2	4230	1475	38607	1.59	AAA	<.5	18.9	37.7	14.9	425	<0.25	26.8	<0.5	102.0
3	07/17/85	17.9	7634	2212	46507	3.55	1840	<.5	24.6	42.4	18.7	518	<0.25	28.6	<0.1	114.0
4	05/07/85	3.5	4180	1243	29304	1.88	AAA	<.5	18.8	34.7	17.8	444	<0.25	25.7	<0.5	105.0
4	07/17/85	12.1	2822	271	34043	1.0	1420	<.5	22.6	37.3	16.7	208	<0.25	24.5	<0.1	88.0
5	05/07/85	10.0	4865	946	22205	1.45	AAA	<.5	13.5	33.8	14.5	535	<0.25	21.2	<0.5	83.6
5	07/17/85	9.3	4016	921	40748	2.36	1460	<.5	23.6	40.4	20.7	209	<0.25	27.6	<0.1	106.0
6	05/07/85	8.7	4013	1210	22231	0.79	AAA	<.5	14.9	19.8	7.94	425	<0.25	15.9	<0.5	63.9
6	07/17/85	14.9	4824	735	35958	1.46	1100	<.5	19.5	39.0	18.5	464	<0.25	25.3	<0.1	98.4
	MEANS	17.5	4286	1108												

Fig. 8A - Total Phosphorus Concentrations in Waters Directly Overlying the Sediments.



The dissolved orthophosphate form represented nearly 50% of total phosphorus in the bottom waters, with a mean of 0.16 mg/l (Fig. 8 B). This fraction was particularly important during August in which dissolved orthophosphate accounted for nearly 72% of total phosphorus.

Nitrogen

The inorganic nitrogen fraction, nitrite plus nitrate, in the euphotic zone of Winchester Lake ranged from 0.01 to 2.44 mg/l with a mean of 0.34 mg/l as nitrogen (Fig. 9A). Ninety-six percent of that component was in the nitrate form. Inorganic nitrogen was available in significant concentrations at the onset of this study. Subsequently it plunged from over 2.0 mg/l to nearly undetectable levels by August 1.

Concentrations of ammonia (Fig. 9B) and total Kjeldahl nitrogen, (Fig. 9C) exhibited wide variation. Total Kjeldahl nitrogen includes organic forms of nitrogen and ammonia, so some similarity in their variations would be expected. No simple explanation is available.

The total nitrogen present in the euphotic zone is comprised of the total organic fraction, ammonia, nitrite, and nitrate. Mean concentrations of total nitrogen declined from 4-5 mg/l in early May to a stable range of 1.5 to 2.0 mg/l throughout the period from July to October (Fig. 9D). Mean concentration of total nitrogen was 2.2 mg/l, expressed as nitrogen.

Nitrogen in Sediments and Overlying Waters

The sediments of Winchester Lake are rich in organic forms of nitrogen, with a mean total Kjeldahl nitrogen of nearly 4300 mg/kg (Table 4). In general, the inorganic nitrogen fraction, nitrite plus nitrate, was on the order of less than 1% of the organic and ammonia fraction. Stations #1 and #2 exhibited concentrations of nitrite plus nitrate in July from 5-30 times greater than those levels in May.

Overlying waters revealed a greater variation in total nitrogen (as determined by summation of total Kjeldahl nitrogen+NO2+NO3) than that in the euphotic zone (Fig.10A). A mean concentration of 2.3 mg/l was approximately the same as that in the euphotic zone. Of that total nitrogen, approximately 36% existed as the ammonia form, 21% as NO2+NO3, and the remainder as organic. Ninety-three percent of the NO2+NO3 fraction was in the nitrate form.

Fig. 8B - Dissolved Orthophosphate Concentrations in Waters Directly Overlying Sediments

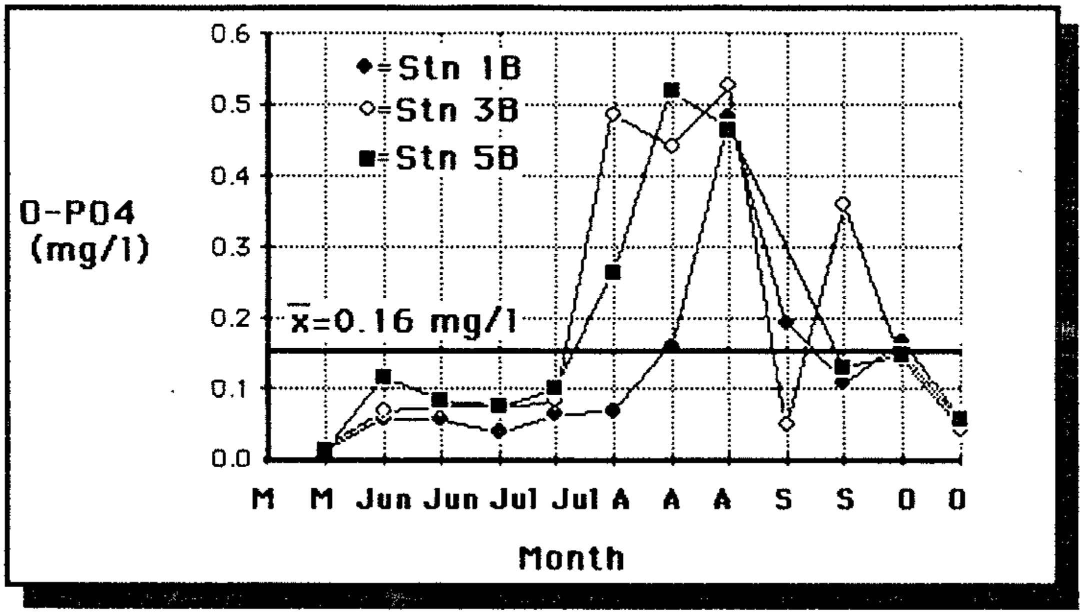


Fig. 9A - Nitrite + Nitrate Concentrations in Euphotic Zone (mean= 0.34 mg/L)

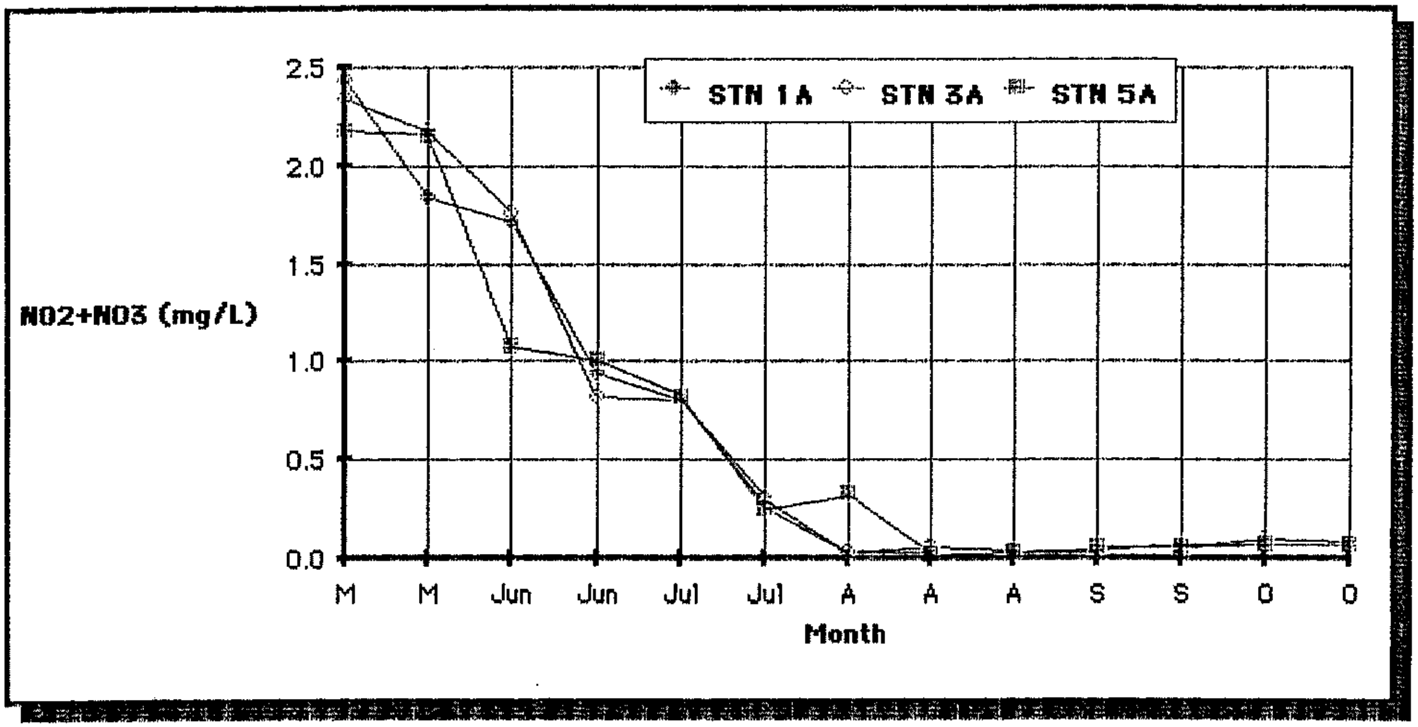


Fig. 9B - Ammonia Concentrations in Euphotic Zone

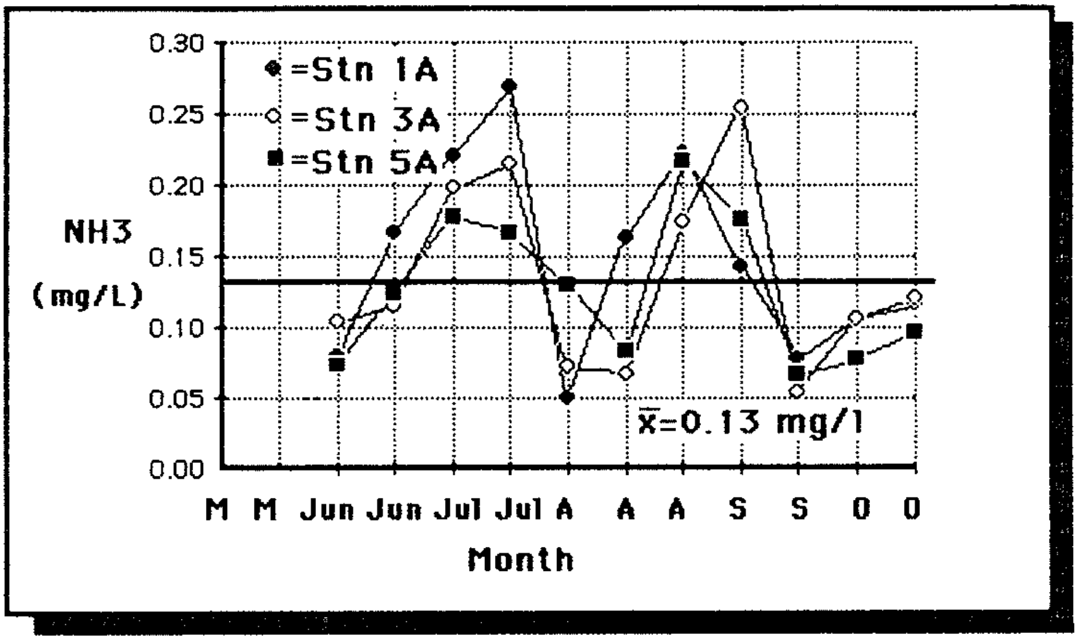


Fig. 9C - Total Kjeldahl Nitrogen Concentrations in Euphotic Zone

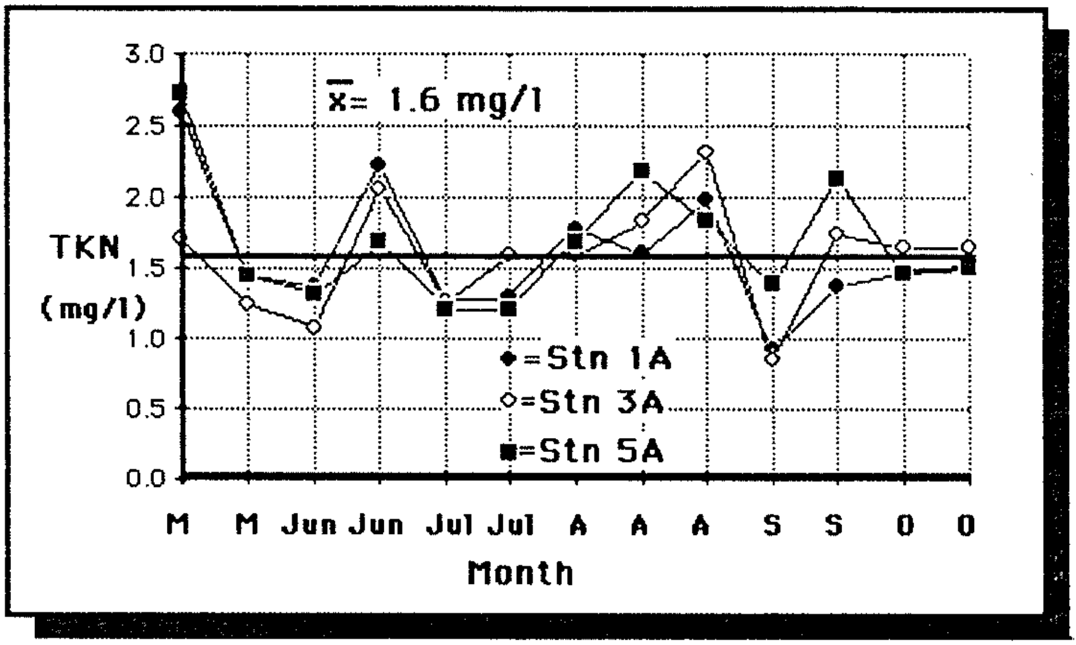


Fig. 9D - Total Nitrogen (TKN + Nitrite + Nitrate)
Concentrations in Euphotic Zone

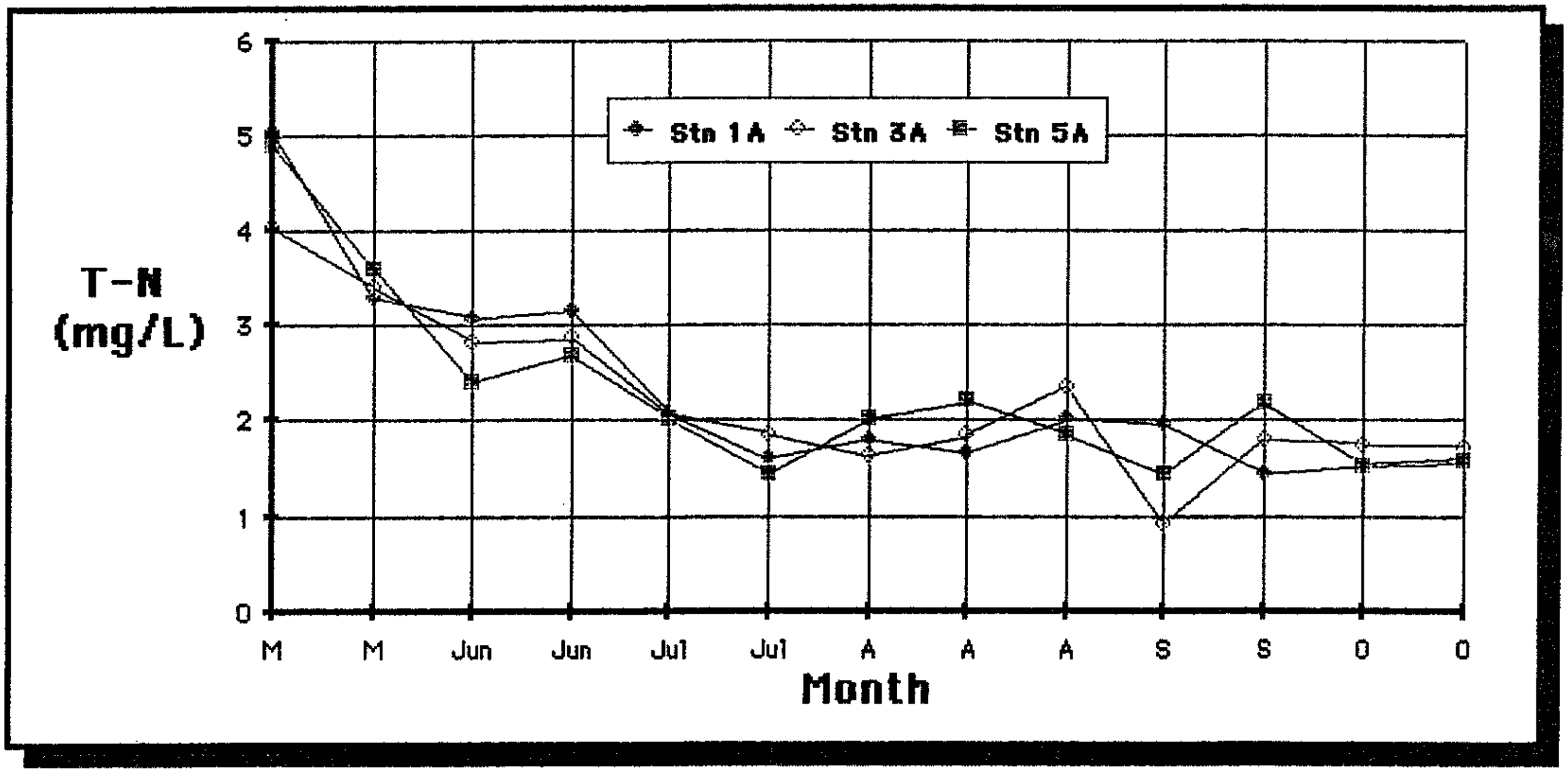
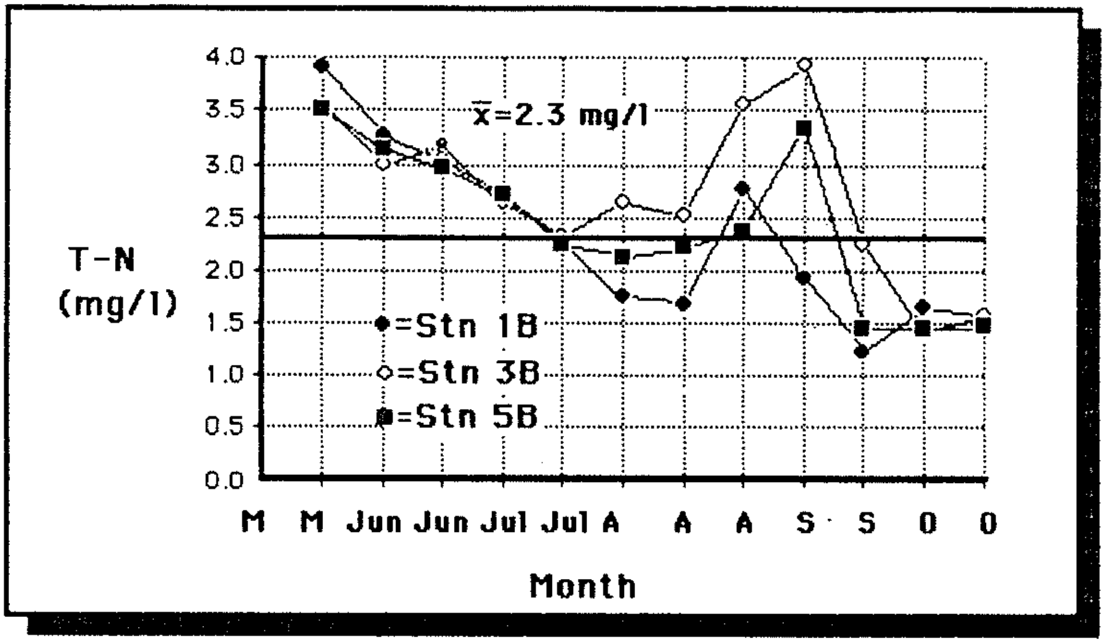


Fig. 10A - Total Nitrogen Concentrations in Waters Directly Overlying Sediments



Ammonia concentrations increased several-fold over the sample period from June through August (Fig.10B). However, it is not unusual for ammonia concentrations to increase under conditions of low oxygen. Ammonia tends to accumulate in the hypolimnion where substantial quantities of organic matter may accumulate. Anaerobic conditions then serve to accelerate the accumulation.

Trace Elements

Samples were analyzed on three occasions at three sites in the euphotic zone, and twice at three sites in the water column near the sediments. Of the 11 elements detected, only manganese exceeded EPA criteria for drinking water (Table 5). However, manganese is not considered a primary contaminant; its effect on drinking water is considered primarily from an aesthetic standpoint. Several differing criteria are referenced in Table 5. In those instances where a criterion for fresh-water biota was not available, the most restrictive usage criterion was substituted.

Productivity

Chlorophyll a

Chlorophyll a concentrations in Winchester Lake were at the highest levels in late May, and then varied erratically through early July (Fig.11). Subsequently, a consistent increase was noted until a precipitous drop in mid-September.

Phytoplankton Dynamics

Warm temperatures, long periods of daylight, and readily available nutrients provided by spring seasonal mixing led to a rapid phytoplankton growth rate and good population diversity as evidenced by the July 17 sample (Table 6A). Nineteen species of phytoplankton were documented, with 57% of algal density and 26% of algal biovolume provided by two dominant green algal species, of the genera *Staurastrum* and *Oocystis.* The third most abundant species was an *Anabaena*, which accounted for only 15% of the density, but over 32% of the biovolume.

Samples collected two weeks later on August 1 showed a remarkable shift in the population structure (Table 6B). The population of *Anabaena* had explosively increased to over 82% of the density of the entire

Fig. 10B - Ammonia Concentrations in Waters Directly Overlying Sediments

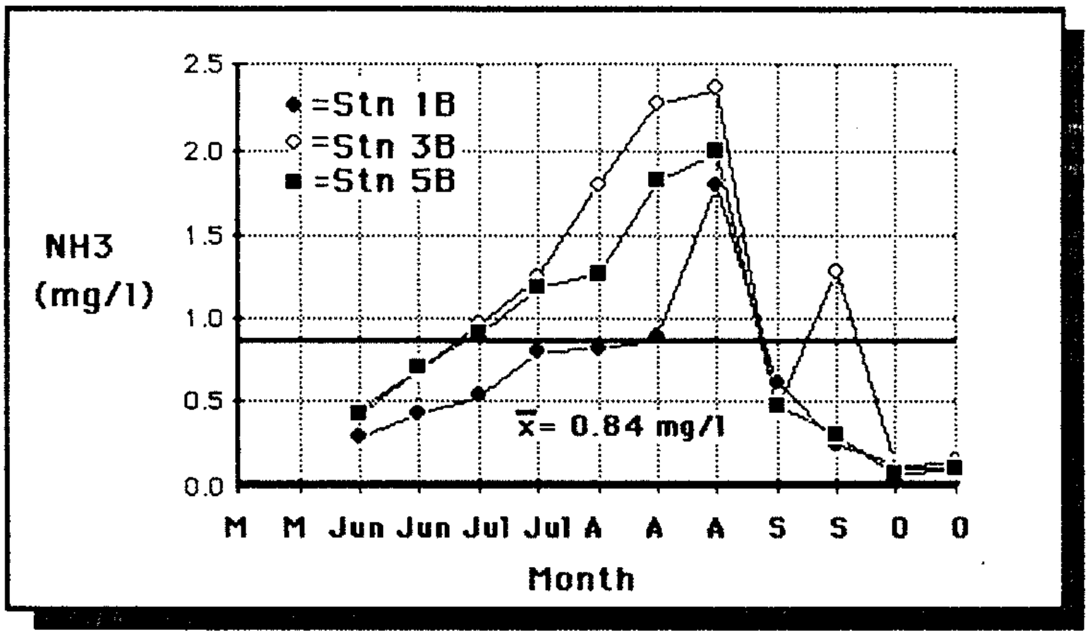


Table 5. Trace Element Analysis in Euphotic Zone and Waters Directly Overlying Sediments, Winchester Lake, 1985 (Total Metals).

ST#	DATE	As µg/L	B µg/L	Cd µg/L	Cr µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Hg µg/L	Ni µg/L	Ag µg/L	Zn µg/L	Al µg/L
1A	05/07/85	<10	81	<1	<50	<10	<50	30	<.5	<50	<1	19	1400
1A	05/23/85	<10	111	<1	<50	20	<50	20	<.5	<50	<1	16	800
1A	07/02/85	<10	62	<1	AAA	10	<50	150	<.5	<50	<1	3	800
1B	05/23/85	<10	92	<1	<50	20	<50	200	<.5	<50	<1	19	2600
1B	07/02/85	<10	78	<1	AAA	10	<50	410	<.5	<50	<1	4	2700
3A	05/07/85	<10	AAA	<1	<50	<10	<50	30	<.5	<50	<1	2	1600
3A	05/23/85	<10	105	<1	<50	20	<50	20	<.5	<50	<1	28	900
3A	07/02/85	<10	50	<1	AAA	10	<50	180	0.5	<50	1.8	1	800
3B	05/23/85	<10	99	<1	<50	20	<50	250	<.5	<50	<1	<1	2300
3B	07/02/85	<10	68	<1	AAA	10	<50	540	<.5	<50	<1	<1	1600
5A	05/07/85	<10	89	<1	<50	<10	<50	30	<.5	<50	<1	<1	1600
5A	05/23/85	<10	85	<1	<50	10	<50	20	<.5	<50	<1	8	900
5A	07/02/85	<10	50	<1	AAA	10	<50	140	<.5	<50	<1	<1	800
5B	05/23/85	<10	109	<1	<50	20	<50	200	<.5	<50	1.4	31	2900
5B	07/02/85	<10	51	<1	AAA	10	<50	500	<.5	<50	<1	1	1600
EPA CRITERIA		100 µg/L ◊	750 µg/L ◊	1.2 µg/L ◊	100 µg/L **	1000 µg/L *	50 µg/L *	50 µg/L *	0.05 µg/L **	100 µg/L **	50 µg/L *	5000 µg/L *	No Std.

◊ Irrigation Water Criteria

* Drinking Water Criteria

** Fresh Water Biota Criteria

Fig. 11 - Chlorophyll a Concentrations

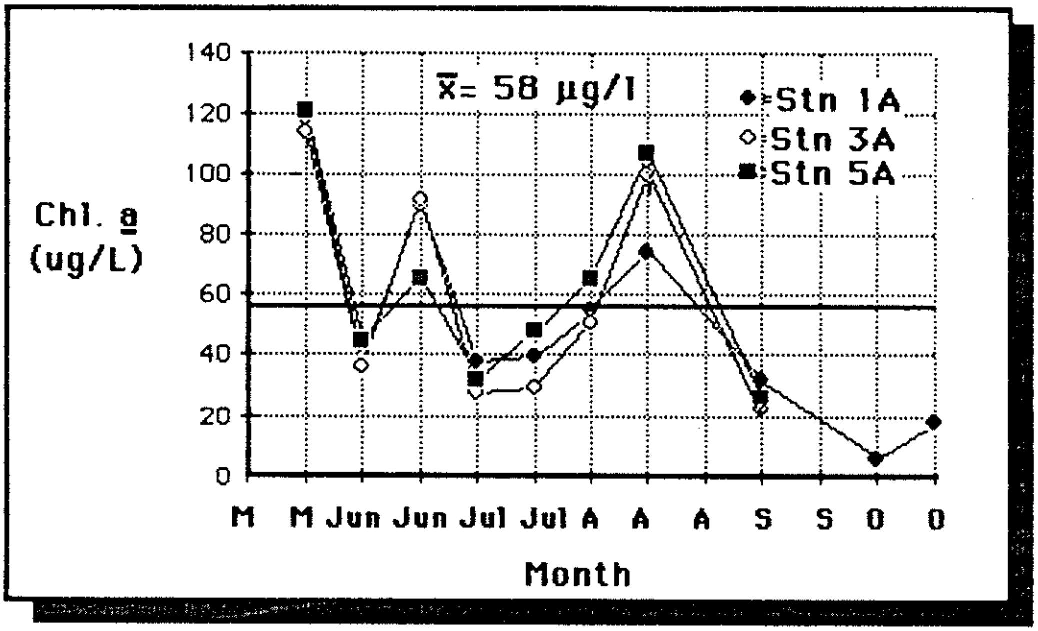


TABLE 6A

PHYTOPLANKTON ON JULY 17, 1985 AT STATION #1.
TOTAL DENSITY (#/ml) : 838
TOTAL BIOVOLUME (cu. µM/ml) : 812120
DIVERSITY INDEX: 2.93

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Staurastrum pinque	305	36.4	106849	13.2
2	Oocystis lacustris	177	21.2	102945	12.7
3	Anabaena circinalis (BG)	128	15.3	263766	32.5
4	Ankistrodesmus falcatus	35	4.2	887	0.1
5	Cryptomonas erosa	35	4.2	18459	2.3
6	Trachelomonas volvocina	28	3.4	53531	6.6
7	Aphanizomenon flos-aquae (BG)	21	2.5	12779	1.6
8	Nitzschia frustulum	14	1.7	1704	0.2
9	Sphaerocystis schroeteri	14	1.7	7384	0.9
10	Fragilaria crotonensis	14	1.7	232584	28.6
11	Navicula cryptocephala	7	0.8	1313	0.2
12	Misc. pennate diatom	7	0.8	1242	0.2
13	Achnanthes linearis	7	0.8	937	0.1
14	Achnanthes minutissima	7	0.8	355	0.0
15	Stephanodiscus astraea minutula	7	0.8	2485	0.3
16	Nitzschia palea	7	0.8	1278	0.2
17	Cymbella minuta	7	0.8	2627	0.3
18	Nitzschia sp.	7	0.8	852	0.1
19	Rhodomonas minuta	7	0.8	142	0.0

BG = Blue-green algae

TABLE 6B

PHYTOPLANKTON ON AUGUST 1, 1985 AT STATION #1
TOTAL DENSITY (#/ml) : 774
TOTAL BIOVOLUME (cu. µM/ml) : 1613637
DIVERSITY INDEX : 1.23

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Anabaena circinalis (BG)	639	82.6	1441789	89.4
2	Cryptomonas erosa	27	3.5	13993	0.9
3	Fragilaria crotonensis	27	3.5	107367	6.7
4	Oocystis lacustris	13	1.7	7804	0.5
5	Cocconeis placentula	13	1.7	6189	0.4
6	Trachelomonas volvocina	13	1.7	25362	1.6
7	Aphanizomenon flos-aquae (BG)	7	0.9	4036	0.3
8	Staurastrum pinque	7	0.9	2355	0.1
9	Gyrosigma spencerii	7	0.9	3027	0.2
10	Scenedesmus acuminatus	7	0.9	1413	0.1
11	Rhodomonas minuta	7	0.9	135	0.0
12	Ankistrodesmus falcatus	7	0.9	168	0.0

TABLE 6C

PHYTOPLANKTON ON AUGUST 15, 1985 AT STATION #1
TOTAL DENSITY (#/ml) : 601
TOTAL BIOVOLUME (cu. µM/ml) : 1057683
DIVERSITY INDEX : 1.63

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Anabaena circinalis (BG)	417	69.4	900832	85.2
2	Cryptomonas erosa	61	10.2	31807	3.0
3	Aphanizomenon flos-aquae (BG)	50	8.3	46843	4.4
4	Trachelomonas volvocina	39	6.5	73373	6.9
5	Staurastrum pinque	6	0.9	1946	0.2
6	Achnanthes lanceolata	6	0.9	1001	0.1
7	Synedra fasciculata truncata	6	0.9	417	0.0
8	Rhodomonas minuta	6	0.9	111	0.0
9	Asterionella formosa	6	0.9	990	0.1
10	Chroomonas sp.	6	0.9	361	0.0

TABLE 6D

PHYTOPLANKTON ON OCTOBER 9, 1985 AT STATION #1
TOTAL DENSITY (#/ml) : 378
TOTAL BIOVOLUME (cu. µM/ml) : 421993
DIVERSITY INDEX : 2.23

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cryptomonas ovata	153	40.6	265080	62.8
2	Rhodomonas minuta	139	36.8	2784	0.7
3	Trachelomonas volvocina	18	4.7	33643	8.0
4	Microcystis aeruginosa (BG)	18	4.7	1785	0.4
5	Stephanodiscus astraea minutula	11	2.8	3748	0.9
6	Fragilaria crotonensis	11	2.8	104975	24.9
7	Cryptomonas erosa	11	2.8	5569	1.3
8	Chroomonas sp.	4	0.9	232	0.1
9	Cocconeis placentula	4	0.9	1642	0.4
10	Staurastrum pinque	4	0.9	1249	0.3
11	Achnanthes lanceolata	4	0.9	643	0.2
12	Nitzschia palea	4	0.9	643	0.2

assemblage, and nearly 90% of total volume of algae. That change was well reflected by the ratio of all blue-green algae to greens (Fig.12). The population shifted from a ratio of less than 0.2:1 to over 2:1 in less than two weeks. The magnitude of the shift in community structure was further evidenced on August 15 when the ratio was nearly 5:1.

Numbers of species continued to decline in mid-August (Table 6C); the diversity index decreased to 1.6 compared to 2.9 in mid-June. In addition total biovolume showed a steep decline to 60% of that only two weeks earlier (Fig.13). Total density can also be seen as continuing the decline begun in mid-June.

The October sample showed the results of a classic "crash" in blue-green algal densities and volumes (Table 6D). The most abundant blue-green alga, Microcystis, accounted for less than 5% of density and 0.4% of volume. Anabaena was not found in the sample. Similarly, the ratio of blue-green to green algae was overwhelmingly indicative of low blue-green densities (Fig. 12). Total density continued to decline in October to less than half of the mid-June density, and total biovolume was less than 25% of the peak in early August (Fig. 13).

Fish Tissue Analysis

Two species of fish were collected in September 1985, and analyzed for heavy metals in muscle tissue to determine if an influence other than nutrient/oxygen/temperature interactions was responsible for the reported decrease in fish numbers. Two individuals of rainbow trout (Salmo gairdneri) and two brown bullhead (Ictalurus nebulosus)were analyzed for arsenic, cadmium, chromium, lead, copper, and mercury (Table 7A).

Criteria for toxicological effects of the intake of heavy metals are based upon human consumption. In order to provide a basis for comparison, the worst concentrations of each metal were extrapolated to eight (8) ounces of flesh (Table 7B). All metals in the trout were substantially below maximum recommended daily intake. However, the amount of mercury in the two bullheads was very close to recommended limits.

Additional analyses for trace organic compounds were completed. Of the 21 persistent pesticides, herbicides, and other common organics which were analyzed, 19 were below detectable limits of 0.001 mg/kg in

Fig. 12 - Ratios of Blue-green to Green Algal Densities, and Diversity Index at Station #1.

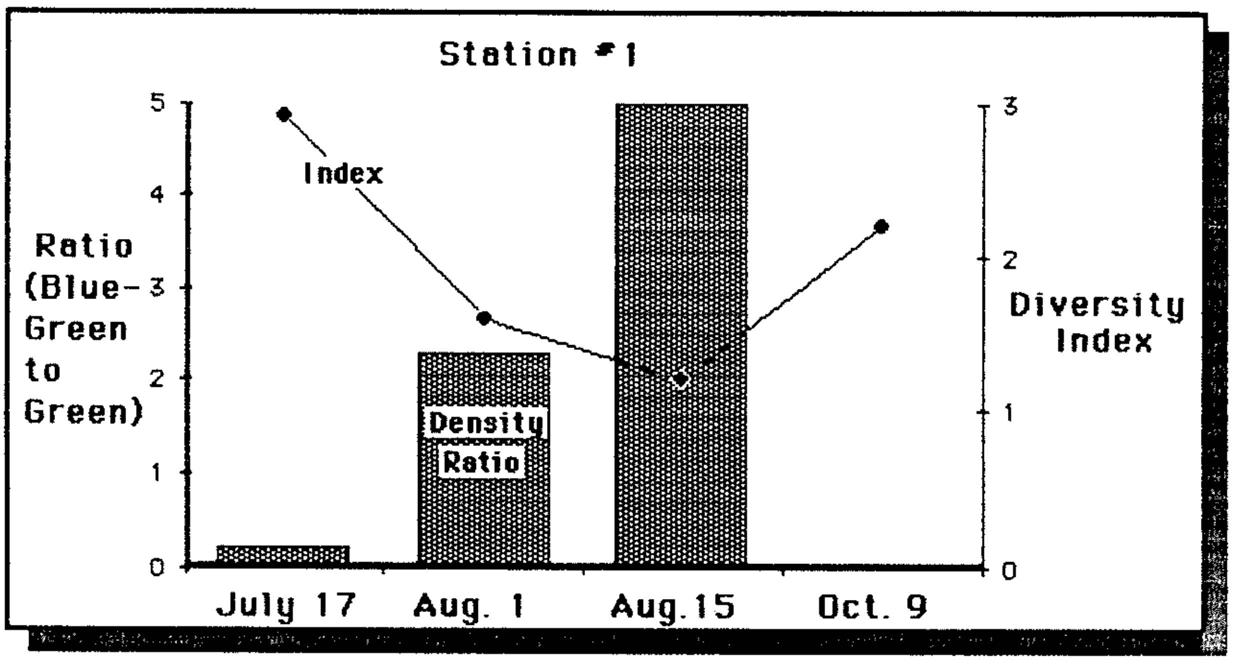


Fig. 13 - Primary Productivity as Measured By Phytoplankton Density and Biovolume

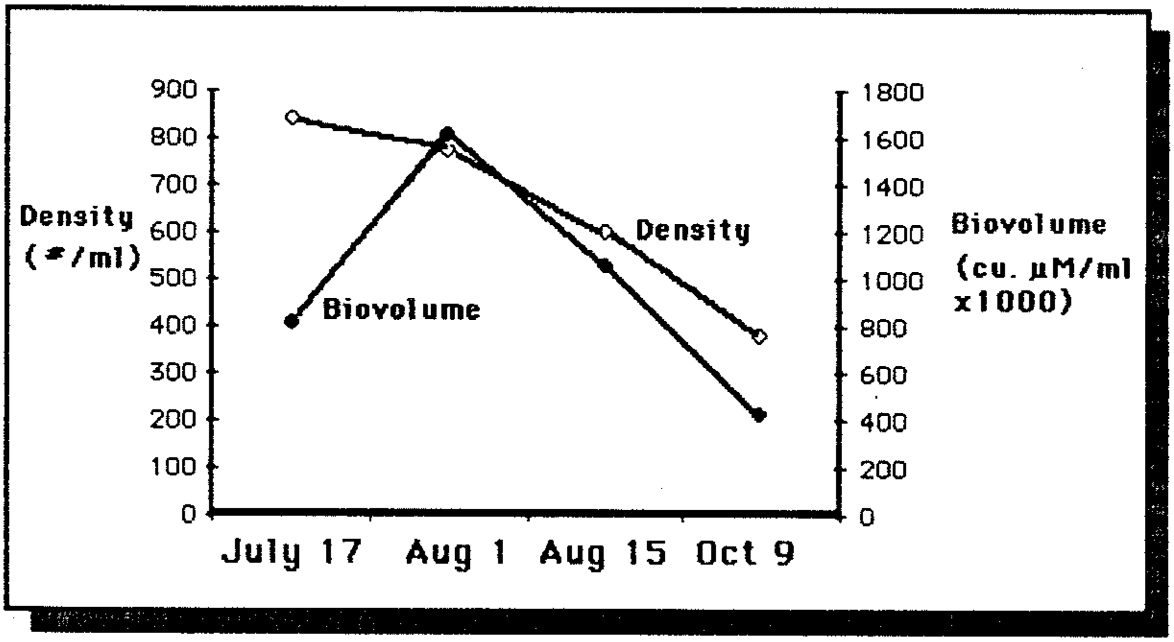


Table 7A. Heavy Metal Analysis of Fish Flesh.

Fish	As	Cd	Cr	Pb	Cu	Hg
Trout #1	<0.1	0.014	0.02	0.28	0.40	0.04
Trout #2	<0.1	0.018	0.04	0.15	0.44	0.04
Bullhead #1	<0.1	0.024	0.63	0.25	0.40	0.12
Bullhead #2	<.01	0.020	0.04	0.20	0.54	0.10

All values in micrograms/gram wet tissue

Table 7B. Quantities of Heavy Metals in Eight Ounces of Fish Flesh

Fish	As	Cd	Cr	Pb	Cu	Hg
Trout	<22	4	9	63	100	9
Bullhead	<22	5	143	57	123	27
(Maximum Recommended Daily Intake)	**900**	**<80**	**20-500**	**300**	**----**	**30**

(U.S. EPA, 1976)

All values in µg/8 oz fish (using highest concentration of each metal from Table 7A.)

rainbow trout. Only Total DDT, by virtue of one of its analogs, showed a trace concentration (0.002 mg/kg) (Table 8). Similarly, one of the brown bullheads showed the exact organic analyses as the two trout. The other bullhead showed trace amounts of three other organic compounds, as well.

DISCUSSION

Physical Parameters

Chlorophyll a concentration is commonly determined in order to estimate the amount of primary production in a water body. Theoretically, greater concentrations of chlorophyll a indicate greater production, which indicates favorable conditions for growth, i.e. adequate nutrients, light, and temperature.

Transparencies, dissolved oxygen, temperature, and pH data indicate that Winchester Lake is not fuctioning as a healthy ecosystem. The interactions among those parameters have significantly compromised the available habitat for fish.

Secchi disk transparencies typically range from only a few centimeters to over 40 meters in lakes. It has been shown that transparency is a function of both suspended and dissolved matter, and specific absorption characteristics of water; empirical and theoretical research have shown the primary cause of light transmission reduction to be due to scattering by suspended particulate matter (Wetzel, 1975). Experience has shown that measurements tend to become erratic both early and late in the day. Therefore, all measurements in Winchester Lake were conducted near midday.

Overall transparency in Winchester Lake was generally much less than that seen in other lakes of the region. Readings in Lake Pend Oreille have ranged from approximately three meters to twenty meters. (Beckwith, pers. comm.). Lake Cocalalla showed readings less than two meters in August 1985; those are still three times the value seen in Wichester Lake.

The dissolved oxygen criterion for waters designated for cold water biota is a minimum of 6.0 mg/l at all times, except for the bottom 20 percent of water depth in natural lakes and reservoirs where depths are less than 35 feet (IDHW/DOE, 1985). In addition, water temperatures must neither exceed 22°C, nor a maximum daily average of 19°C.

Table 8.

Trace Organic Analysis of Trout & Bullhead Fish (mg/Kg)

Organic	Trout #1	Trout #2	Bullhead #1	Bullhead #2
Total PCB	<0.001	<0.001	<0.001	<0.001
Aldrin	<0.001	<0.001	<0.001	<0.001
Dieldrin	<0.001	<0.001	<0.001	<0.001
Total DDT (and Analogs)	0.002	0.004	0.002	0.017
o.p. DDE	<0.001	<0.001	<0.001	<0.001
p.p. DDE	0.002	0.004	0.002	0.012
o.p. DDD	<0.001	<0.001	<0.001	<0.001
p.p. DDD	<0.001	<0.001	<0.001	0.004
o.p. DDT	<0 001	<0.001	<0.001	<0.001
p.p. DDT	<0.001	<0.001	<0.001	<0.001
Endrin	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.001	<0.001	<0.001	<0.001
Hexachlorobenzene	<0.001	<0.001	<0.001	0.002
PCP	<0.001	<0.001	<0.001	<0.001
Total Chlordane	<0.001	<0.001	<0.001	<0.001
cis isomer	<0.001	<0.001	<0.001	<0.001
trans isomer	<0.001	<0.001	<0.001	<0.001
nonachlor, cis	<0.001	<0.001	<0.001	<0.001
nonachlor, trans	<0.001	<0.001	<0.001	<0.001
Hexachlorocyclohexane				
alpha BHC is.	<0.001	<0.001	<0.001	0.003
gamma is.	<0.001	<0.001	<0.001	<0.001

Winchester Lake violated both of these criteria during our 1985 sampling regime. Dissolved oxygen concentrations were extremely low throughout most of the summer, and maximum daily water temperatures exceeded that criterion between mid-June and mid-July. No samples were obtained throughout a complete day so it is not possible to surmise whether the maximum daily average criterion was violated.

In general, oxygen concentrations below 6-10 feet were sufficiently reduced as to preclude most game fish survival. In the upper layer of the lake which typically exhibited adequate oxygen, water temperatures were probably high enough to elicit avoidance by cold-water fish.

The very high water temperatures (>22°C) and altitude at Winchester Lake dictate that maximum saturated oxygen concentrations will be less than 7.4 mg/l. However, high rates of algal activity accompanied by high oxygen liberation resulted in euphotic zone oxygen concentrations greatly in excess of saturation. Concurrently, the high productivity resulted in pH readings of 9-10; it is likely that trout will attempt to avoid those areas too.

Chemical Parameters

Phosphorus plays a major role in biological metabolism, and yet it is normally one of the limiting components of biological productivity. The phosphorus cycle is complex and it functions very rapidly in converting one form of phosphorus to another. The rate of biological productivity in lakes is usually governed to a great extent by the rate of phosphorus cycling in relation to external inputs of phosphorus. This ecological relationship has been upset in recent years by human influence, however, due to our accelerated usage of phosphorus chemicals and detergents.

"Total phosphorus" refers to the particulate form as well as the dissolved component. The particulate component includes: 1) those many organic forms which are tied up in living or recently-living organisms; 2) minerals; and 3) those particles absorbed into dead particulate matter. Dissolved inorganic phosphorus is primarily composed of: 1) orthophosphate; 2) polyphosphates usually of synthetic detergent origin, and 3) organic colloids (Wetzel,1975).

Total phosphorus concentrations in uncontaminated surface waters range between 0.01 and 0.05 mg/l; most of that is in the organic form. Normally, inorganic soluble phosphorus (orthophosphate, etc.) is consistently very low, usually amounting to only a few percent of total phosphorus (Wetzel,1975). This is indicative of the rapid incorporation of soluble orthophosphate by plytoplankton and bacteria.

A major component of the phosphorus cycle in natural waters is the exchange between sediments and overlying waters. It is not uncommon for phosphorus content of the sediments to be several orders of magnitude greater than that of the water. Thus sediments tend to act as a net phosphorus sink in healthy lake ecosystems. Under anaerobic conditions, however, the sediments can actively release previously-bound phosphorus to the water column. Water agitation and sediment disturbance can greatly increase the exchange (Wetzel,1975).

It is believed that the increase in total phosphorus concentrations in the euphotic zone (Fig. 6A) in September and October reflect the cycling suggested above. Fall "turnover," during which lake waters are mixed as a result of isothermal conditions, could result in phosphorus-rich waters near the bottom being distributed throughout the water column. These nutrients would subsequently be available to phytoplankton.

The large increase in dissolved orthophospate concentrations in the euphotic zone after August (Fig. 6B) corresponded to the large decreases in chlorophyll a concentration and declines in phytoplanktonic productivity, as estimated by biovolume and cell density (Fig. 13). The reason for that increase is probably two-fold in nature. The steep decline in phytoplankton numbers resulted in less uptake of available nutrients; secondly, the massive cellular die-off and subsequent lysis also resulted in additional nutrients being made available to the water column for recycling.

Total phosphates as phosphorus should not exceed 0.025 mg/l within a lake or reservoir (Mackenthun,1973). Mean total phosphate concentration in the euphotic zone of Winchester Lake was 0.14 mg/l, and in the waters directly overlying the sediments it was 0.33 mg/l. These values were 6 and 13 times the criteria concentrations, respectively.

Another method of assessing trophic status attributable to phosphorus is through estimates of annual loading to the receiving water. Vollenweider (1973) suggested ranges of total phosphorus loading which would be critical for eutrophic conditions within the receiving waterway. His determinations of water volume were based upon mean depth divided by the hydraulic retention time.

In the case of Winchester Lake, the hydraulic retention time is estimated to be approximately 1.5 years; mean depth is estimated at 7 meters. Thus the ratio is equal to 4.7 meters/year. Vollenweider suggested a loading range for 5.0 meters/year of 0.22 $g/m^2/yr$ for oligotrophic loading to 0.45 $g/m^2/yr$ for eutrophic loading. The surface area of Winchester Lake is 344,000 m^2, and the loading by Lapwai Creek was 383,000 grams. The loading rate in 1985 was approximately 1.1 $g/m^2/yr$. That rate was nearly 2 1/2 times the rate suggested as critical loading.

The nitrogen cycle in lakes is predominately microbial, in nature. Photosynthetic processes utilize nitrogen compounds which have been oxidized and reduced by bacteria. The forms of nitrogen are many and varied. They include molecular nitrogen (N_2), organic compounds, ammonia, nitrite, and nitrate. Nitrate and ammonia are assimilated into nitrogenous compounds within organisms. Normal metabolism as well as the deaths of those organisms results in liberation of nitrogen as ammonia and other forms. Under aerobic conditions, the ammonia is oxidized to nitrite and nitrate, whereupon the cycle continues.

The recommended level of inorganic nitrogen in waters flowing into a lake or reservoir is 0.3 mg/l-N (Mackenthun 1973). Concentrations in Lapwai Creek prior to entering Winchester Lake ranged from 0.61 to 8.39 mg/l. Mean concentration in the euphotic zone of the lake was 0.34 mg/l, and in the bottom water layer was 0.48 mg/l (ranging from 0.006 - 2.7 mg/l). Thus, the influent stream was shown to contribute from 2-28 times the concentrations which are suggested to avoid eutrophic conditions.

Tons of nutrients lie in the sediments of Winchester Lake where they are available for recycling. Results from this study show that phosphorus release from lake sediments is occurring. This internal nutrient cycling is a major reason for the eutrophic nature of the lake.

It was not possible to construct a nutrient budget for the lake based upon all inflows and outflows. Quantities of water flowing out of the lake are unknown. The dam leaks in many places, and an unknown and variable amount continually escapes. Two manual methods of water release are available, but no records are available on spillage quantities. In addition, the City of Winchester wastewater treatment facility discharges overland in the vicinity of the dam further confusing the contribution of the lake. Similar shortages of information on other influents (including precipitation) preclude even crude estimates of inflow.

Three streams enter Winchester Lake, but upper Lapwai Creek is of prime importance due to the size of the watershed it drains. The acreage and, consequently, stream discharge are several times greater in the upper Lapwai drainage than in adjacent waterways.

Five sets of samples were collected in Lapwai Creek upstream of its entrance into the lake. Stream discharges and concentrations were used to determine loading rates for phosphorus and nitrogen. Those figures were extrapolated to provide estimates for the year through the use of weighted averages, i.e. the discharges and concentrations on specific dates were considered to be representative for a time period which bracketed those sample dates. Annual influx was determined by summation of the five estimates (Appendix 2).

Over 840 pounds of total phosphorus, 3300 pounds of organic and ammonia nitrogen, and 12,000 pounds of inorganic nitrogen were estimated to enter Winchester Lake by way of Lapwai Creek in 1985. Based upon a conservative and constant volume of water in Winchester Lake, it was possible to determine theoretical concentrations of those nutrients. They were as follows: Total phosphorus = 2.6 mg/l; total Kjeldahl nitrogen = 10.3 mg/l; and nitrite + nitrate = 37.7 mg/l.

It is important to realize that these figures do not reflect actual concentrations, nor do they account for microbial or other biological mechanisms for usage and decomposition. It is equally true that potentially significant contributions from precipitation, direct overland flow to the lake, groundwater, and smaller influent streams were also not accounted. However, it is apparent that significant quantities of nutrients entered Winchester Lake, and any attempt to rehabilitate the lake must consider those contributions.

Relative concentrations of nutrients provide another means of assessing the causes of eutrophy. The annual euphotic zone ratio of total inorganic nitrogen to dissolved orthophosphate in Winchester Lake was 12.6:1 (0.34 mg/l nitrite plus nitrate divided by 0.027 mg/l dissolved orthophosphate). Ratios greater than 10:1 of total inorganic nitrogen to total orthophosphate are considered to be indicative of phosphorus limitation (Chiaudani and Vighi,1974).

Total nitrogen to total phosphorus ratios of 20:1 are likewise considered indicative of phosphorus limiting conditions. Annual concentrations in the euphotic zone of Winchester Lake for total nitrogen and total phosphorus were 2.2 mg/l and 0.14 mg/l, respectively. This ratio of 15.7:1 does not conclusively identify phosphorus limitation, but the ratio is of sufficient magnitude to lend concurrence to the first estimate.

Phytoplankton dynamics also reveal a system under severe stress conditions. It is well known that once basic physiological requirements of light and temperature are met, a number of inorganic and organic nutrients play critical roles in phytoplanktonic population changes. High growth rates are promoted in the spring and early summer by long periods of sunlight, favorable temperatures, and large supplies of nutrients. Those growth rates slow due to reduced light penetration as a result of large masses of algae, and to competition for nutrients and oxygen.

Chlorophyll a concentration is commonly utilized as an indicator of primary production in a water body. Theoretically, greater concentrations of chlorophyll indicate greater production, which indicates favorable conditions for growth, i.e. adequate nutrients, light, and temperature.

The mean concentration of chlorophyll a for all three euphotic zone stations in Winchester Lake was 58 µg/l. Summertime average concentrations of chlorophyll a between 5 and 10 µg/l are considered the dividing line between oligotrophy and eutrophy (Carlson, 1973).

Conditions developed by August which precluded successful competition by green algae with the blue-green algae, and the phytoplanktonic community structure shifted. Blue-greens are able to proliferate under conditions of anaerobiosis and low nitrogen concentrations due to their ability to fix molecular nitrogen into organic forms. In general, an inverse relationship is seen between the rate of nitrogen fixation by blue-green algae and concentration of inorganic nitrogen (Wetzel 1975).

Blue-green algae are evolutionarily primitive, and most representatives are filamentous in structure; however some unicellular members form large colonies. All occur with mucilaginous sheets. These physical characteristics enable blue-green algae to form large mats which can cover the surface of Winchester Lake. In addition, these algae are notable for causing taste and odor which have been common complaints from lake users. Some blue-green species may be toxic to animals and other algae.

This study also addressed the potential effects of heavy metals, pesticides, and herbicides on lake water quality. Although sampling was limited, less-than-detectable levels were determined for nearly all of these parameters in both water and fish flesh. They do not appear to be of significance in the degradation of Winchester Lake water quality.

CONCLUSIONS AND MANAGEMENT CONSIDERATIONS

Winchester Lake exhibits all classic symptoms of eutrophication. Phosphorus is considered as limiting, but the concentrations of both phosphorus and nitrogen are extremely high. There are numerous techniques available which may be successful in treating both the symptoms and causes of the decline in water quality. Many of these techniques have been summarized by Peterson (1985).

Both external and internal nutrient loading must be addressed in any rehabilitation plan for the lake. External contributions will be addressed through watershed management. Implementation of Best Management Practices on cropland, rangeland, and forested lands will assist by mitigating on-going loading. In addition, control of silt income is necessary to prevent development of shallow water and macrophytic growth.

Internal cycling of nutrients will require treatment and management which serve either to remove or to render inactive those materials already in the lake ecosystem, primarily in the sediments. Phosphorus in the water column may be precipitated by sorbtion to salts of aluminum (aluminum sulfate or sodium aluminate). If sufficient aluminum is added to create a barrier on the lake sediments, release of phosphorus at the sediment water interface will be prevented. Care must be taken to prevent aluminum toxicity, however, insufficient dosages or mixing will prevent effective treatment. Sediment covers have also been used, but only on limited basis, due to high cost. Plastic sheeting material is typically placed directly over the sediment so as to prevent macrophyte growth.

It may be necessary to remove the sediments already in the lake. That action will not only serve to deepen the lake, thereby mitigating high temperature conditions, but also to remove the nutrients now lying in the sediments. Numerous problems must be considered if that alternative is selected including short term effects on recreation, amount of time required, and availability and appropriateness of sites on which to dispose of dredged material. However, costs may be lowered by selling dredge material for top soil dressing.

Some studies have suggested that removal of the lake bottom waters (hypolimnetic withdrawal) will also remove nutrients. The waters are pumped or siphoned both of which are relatively inexpensive and simple. However, the water, which is low in oxygen and high in nutrients, must be disposed without impacting surface water or nearby groundwater. In addition, the inherent conditions which caused the eutrophication will be essentially unchanged.

Artificial circulation and hypolimnetic aeration are also possible. The theory is that introduction of oxygen will inhibit the release of phosphorus from the sediments. However, real-life experiences in evaluating these techniques are lacking.

Naturally, various combinations of these techniques may be appropriate and should be considered. In addition, management of the fisheries at Winchester Lake should be evaluated. It is possible that the physical conditions of the lake will not support a cold-water fisheries. Perhaps bass and bluegill or other warm-water species will provide greater opportunities for quality angling.

LITERATURE CITED

APHA, 1985. Standard Methods for the Examination of Water and Wastewater. 16th Edition. Washington, D.C., 1268 p.

Carlson, R.E. 1973. A review of the philosophy & construction of trophic state indices, p.1-52. In T.E. Maloney. Lake & Reservoir Classification system. U. S. Environmental Protection Agency, Washington, D.C. EPA-600 3-79-074.

Chiaudani, G. & Vighi, M. 1974. The N:P ratio & tests with Selenestrum to predict eutrophication in lakes. Water Research. 8:1063-1069.

EPA, 1979. Methods for Chemical Analysis of Water & Wastes. EPA-0600 14-79-020.

IDHW/DOE, 1985. Idaho Water Quality Standards and Wastewater Treatment Requirements. Idaho Department of Health & Welfare. 72p.

Mackenthun, K. M. 1973. Toward a Cleaner Aquatic Environment, U. S. Environmental Protection Agency. Washington, D.C.

Peterson, S. A. 1975. Lake restoration methods; some work, some don't U.S. Environmental Protection Agency, Corvalis, OR.

U. S. EPA, 1976. Quality Criteria for Water, Washington, D.C. 256 p.

Vollenweider, R. A. 1973. Input Output Models, Schweiz Z. Hydrol.

Wetzel, R. G. 1975. Limnology. W. B. Saunders, Co. Philadelphia. 743 p.

Appendix 1. Results of Water Quality Analyses, Winchester Lake, 1985.

SAMPLING STATION 1A

Date	Sec. Trans m	T° °C	Cond. @25°C µmhos/cm	D.O. mg/L	pH S.U.	Chl.a µg/L	NH3 mg/L	NO2 mg/L	NO3 mg/L	NO2+ NO3 mg/L	TKN mg/L	Total PO4 mg/L	Ortho PO4 mg/L	Hard. mg/L	Total Alk. mg/L	SO4 mg/L	S.S. mg/L	Total Coli. #/.1L	Fecal Coli. #/.1L
05/07	0.5	14.0	174.7	14.0	9.0	AAA	AAA	AAA	AAA	2.44	2.59	0.21	0.012	55	50	11	11.0	AAA	AAA
05/23	1.2	19.5	179.8	9.0	6.6	120.6	AAA	AAA	AAA	1.84	1.45	0.06	0.009	57	54	11	8.4	AAA	AAA
06/05	1.1	16.0	120.7	9.4	6.4	36.8	0.080	0.061	1.10	1.71	1.36	0.10	0.060	54	52	12	7.4	7	4
06/19	0.9	23.0	149.7	13.0	9.1	90.0	0.167	0.051	0.89	0.94	2.22	0.60	0.003	56	59	8	25.0	<1	<1
07/02	1.5	22.0	129.4	8.1	7.3	37.5	0.221	0.028	0.77	0.80	1.28	0.07	0.002	56	60	9	8.4	46	1
07/17	1.2	22.2	137.3	11.2	8.3	39.8	0.269	0.009	0.29	0.30	1.29	0.07	0.027	54	65	8	12	60	<10
08/01	0.7	21.0	132.0	8.5	9.0	54.9	0.049	0.002	0.02	0.02	1.78	0.09	0.004	60	66	8	15	20	<1
08/15	0.7	17.6	137.4	10.4	9.0	74.0	0.163	0.003	0.043	0.05	1.61	0.08	0.003	56	66	<6	12	62	<2
08/29	0.6	20.0	130.4	5.8	8.6	AAA	0.223	0.006	0.021	0.03	1.99	0.11	0.008	52	65	<7	5.6	AAA	<1
09/12	1.4	14.2	136.0	5.8	7.2	32.1	0.142	0.012	0.029	0.041	0.92	0.11	0.051	66	68	54	24.4	<1	<1
09/26	1.2	12.0	119.7	7.4	6.0	AAA	0.078	0.008	0.063	0.071	1.37	0.16	0.071	56	69	<6	14.0	2	<1
10/09	1.3	9.0	244.8	7.9	6.9	6.0	0.106	0.007	0.062	0.069	1.48	0.15	0.056	62	68	7	10.0	<1	<1
10/24	1.3	6.8	150.2	8.8	7.1	18.1	0.116	0.005	0.075	0.080	1.52	0.20	0.054	60	69	8	8	AAA	1
AVG.	1.04	16.7	149.4	9.17	7.7	51.0	0.147	0.017	0.30	0.33*	1.60	0.15	0.027	57	62	14	12	22	2
MIN.	0.5	6.8	119.7	5.8	6.0	6.0	0.049	0.002	0.02	0.02	0.92	0.06	0.002	52	50	<6	5.6	<1	<1
MAX.	1.5	23.0	244.8	14.0	9.1	120.6	0.269	0.061	1.10	2.44	2.59	0.60	0.071	66	69	54	25.0	62	4

* May Data Omitted

AAA Unreported Datum

< Bacteriological data reported as "less than" are entered as that number in logarithimic means.

Appendix 1. Results of Water Quality Analyses, Winchester Lake, 1985.

SAMPLING STATION 1B

Date	Sec. Trans m	T° °C	Cond. @25°C µmhos/cm	D.O. mg/L	pH S.U.	Chl.a µg/L	NH3 mg/L	NO2 mg/L	NO3 mg/L	NO2+NO3 mg/L	TKN mg/L	Total PO4 mg/L	Ortho PO4 mg/L	Hard. mg/L	Total Alk. mg/L	SO4 mg/L	S.S. mg/L	Total Coli. #/.1L	Fecal Coli. #/.1L
05/23	AAA	8.0	136.2	0.6	6.4	AAA	AAA	AAA	AAA	2.40	1.50	0.14	0.013	12	150.0	10	39	AAA	AAA
06/05	AAA	8.8	141.9	0.2	6.5	AAA	0.283	0.173	1.90	2.07	1.19	0.15	0.054	52	153.0	13	24	14	29
06/19	AAA	9.0	144.0	0.2	AAA	AAA	0.429	0.130	1.41	1.54	1.49	0.15	0.055	56	157.0	9	14	20	25
07/02	AAA	9.0	146.8	0.6	6.5	AAA	0.534	0.023	1.15	1.17	1.55	0.19	0.034	58	160.0	9	44	23	8
07/17	AAA	9.0	161.2	0.4	6.7	AAA	0.807	0.021	0.48	0.50	1.78	0.35	0.062	56	167.0	7	22	140	<10
08/01	AAA	9.8	157.8	0.2	6.1	AAA	0.822	0.004	0.07	0.08	1.66	0.24	0.066	60	70	<6	12	52	<1
08/15	AAA	12.0	156.9	0.2	6.4	AAA	0.893	0.003	0.009	0.01	1.66	0.25	0.159	64	82	<6	16	8	4
08/29	AAA	11.0	203.3	0.3	6.3	AAA	1.79	0.002	0.319	0.32	2.44	0.49	0.482	62	83	<7	16	<1	<1
09/12	AAA	12.0	170.2	0.3	6.6	AAA	0.613	0.006	0.028	0.034	1.89	0.29	0.192	66	71	8	9	<1	<1
09/26	AAA	11.0	139.2	2.1	6.9	AAA	0.241	0.007	0.049	0.056	1.19	0.18	0.106	60	69	<6	20	<1	<1
10/09	AAA	8.2	250.2	6.1	6.9	AAA	0.121	0.008	0.087	0.095	1.54	0.19	0.166	60	69	AAA	28	8	<1
10/24	AAA	6.2	159.1	7.2	7.3	AAA	0.141	0.007	0.088	0.095	1.45	0.14	0.057	58	67	8	6	<1	3
AVG.		9.5	163.9	1.5	6.6		0.607	0.035	0.51	0.54*	1.61	0.23	0.120	55	166.5	8	21	24	7
MIN.		6.2	136.2	0.2	6.1		0.121	0.002	0.009	0.01	1.19	0.14	0.013	12	150.0	<6	6	<1	<1
MAX.		12.0	250.2	7.2	7.3		1.79	0.173	1.90	2.40	2.44	0.49	0.482	66	183.0	13	44	140	29

* May Data Omitted

AAA Unreported Datum

< Bacteriological data reported as "less than" are entered as that number in logarithimic means.

Appendix 1. Results of Water Quality Analyses, Winchester Lake, 1985.

SAMPLING STATION 3A

Date	Sec. Trans m	T° °C	Cond. @25°C µhos/cm	D.O. mg/L	pH S.U.	Chl.a µg/L	NH3 mg/L	NO2 mg/L	NO3 mg/L	NO2+ NO3 mg/L	TKN mg/L	Total PO4 mg/L	Ortho PO4 mg/L	Hard. mg/L	Total Alk. mg/L	SO4 mg/L	S.S. mg/L	Total Coli. #/.1L	Fecal Coli. #/.1L
05/07	0.6	12.5	181.2	12.5	8.9	AAA	AAA	AAA	AAA	2.34	1.70	0.21	0.013	54	150.0	10	15.0	AAA	AAA
05/23	1.3	20.8	119.5	9.8	8.4	114.0	AAA	AAA	AAA	2.17	1.24	0.09	0.006	51	152.0	AAA	4.8	AAA	AAA
06/05	1.2	15.6	156.0	10.0	6.6	36.4	0.103	0.064	1.69	1.75	1.08	0.15	0.013	AAA	AAA	11	5.0	<1	1
06/19	0.7	23.2	144.9	15.8	9.5	91.5	0.115	0.039	0.78	0.82	2.05	0.14	0.024	52	157.0	9	20	5	<1
07/02	1.4	23.2	135.6	9.4	7.4	27.0	0.198	0.024	0.78	0.80	1.26	0.06	0.007	56	159.0	9	11	2	1
07/17	1.2	23.0	145.5	11.4	9.0	29.2	0.215	0.013	0.25	0.26	1.60	0.11	0.021	56	164.0	7	9.4	160	<10
08/01	0.8	20.4	140.3	9.1	9.2	50.9	0.071	0.005	0.013	0.02	1.60	0.10	0.011	56	66	6	14	82	14
08/15	0.5	18.2	117.2	11.2	9.2	100.2	0.067	0.007	0.001	0.01	1.83	0.15	0.005	58	65	<6	18	<2	<2
08/29	0.7	20.8	135.8	6.6	8.4	AAA	0.174	0.006	0.026	0.03	2.32	0.13	0.009	54	65	<7	8.0	<1	TNTC
09/12	1.3	14.0	131.6	5.3	6.7	22.1	0.254	0.007	0.040	0.047	0.84	0.12	0.059	60	69	<6	13.3	1	1
09/26	1.2	12.0	125.0	8.1	6.8	AAA	0.054	0.007	0.042	0.049	1.74	0.18	0.071	56	67	<6	16.0	<1	<1
10/09	1.2	10.0	185.0	7.5	7.0	AAA	0.105	0.004	0.094	0.098	1.64	0.16	0.054	58	69	7	12.0	21	<1
10/24	1.3	7.2	159.0	7.6	7.3	AAA	0.120	0.004	0.074	0.078	1.64	0.18	0.028	60	67	8	10.0	5	4
AVG.	1.03	17.0	144.4	9.56	8.0	58.9	0.134	0.015	0.34	0.36*	1.58	0.13	0.024	56	62	8	12.0	25	12
MIN.	0.5	7.2	117.2	5.3	6.6	22.1	0.054	0.004	0.001	0.01	0.84	0.06	0.005	51	150.0	<6	4.8	<1	<1
MAX.	1.4	23.2	185.0	15.8	9.5	114.0	0.254	0.064	1.69	2.34	2.32	0.21	0.071	60	169.0	11	20.0	160	14

* May Data Omitted

AAA Unreported Datum

< Bacteriological data reported as "less than" are entered as that number in logarithimic means.

Appendix 1. Results of Water Quality Analyses, Winchester Lake, 1985.

SAMPLING STATION 3B

Date	Sec. Trans. m	T° °C	Cond. 325°C µmhos/cm	D.O. mg/L	pH S.U.	Chl.a µg/L	NH3 mg/L	NO2 mg/L	NO3 mg/L	NO2+ NO3 mg/L	TKN mg/L	Total PO4 mg/L	Ortho PO4 mg/L	Hard. mg/L	Total Alk. mg/L	SO4 mg/L	S.S. mg/L	Total Coli. #/.1L	Fecal Coli. #/.1L
05/23	AAA	7.2	189.3	0.0	7.1	AAA	AAA	AAA	AAA	2.38	1.18	0.14	0.016	51	150.0	AAA	25.0	AAA	AAA
06/05	AAA	7.4	219.9	0.1	6.5	AAA	0.459	0.225	1.56	1.78	1.21	0.16	0.066	AAA	AAA	13	9.8	33	12
06/19	AAA	7.8	151.8	0.1	6.5	AAA	0.695	0.107	1.26	1.37	1.80	0.19	0.074	60	159.0	9	17	11	16
07/02	AAA	8.0	151.0	0.6	6.3	AAA	0.968	0.011	0.95	0.97	1.67	0.21	0.072	60	164.0	9	60	27	26
07/17	AAA	8.6	160.1	0.4	6.2	AAA	1.250	0.009	0.30	0.30	2.02	0.30	0.079	60	170.0	6	14	60	10
08/01	AAA	8.4	187.4	0.3	6.2	AAA	1.790	0.003	0.007	0.01	2.64	0.63	0.485	66	81	<6	11	41	6
08/15	AAA	8.8	182.4	0.1	6.5	AAA	2.28	0.003	0.003	0.01	2.51	0.73	0.443	66	85	<6	18	6	<2
08/29	AAA	9.0	187.2	0.1	6.5	AAA	2.37	0.004	0.060	0.06	3.51	0.68	0.526	62	86	<7	15.4	<1	<1
09/12	AAA	9.0	201.6	0.3	6.7	AAA	0.458	0.003	0.001	0.006	3.94	1.02	0.048	70	92	<6	11.1	3	<1
09/26	AAA	9.4	213.6	0.2	6.5	AAA	1.280	0.007	0.020	0.027	2.23	0.51	0.360	62	77	<6	14.0	<1	<1
10/09	AAA	8.0	251.7	3.9	7.0	AAA	0.105	0.005	0.101	0.106	1.33	0.17	0.138	58	69	7	20.0	3	<1
10/24	AAA	7.0	166.1	7.6	7.3	AAA	0.116	0.008	0.114	0.122	1.45	0.18	0.039	58	68	8	10.0	14	1
AVG.		8.21	189	1.14	6.61		1.069	0.035	0.40	0.60	2.12	0.41	0.195	61	73	9	19	9	3
MIN.		7.0	151.0	0.0	6.2		0.105	0.003	0.001	0.006	1.18	0.14	0.016	51	150.0	<6	9.8	<1	<1
MAX.		9.4	252	7.6	7.3		2.37	0.225	1.56	2.38	3.94	1.02	0.526	70	192.0	13	60.0	60	26

* May Data Omitted

AAA Unreported Datum

< Bacteriological data reported as "less than" are entered as that number in logarithimic means.

Appendix 1. Results of Water Quality Analyses, Winchester Lake, 1985.

SAMPLING STATION 5A

Date	Sec. Trans m	T° °C	Cond. @25°C µhos/cm	D.O. mg/L	pH S.U.	Chl.a µg/L	NH3 mg/L	NO2 mg/L	NO3 mg/L	NO2+NO3 mg/L	TKN mg/L	Total PO4 mg/L	Ortho PO4 mg/L	Hard. mg/L	Total Alk. mg/L	SO4 mg/L	S.S. mg/L	Total Coli. #/.1L	Fecal Coli. #/.1L
05/07	0.4	15.0	185.4	14.0	9.2	AAA	AAA	AAA	AAA	2.17	2.72	0.24	0.022	52	51.5	11	20.0	AAA	AAA
05/23	1.1	19.8	122.1	9.1	7.3	121.4	AAA	AAA	AAA	2.15	1.44	0.08	0.007	52	52.0	11	5.2	AAA	AAA
06/05	1.3	16.0	138.8	9.6	6.7	45.1	0.073	0.063	1.01	1.07	1.32	0.12	0.043	56	52.0	11	6.6	4	3
06/19	0.7	23.2	142.9	14.9	9.1	65.2	0.124	0.041	0.95	1.00	1.68	0.09	0.006	54	58.0	8	25	<1	<1
07/02	1.5	23.2	132.5	9.6	6.5	31.5	0.178	0.028	0.79	0.82	1.20	0.07	0.010	58	59.0	9	12	2	7
07/17	1.2	22.4	140.9	11.6	8.7	48.0	0.167	0.008	0.23	0.24	1.20	0.10	0.009	52	62.0	8	8.4	<10	<10
08/01	0.8	20.4	133.7	8.6	9.1	65.7	0.130	0.005	0.318	0.32	1.69	0.12	0.003	58	65	7	12	<1	<1
08/15	0.6	17.6	128.1	12.4	9.3	107.2	0.083	0.006	0.003	0.01	2.19	0.13	0.005	56	66	<6	16	2	<2
08/29	0.7	20.4	133.7	6.9	8.5	AAA	0.216	0.006	0.026	0.03	1.83	0.10	0.008	54	64	<7	7.6	<1	<1
09/12	1.4	14.2	136.0	6.1	7.0	25.4	0.176	0.010	0.039	0.049	1.38	0.14	0.128	58	65	<6	6.7	<1	<1
09/26	1.0	12.6	120.5	8.6	7.2	AAA	0.066	0.005	0.044	0.049	2.13	0.22	0.080	58	68	<6	22.0	<1	1
10/09	1.4	9.4	205.0	7.6	7.0	AAA	0.077	0.005	0.057	0.063	1.46	0.16	0.062	64	69	7	6.0	15	<1
10/24	1.4	6.8	162.4	8.7	7.2	AAA	0.096	0.005	0.063	0.068	1.50	0.18	0.031	58	66	8	12.0	47	1
AVG.	1.0	17.0	145	9.8	7.9	63.7	0.125	0.017	0.32	0.62	1.67	0.13	0.031	56	61	9	12	3	2
MIN.	0.4	6.8	121	6.1	6.5	25.4	0.066	0.005	0.003	0.01	1.20	0.07	0.003	52	51.5	<6	5.2	<1	<1
MAX.	1.5	23.2	205	14.9	9.3	121.4	0.216	0.063	1.01	2.17	2.72	0.24	0.128	64	69	11	25	47	7

* May Data Omitted
AAA Unreported Datum
< Bacteriological data reported as "less than" are entered as that number in logarithimic means.

Appendix 1. Results of Water Quality Analyses, Winchester Lake, 1985.

SAMPLING STATION 5B

Date	Sec. Trans m	T° °C	Cond. @25°C µmhos/cm	D.O. mg/L	pH S.U.	Chl.a µg/L	NH3 mg/L	NO2 mg/L	NO3 mg/L	NO2+NO3 mg/L	TKN mg/L	Total PO4 mg/L	Ortho PO4 mg/L	Hard. mg/L	Total Alk. mg/L	SO4 mg/L	S.S. mg/L	Total Coli. #/.1L	Fecal Coli. #/.1L
05/23	AAA	7.6	161.7	0.0	6.5	AAA	AAA	AAA	AAA	2.71	0.79	0.63	0.011	48	50.0	AAA	32.0	AAA	AAA
06/05	AAA	7.8	178.7	0.0	AAA	AAA	0.431	0.228	1.65	1.88	1.27	0.12	0.114	AAA	AAA	13	13.0	13	10
06/19	AAA	8.0	151.0	0.1	6.1	AAA	0.701	0.102	1.19	1.29	1.68	0.23	0.081	58	61.0	8	23	16	5
07/02	AAA	8.2	150.1	0.7	6.5	AAA	0.905	0.008	1.00	1.01	1.70	0.21	0.072	60	64.0	9	10	41	8
07/17	AAA	8.2	159.0	0.5	6.3	AAA	1.190	0.010	0.37	0.38	1.86	0.29	0.099	60	68.0	6	13	30	<10
08/01	AAA	9.2	168.9	0.2	6.2	AAA	1.27	0.004	0.006	0.01	2.12	0.39	0.261	64	75	7	18	12	<1
08/15	AAA	9.2	174.7	0.1	6.3	AAA	1.82	0.006	0.084	0.09	2.13	0.58	0.518	60	75	<6	20	28	<2
08/29	AAA	9.6	184.1	0.2	AAA	AAA	1.99	0.002	0.216	0.22	2.15	0.45	0.464	60	81	<7	10.0	3	<1
09/12	AAA	9.4	188.0	0.3	6.5	AAA	0.472	0.009	0.081	0.090	3.24	0.86	AAA	74	92	<6	11.1	1	<1
09/26	AAA	11.0	136.5	1.7	7.0	AAA	0.309	0.007	0.037	0.044	1.42	0.22	0.127	58	69	<6	12.0	1	<1
10/09	AAA	7.8	259.1	4.9	7.2	AAA	0.066	0.004	0.049	0.053	1.41	0.15	0.148	62	68	7	20.0	12	<1
10/24	AAA	6.8	168.6	7.4	7.3	AAA	0.094	0.007	0.063	0.070	1.41	0.17	0.054	58	68	8	10.0	<1	<1
AVG.		8.6	173.3	1.34	6.6		0.84	0.035	0.43	0.65	1.76	0.35	0.177	60	70	8	16	4	2
MIN.		6.8	136.5	0.0	6.1		0.066	0.002	0.006	0.01	0.79	0.12	0.011	48	50.0	<6	10	<1	<1
MAX.		11.0	259.1	7.4	7.3		1.99	0.228	1.650	2.710	3.24	0.86	0.518	74	92	13	32	41	10

* May Data Omitted
AAA Unreported Datum
< Bacteriological data reported as "less than" are entered as that number in logarithimic means.

Appendix 2. Lake Loading by Lapwai Creek Nutrients

I.

Sample Date	3/18	3/28	4/2	4/18	6/18
Flow(mgd)	2.6	5.7	26.3	2.8	0.3
Time Period	3/3-3/23	3/24-3/31	4/1-4/4	4/5-5/18	5/19-7/18
No of Days	20	7	4	43	60
T-P (mg/l	0.26	0.13	0.51	0.18	0.14
T-P (lb/d)	6	6	112	4	1
TKN (mg/l)	0.98	0.86	1.92	0.81	0.58
TKN (lb/d)	21	41	421	19	2
NO2+NO3 (mg/l)	3.21	7.14	8.39	0.91	0.61
NO2+NO3 (lb/d)	70	339	1840	21	2

II. T-P(Annual Influx) = 20(6) + 7(6) + 4(112) + 43(4) + 60(1) = 842 lbs.

TKN(Annual Influx) = 20(21) + 7(41) + 4(421) +43(19) + 60(2) = 3329 lbs.

NO2+NO3(Annual Influx)=20(70)+7(339)+4(1840)+43(21)+60(2)=12,156 lbs.

III. Winchester Lake Volume (85 acres & 20' average depth acre) = 554 million gallons

IV. Theoretical Concentrations of Nutrients $\frac{\text{(Annual Influx)}}{\text{(Lake Volume)}}$

T-P = 2.6 mg/l
TKN = 10.3 mg/l
NO_2+NO_3 = 37.7 mg/l