EPA-908/2-77-003 SA/TIB-33

GREEN MOUNTAIN RESERVOIR - LOWER BLUE RIVER STUDY

COLORADO

SEPTEMBER, 1976

TECHNICAL INVESTIGATIONS BRANCH

SURVEILLANCE AND ANALYSIS DIVISION

U. S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII

AUGUST, 1977

GREEN MOUNTAIN RESERVOIR - LOWER BLUE RIVER STUDY

COLORADO

SEPTEMBER, 1976

by

Ronald M. Eddy

and

Robert L. Fox

TECHNICAL INVESTIGATIONS BRANCH
SURVEILLANCE AND ANALYSIS DIVISION
U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

AUGUST, 1977

Document is available to the public from the National Technical Information Service, U. S. Dept. of Commerce, Springfield, VA 22161

DISCLAIMER

This report has been reviewed by the Surveillance and Analysis Division, U.S. Environmental Protection Agency, Region VIII, and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the efforts of the Laboratory Services Section of the Technical Investigations Branch, EPA, Region VIII, in providing analytical chemistry support for this project. Additional analytical support was provided by the regional microbiology staff, whose efforts are also acknowledged.

The project was conducted under the supervision and direction of C.E. Runas, Chief, Water Quality Investigations Section, EPA, Region VIII. Field work was conducted by C.E. Runas, W.A. Warner, T.E. Braidech, D.R. McDonough, and R.L. Fox. The algal assay was conducted by R.M. Eddy.

TABLE OF CONTENTS

ABSTRACT

During September, 1976, a study was conducted by the Environmental Protection Agency, Region VIII, to determine existing nutrient and organic loadings to Green Mountain Reservoir, present trophic status of the reservoir, and possible effects of increased nutrient addition on algal growth potential. Sampling was conducted during a four day period, with additional samples collected in November, 1976.

Samples in Green Mountain Reservoir were collected at quarter points along six transects, three depths per sampling site. Samples were also collected from the Dillon-Silverthorne STP, the mainstem Blue River, and eight tributaries in the lower Blue River drainage.

Of the computed total phosphorus and total nitrogen loadings to the reservoir, 12.8% and 7.0%, respectively, were attributable to the Dillon-Silverthorne STP. Non-point loadings from the lower Blue River drainage (omitting the discharge from Dillon Reservoir) comprised 51.1% of the total phosphorus and 36.4% of the total nitrogen entering Green Mountain Reservoir. Results of the laboratory algal assays indicated phosphorus limitation at all stations with micronutrient limitation also evident at stations 3b and 6b. On the basis of chlorophyll *a* and primary productivity values, Green Mountain Reservoir, at the time of sampling, was oligotrophic. Dry weight yields in the algal assays indicated that potential primary productivity was moderate at the time of sampling.

LIST OF FIGURES

LIST OF TABLES

CONVERSION FACTORS

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters/sec x 35.315 = cubic feet/sec
(cms) (cfs)

Square kilometers x 0.3861 = square miles

Kilograms/square kilometer x 8.923 x 10^{-3} = pounds/acre

Kilograms x 2.205 = pounds

Centimeters x 0.3937 = inches

Liters x 0.946 = quarts

m^3/s x mg/l x 86.4 = Kg/day

INTRODUCTION

In 1974, a study of Dillon Reservoir and the upper Blue River drainage was conducted to assess the trophic status of the reservoir and determine the possible effects of nutrient addition (EPA, 1974). The study was in partial fulfillment of a commitment by the Environmental Protection Agency, Region VIII, to study the entire Blue River Basin. The present study of Green Mountain Reservoir and the lower Blue River drainage, a project similar in scope to the Dillon Reservoir study, fulfills that commitment.

The investigation was conducted over a four day period in September, 1976, with additional samples collected during November, 1976. The study objectives for the Green Mountain study were similar to those of the Dillon study:

1. Determine the existing nutrient levels in Green Mountain Reservoir,

2. determine the organic and nutrient loadings from the major tributaries in the lower Blue River drainage,

3. determine the organic and nutrient loadings from municipal wastewater treatment facilities discharging into the lower Blue River drainage, and

4. determine the probable consequences of increased nutrient concentrations on algal growth potential.

SUMMARY AND CONCLUSIONS

A water quality study was conducted by the Environmental Protection Agency during September and November, 1976 in the lower Blue River drainage, including Green Mountain Reservoir, in order to assess the trophic status of the lake and the possible effects of nutrient addition on algal growth potential. Water samples were collected from eight tributaries to the Blue River, the Dillon-Silverthorne Sewage Treatment Plant (STP), four mainstem Blue River locations, and along six transects of the reservoir.

The Dillon-Silverthorne STP and each stream location was sampled three times during a four day period for 19 water quality parameters. Measurements for several common parameters (temperature, pH, D.O., conductivity, BOD_5 and TSS) were generally indicative of high quality water in the lower Blue River drainage. Evidence of possible microbiological pollution, as indicated by fecal coliform measurements, was found in Otter Creek (597 FC/100 ml). Runoff from livestock grazing areas is considered the likely cause for the high coliform counts in Otter Creek. Metals data indicated that concentrations of total molybdenum, iron, and zinc exceeded recommended EPA criteria and/or proposed Colorado water quality standards. The molybdenum criterion of 10 μg/l was exceeded by a factor of 10 in the Blue River, while the proposed total iron and zinc standards (500 μg/l and 50 μg/l, respectively) were only slightly exceeded.

Measurements of total nitrogen (T-N) and total phosphorus (T-P) indicated the following:

1. The only point source in the lower Blue River drainage, the Dillon-Silverthorne STP, contributed 7.0% of the T-N and 12.8% of the T-P entering Green Mountain Reservoir during the study period. The phosphorus load of 0.78 kg/day (1.73 lb/day) was substantially less than the wasteload allocation of 1.42 kg/day (3.13 lb/day).

2. The nonpoint nutrient load from the lower Blue River drainage (excluding the contribution from Dillon Reservoir) comprised 36.4% of the T-N and 51.1% of the T-P entering Green Mountain Reservoir.

3. The discharge from Dillon Reservoir comprised 56.6% of the T-N and 36.1% of the T-P entering Green Mountain Reservoir.

4. Nutrient measurements obtained during this study were generally in agreement with the results obtained during the 1974-1975 EPA National Eutrophication Survey on Green Mountain Reservoir.

5. The Black Creek and Otter Creek drainages had the highest total phosphorus export rates (approximately 5 and 6 $kg/km^2/yr$, respectively).

6. On the basis of chlorophyll *a* concentrations, primary productivity values, and plankton cell counts, Green Mountain Reservoir, at the time of sampling, was oligotrophic.

7. Algal assay results indicated that phosphorus was the limiting nutrient in Green Mountain Reservoir. A concurrent micronutrient limitation was also noted for samples collected from stations 3b and 6b.

DESCRIPTION OF STUDY AREA

Located west of the Continental Divide, Green Mountain Reservoir is an impoundment of the Blue River situated 40.2 km (25 mi) downstream from Dillon Reservoir and 24.1 km (15 mi) upstream from the town of Kremmling, Colorado (Figure 1). Approximately 48.3 km (30 mi) downstream from the dam, the Blue River joins the Colorado River.

Green Mountain Reservoir was the initial feature of the Bureau of Reclamation's Colorado-Big Thompson Project, a trans-mountain diversion project to supply water from the Colorado River on the western slope of the Divide to the eastern slope for multiple purpose usage. The reservoir, which was created mainly for replacement of project-induced water shortages, also has power production capabilities. Completed in the Spring of 1943, Green Mountain Dam created a reservoir of 191 x 10^6 m^3 (154,645 acre-feet) total capacity of which 64 x 10^6 m^3 (52,000 acre-feet) are reserved exclusively for replacement while 117 x 10^6 m^3 (94,888 acre-feet) are for power production. Inactive storage (dead storage) is 10 x 10^6 m^3 (7,757 acre-feet) (U.S.B.R., 1957).

The Blue River is the major tributary of Green Mountain Reservoir, comprising approximately 70% of incoming flows (EPA, 1976b). Flow in the Blue River is, for the most part, regulated upstream by Dillon Dam. Between Dillon and Green Mountain Reservoirs, the Blue River flows through an area comprised of several different types of land uses. These types include mountainous forest lands, open meadows utilized for livestock grazing, light agricultural lands (hay fields), scattered vacation and/or retirement homes, and light residential/commercial lands. Because of the area's highly desirable natural setting and its proximity to several major skiing areas, the Blue River basin is the focus of considerable debate concerning future growth patterns.

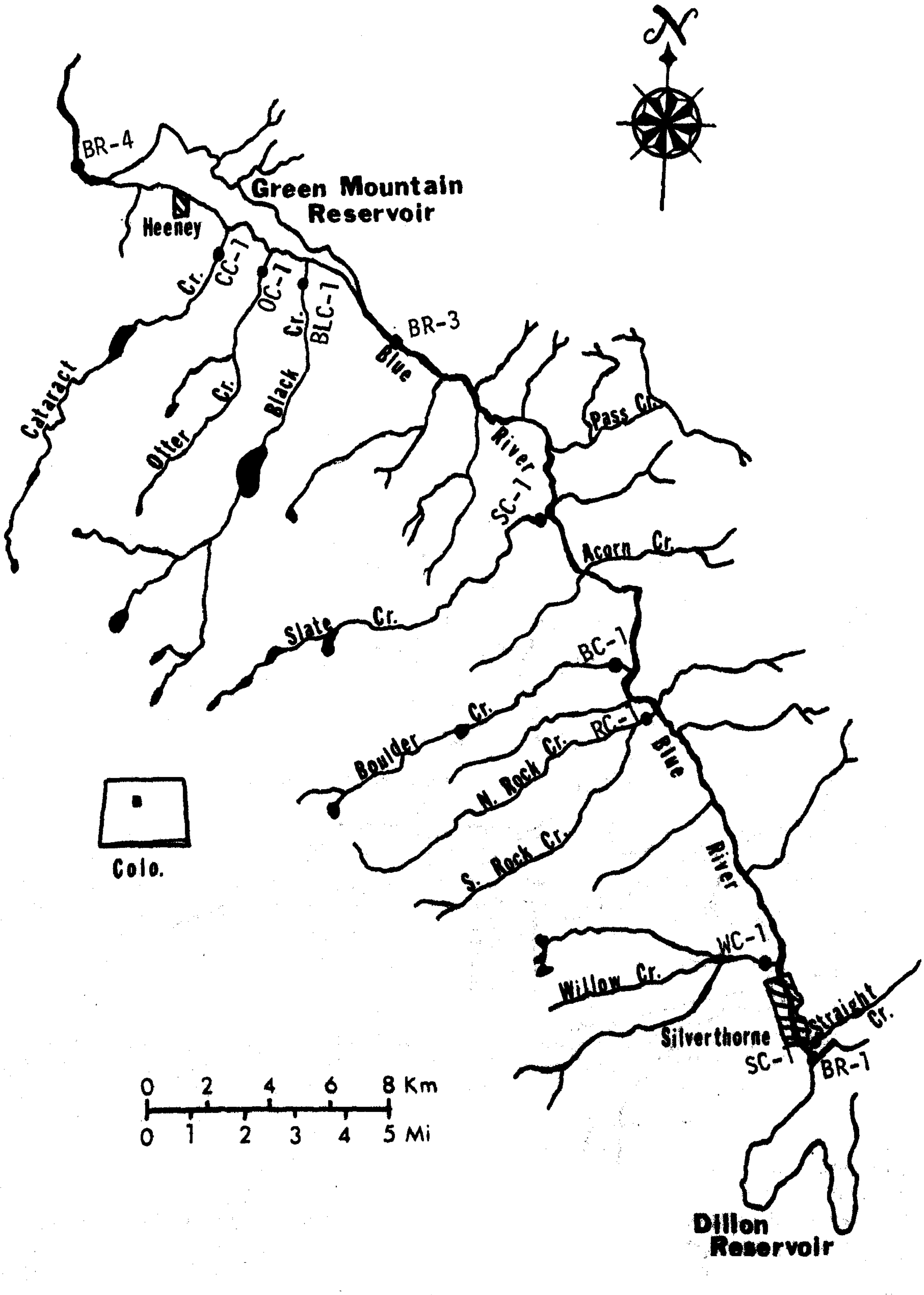


Figure 1. Sampling station locations in the lower Blue River drainage, Colorado, September, 1976 (adapted from EPA, 1976b).

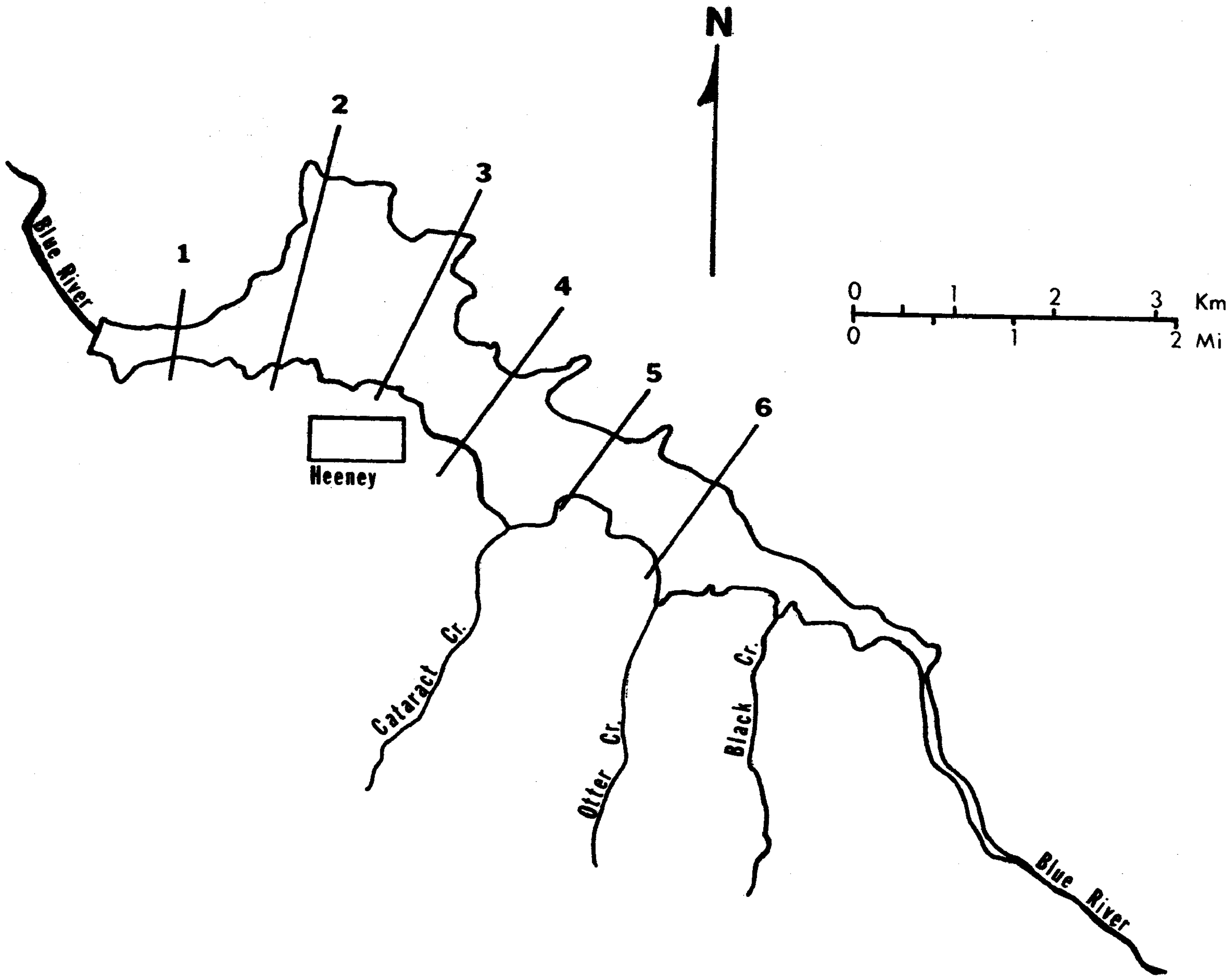


Figure 2. Sampling transect locations on Green Mountain Reservoir, Colorado, September, 1976.

METHODS AND MATERIALS

GENERAL

Water quality sampling during the September, 1976 survey consisted of two major parts: (1) the main body of the reservoir and (2) the tributaries and associated sewage treatment plant. Six transects were established on Green Mountain Reservoir with samples collected at quarter points on each transect (Figure 2). At each sampling location on each transect, water was collected one meter below the surface, at the thermocline (plane of maximum temperature gradient) and approximately 2 meters above the bottom. In the event that the water depth at any sampling location was less than the mid-channel thermocline depth, samples were collected only at the surface and the bottom. Sampling stations were also located on nine tributaries in the lower Blue River drainage- Blue River, Cataract Creek, Otter Creek, Black Creek, Slate Creek, Boulder Creek, Rock Creek, Willow Creek, and Straight Creek (Table 1). Samples were also collected from the Dillon-Silverthorne Sewage Treatment Plant (STP). Figure 1 shows the respective locations of the tributary sampling stations.

All water samples collected were "grab" type samples. Samples from the reservoir were taken with a polypropylene Kemmerer water bottle. Samples for nutrient (TKN, NH_3, NO_2 + NO_3, T-P, ortho-P) and metal (total and dissolved Si, Mo, Fe, Zn, Cu) analysis were placed in plastic cubitainers and preserved with 4 ml $HgCl_2$ per liter and 5 ml HNO_3 per liter, respectively. Aliquots for dissolved metals were field filtered with a 0.45µ filter prior to preservation. In addition to collection of metal and nutrient samples, field determinations for temperature, pH, dissolved oxygen, and conductivity were made. Also, at all tributary sampling stations and the Dillon-Silverthorne STP, samples were collected for 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and total and fecal coliform. All total and fecal coliform analyses were conducted by Membrane Filter (MF) technique unless the Most Probable Number (MPN) value is shown, indicating the alternate technique was used. Where possible, instantaneous stream flow measurents were also made using an electromagnetic current meter.

Temperature and depth profiles were recorded at each lake transect. A direct read-out thermistor-thermometer equipped with a 62 m (200 ft) cable was used to establish the temperature gradients. Depth profiles were determined using Sonar.

A submarine photometer was used to determine the depth of the euphotic zone (1% level of light penetration) at transect mid-points. Determination of the euphotic zone was necessary prior to collection of euphotic zone composite samples for algal assays and collection of samples for primary productivity studies (C^{14}). Methodology employed in determining the algal growth potential of the reservoir water is discussed in detail in a separate section.

Table 1. Description of sampling station locations in the lower Blue River drainage, Colorado.

Station No.	River Kilometer	River Mile	Description
BR-1	63.1	39.2	Blue River immediately downstream from Dillon Reservoir at USGS gaging station
SC-1	62.9	39.1	Straight Creek at mouth
WC-1	59.7	37.1	Willow Creek at Highway 9 Crossing
DS-STP	57.6	35.8	Dillon-Silverthorne Sewage Treatment Plant effluent
BR-2	52.5	32.6	Blue River at point where river bends close to Highway 9, approximately 2.6 km (1.6 mi) upstream from Rock Creek
RC-1	49.9	31.0	Rock Creek at Highway 9 crossing
BC-1	47.6	29.6	Boulder Creek at Boulder Creek Picnic Ground
SLC-1	40.9	25.4	Slate Creek at mouth
BR-3	35.1	21.8	Blue River at Highway 9 crossing at upstream end of Green Mountain Reservoir
BLC-1	-	-	Black Creek at Heeney Road crossing
OC-1	-	-	Otter Creek at Heeney Road crossing
CC-1	-	-	Cataract Creek at Heeney Road crossing
BR-4	22.5	14.0	Blue River immediately downstream from Green Mountain Reservoir at USGS gaging station

Primary productivity was estimated by measuring the uptake of radioactive carbon (C^{14}) by the indigenous phytoplankton. The methodology employed was that outlined in Standard Methods, 14th Edition, 1975. Estimates of primary productivity were made in duplicate at three depths at stations 1b, 3b, and 6b. Samples were collected at three-meter intervals from the surface to the lower level of the euphotic zone. Light energy during the incubation period and daily photoperiods were measured with a pyroheliometer, with values reported in gram calories per cm^2 per day.

Water samples for the C^{14} study were collected at 3 depths with a polypropylene Kemmerer water bottle and placed in 300 ml BOD bottles. At each depth two of the bottles were unaltered for use as light bottles while light penetration was eliminated from the two remaining bottles. Five microcuries of C^{14} as sodium carbonate in solution were added to each bottle. After inoculation, the bottles were suspended at the original depth of collection and incubated four to six hours. Following incubation 300 ml were filtered through 0.45μ membrane filters which were then stored in a desiccator.

Upon arrival at the laboratory, the filters were dissolved in 2 ml of dimethyl-foramide in a liquid scintillation counting vial and filled with Cab-O-Sil. The Cab-O-Sil was then dissolved with 15 ml of liquid scintillation counting media (Permafluor). Samples were counted for 20 minutes by a Packard liquid scintillation counter Model 3390. Counting efficiency was determined by measuring a standard C^{14} solution.

Carbon assimilation was determined using the following formula:

$$C\ mg/m^3/day = \frac{1.06\ (A/t - B)\ C \cdot D \cdot E \cdot 10^3}{2.22\ F \cdot G \cdot H \cdot J \times 10^6}$$

$$mg\ Carbon/m^3/day \times euphotic\ zone\ depth\ (m) = mg\ C/m^2/day$$

Where:

- 1.06 = Ratio of C^{12}/C^{14} uptake rates
- A = Total counts of sample
- t = Counting time in minutes
- B = Instrument background in counts per minute
- C = Volume inoculated in C-14
- D = Carbon-12 concentration in sample media, mg/l
- E = Total photic period
- 10^3 = Conversion of liters to cubic meters
- 2.22 = Conversion factor for disintegration per min. to pCi
- F = Counting efficiency, counts per min./disintegration per min.
- G = Volume of sampled filtered (300 ml)
- H = Amount of C-14 added to sample, μCi
- J = Incubation period in same units as photic period
- 10^6 = Conversion of pCi to μCi

Chlorophyll a concentrations were determined for individual depth samples and for each euphotic zone composite sample (see Methods and Materials - Algal Assay). The methodology employed was the trichrometric procedure as outlined in the EPA Biological Methods Manual (1973). Phaeophytin a concentrations were also determined.

Phytoplankton concentrations were determined for an aliquot of each euphotic zone sample collected only during November. Samples were placed in cubitainers, preserved with formalin, and stored in the dark until analysis. Phytoplankton were enumerated following the general sedimentation procedures outlined in Schwoerbel (1970) and Vollenweider (1969) for inverted microscopes. Phytoplankton were identified to the lowest taxonomic level possible using the keys of Smith (1950), Patrick and Reimer (1966), Ward and Wipple (1959), and Weber (1971).

ALGAL ASSAY

Water was collected from three locations on Green Mountain Reservoir, (stations 1b, 3b, and 6b) on November 17, 1976 (Figure 2). A euphotic zone composite sample was collected for use as the algal assay test water. At each station, equal-volume water samples were collected at two-meter intervals in the euphotic zone and composited in a 3.78 liters carboy (pre-washed with 10% HCL). Aliquots of the composite sample were withdrawn and preserved for nutrient and metal analysis (4 ml $HgCl_2$ per liter and 5 ml HNO_3 per liter, respectively). Separate aliquots were also taken for chlorophyll analysis and phytoplankton counts. In addition to the composite sample, water for nutrient determinations was collected at a depth of one meter, at the mid-depth of the water column and at two meters above the bottom at all three sampling stations. Temperature, dissolved oxygen concentration, pH and conductivity were also recorded at each sampling location and depth. After compositing the euphotic zone samples, the algal assay test water was refrigerated and transported to the laboratory.

Upon arrival, the test water was transferred to glass media bottles and autoclaved for 30 minutes at 121 C. After cooling, the test waters were carbonated with a mixture of 1% CO_2 in air until the original pH was obtained. The samples were then filtered through a 0.45μ Millipore filter to remove any particulate matter which would interfere with the electronic particle counter (Coulter Model ZBI). An additional aliquot of the autoclaved and filtered composite samples was then removed for nutrient analysis to note any changes in chemical composition of the test water.

All algal assays were conducted following the procedures outlined in the Algal Assay Procedure, Bottle Test (EPA, 1971). <u>Selenastrum capricornutum</u> Printz was used as the test alga. Assays were conducted in triplicate using 250 ml wide mouth Erlenmeyer flasks, each flask containing 100 ml total volume of culture. Each test flask was inoculated from a 7-day old stock culture to yield a starting concentration of 1×10^3 cell/ml. All flasks were then incubated for 14 days in a Psycotherm Incubator at 24 ± 0.5 C. All flasks were continuously illuminated with cool-white fluorescent lighting of 400 ft-c (4303 lux).

RESULTS AND DISCUSSION

RESERVOIR - PHYSICAL AND CHEMICAL CHARACTERISTICS

The complete tabulation of results of physical and chemical parameters sampled at each depth at each station in Green Mountain Reservoir is given in Appendix A.

Temperature

Figures 3-5 and Appendix B show the thermal and depth profiles determined at each of the sampling tansects during the September, 1976 survey, respectively. In general, temperature gradients were similar at all stations. Surface temperatures ranged from 15-18 C (mean - ca. 16 C), while the temperatures at 15 meters (49 ft) and 30 meters (98 ft) ranged from 14 to 15.3 C and from 12 to 13 C, respectively. At 45 meters (148 ft) temperatures ranged from 9.5 to 10 C and averaged 9.8 C. During the November sampling, Green Mountain Reservoir was essentially isothermal. Surface temperatures were 7 C while temperatures at 45 meters (148 ft) were 6.5 C.

In general, these findings are in agreement with previous studies (Nelson, 1955 and 1971). Nelson (1955) reported that during 1949 and 1950, thermal stratification existed in Green Mountain Reservoir from June through August. Maximum temperature gradients, however, rarely exceeded 1.0 C per meter (2.75 F per 5 ft). Thermal conditions in the upper end of the reservoir were reported to have reflected the thermal characteristics of the incoming Blue River.

pH

During the September survey, pH values were generally uniform throughout the reservoir. Values for pH for all sampling stations at surface, mid, and bottom depths ranged from 6.5 to 7.6, 6.4 to 7.3, and 6.3 to 7.3, respectively. The mode pH at surface, mid, and bottom depths was 7.3, 7.2, and 7.1, respectively, while median pH for surface, mid, and bottom depths was 7.2, 7.0, and 6.9, respectively. During November, pH values at all stations and depths sampled were slightly higher than recorded in September.

Dissolved Oxygen Concentration

During the September survey, dissolved oxygen concentrations of surface samples (1 m depth) were similar throughout the reservoir, ranging from 6.9 to 7.6 mg/l O_2 and averaging 7.1 mg/l O_2. In general, dissolved oxygen concentrations decreased with depth at all sampling stations except along transect 6, the furthest upstream transect. Samples collected along transects 1, 2, and 3 in the downstream half of the reservoir showed lower concentrations of dissolved oxygen than did samples collected at similar depths along transects 4, 5, and 6, a condition likely indicative of the influence

Figure 3. Temperature profiles recorded at transects 1 and 2, Green Mountain Reservoir, Colorado.

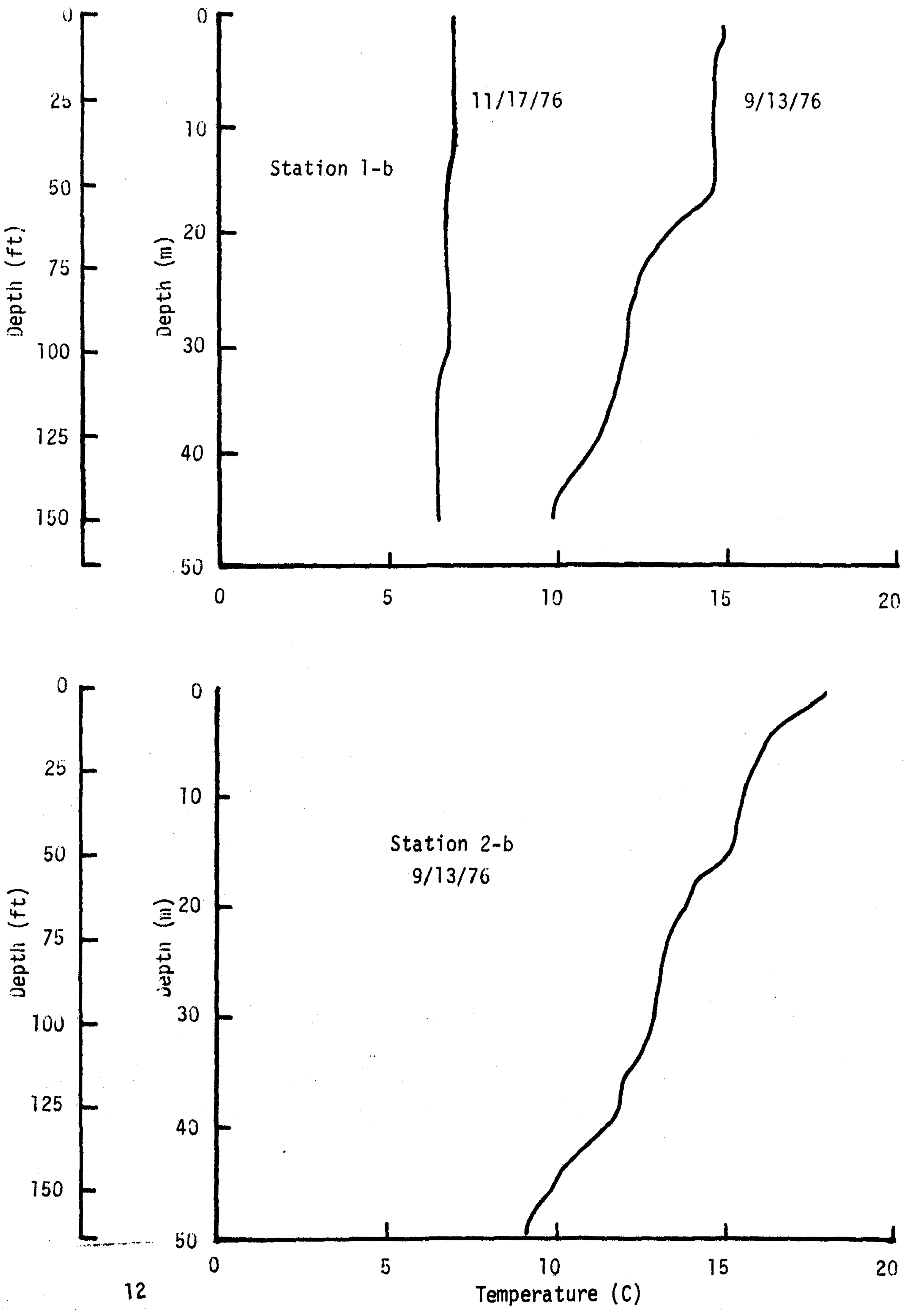


Figure 4. Temperature profiles recorded at transects 3 and 4, Green Mountain Reservoir, Colorado.

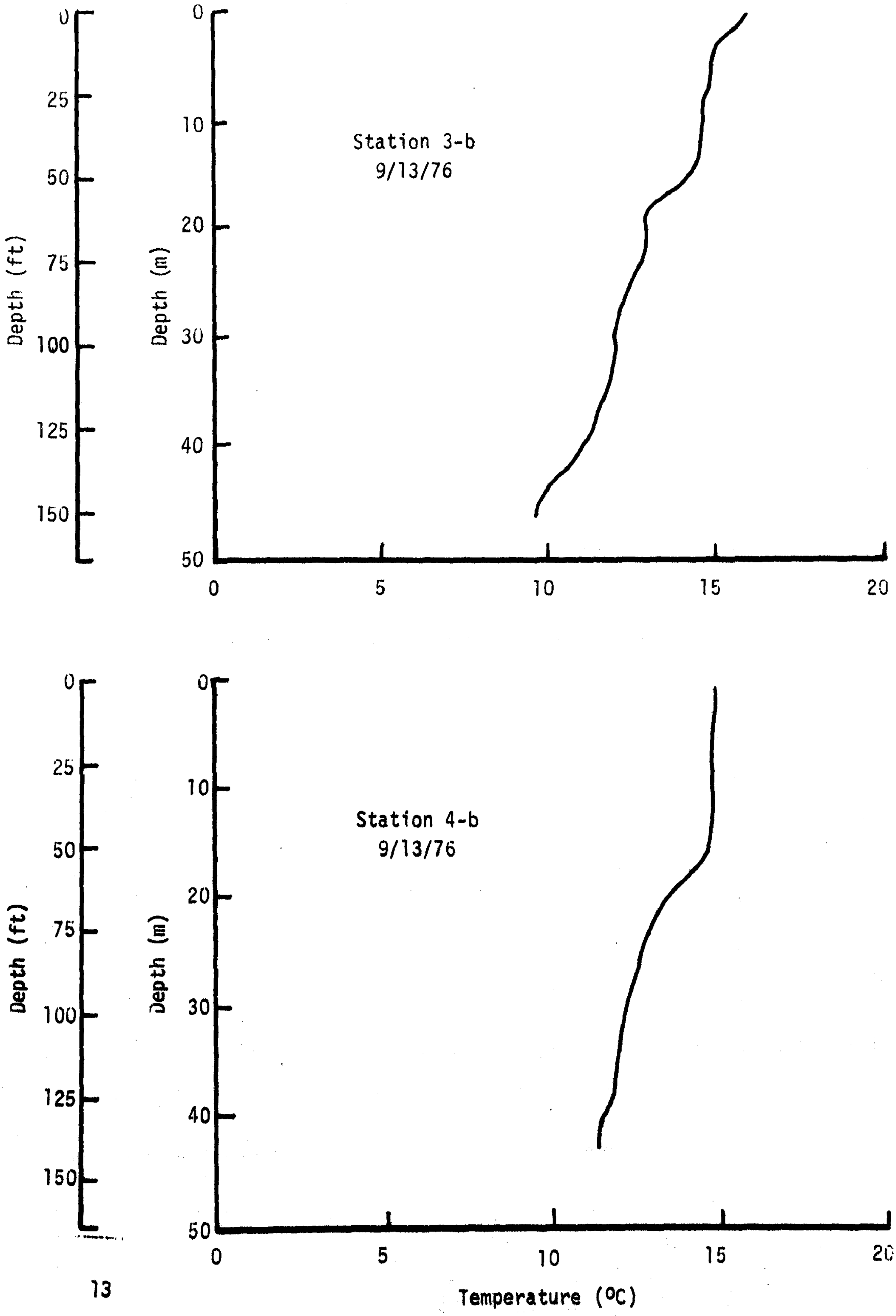
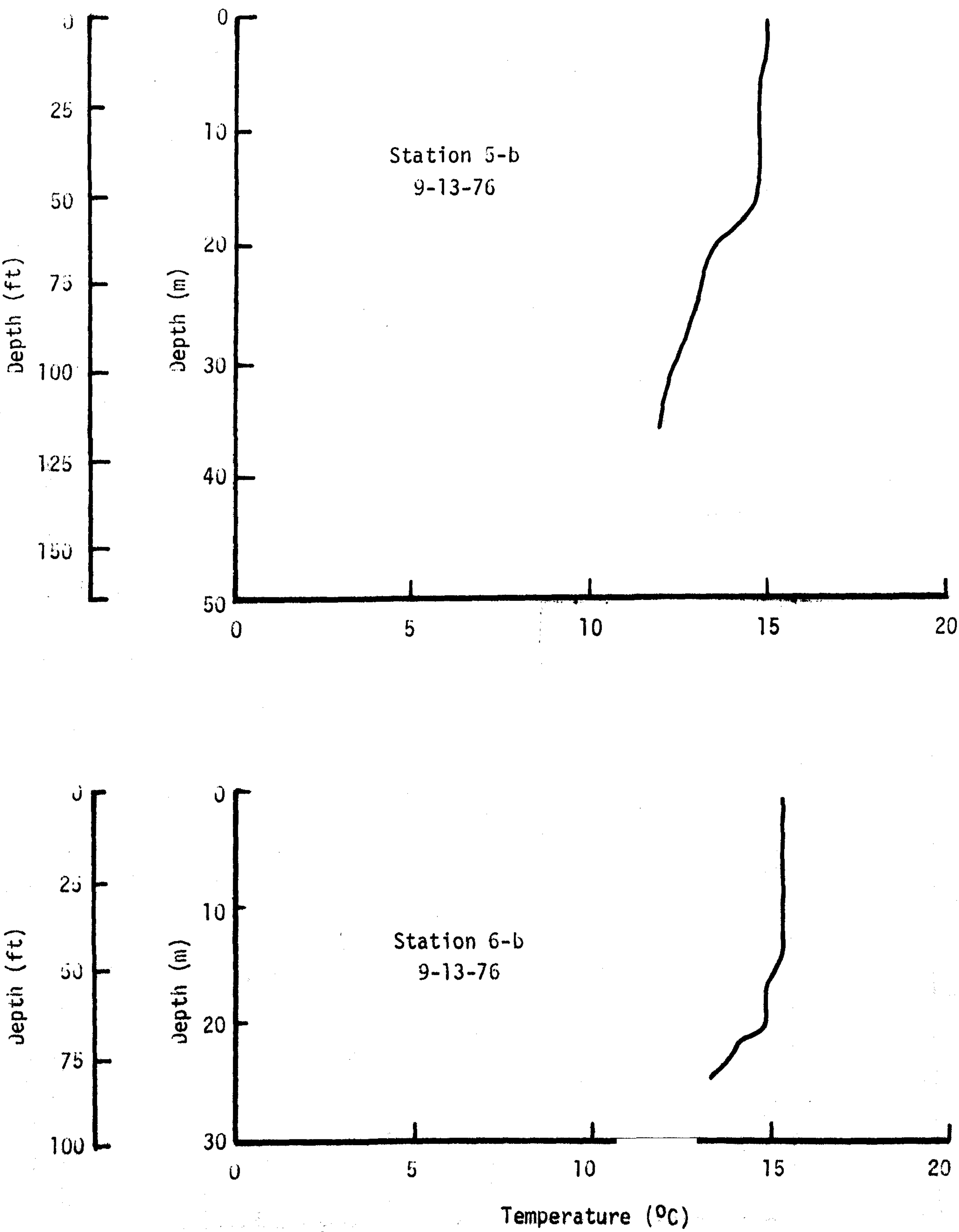


Figure 5. Temperature profiles recorded at transects 5 and 6, Green Mountain Reservoir, Colorado.



by the Blue River. The lowest dissolved oxygen levels recorded (4.0 and 4.1 mg/l) were from bottom samples at stations 1b and 2b (67 and 58 m depth, respectively).

Nutrients

Ammonia concentrations were, in general, low throughout the reservoir. The highest concentration recorded during the September survey was 0.033 mg/l, while values of less than 0.005 mg/l were reported frequently. No correlation between ammonia and depth or ammonia and station location was evident. Ammonia concentrations recorded in November were similar to those found during the September study.

Total Kjeldahl nitrogen (TKN) concentrations ranged from 0.04 to 0.38 mg/l N. The 96 samples collected were distributed accordingly: 0.00-0.10 mg/l, 24%; 0.11-0.20 mg/l, 33%; 0.21-0.30 mg/l, 30%; 0.31-0.40 mg/l, 9%; and greater than 0.41 mg/l, 3%. TKN concentrations were not correlatable to either depth or sampling station location.

Of all the nutrient parameters sampled during the September survey, nitrite plus nitrate (NO_2 + NO_3) concentration was the only one showing distint chemical stratification. At all stations sampled, NO_2 + NO_3 concentrations increased with depth. Surface concentrations ranged from less than 0.005 to 0.012 mg/l N with a median of 0.006 mg/l N, while samples collected from 16 to 40 m ranged from 0.210 to 0.142 mg/l N. The two highest NO_2 + NO_3 concentrations recorded (0.260 and 0.223 mg/l) were collected at station 2b at a depth of 58 m.

The NO_2 + NO_3 stratification observed during the September survey was not evident during November sampling. As expected, in view of the isothermal state of the reservoir in November, concentrations were similar at all depths and stations sampled, with concentrations averaging 0.055 mg/l N.

Total phosphorus and ortho-phosphorus concentrations were consistently low at all depths and stations sampled during the September survey. Ortho-phosphorus concentrations were consistently less than 0.005 mg/l P while total phosphorus concentrations were consistently less than 0.010 mg/l P. Rejecting the total phosphorus value of 0.14 mg/l P collected from station 2b at 58 m as an outlier, the highest total phosphorus value recorded was 0.024 mg/l P at station 1b at 67 m. Neither ortho-phosphorus nor total phosphorus concentrations exhibited any trends with respect to depth or station location.

Chlorophyll a

Table 2 shows the chlorophyll a concentrations of samples collected at depths of 1, 3, and 5 meters at stations 1b, 3b, and 6b. Also shown are the chlorophyll a concentrations of aliquots of the composite samples collected from the above stations during the September survey. As shown in Table 2, during the November sampling, chlorophyll a concentrations were determined only for the composite samples.

Table 2. Chlorophyll a and phaeophytin a concentration of samples collected from Green Mountain Reservoir, September and November, 1976.

Date	Station - Depth (m)	Chlorophyll a µg/l	Phaeophytin a µg/l	OD_{663} Ratio[1]
9/13-17/76	1b - composite	3.12	1.56	1.47
	1b - 1	3.56	1.42	1.50
	1b - 3	3.56	1.11	1.53
	1b - 5	4.30	-	-
	3b - composite	2.67	1.07	1.50
	3b - 1	3.12	3.43	1.33
	3b - 3	4.01	1.91	1.47
	3b - 5	3.56	0.80	1.57
	6b - composite	2.67	1.07	1.50
	6b - 1	-	-	-
	6b - 3	3.18	-	-
	6b - 5	3.56	2.67	1.40
11/17/76	1b - composite	2.14	0.11	1.67
	3b - composite	2.14	0.11	1.67
	6b - composite	2.67	0.05	1.71[2]

[1] $OD_{663} \text{ ratio} = \dfrac{OD_{663} \text{ before acidification}}{OD_{663} \text{ after acidification}}$

A solution of pure chlorophyll would yield an OD_{663} ratio of 1.70. Conversely, a solution containing phaeophytin a but no chlorophyll a would yield an OD_{663} ratio of 1.0.

[2] Theoretical maximum is 1.70. Error is likely analytical.

Algal biomass determinations based solely on chlorophyll a measurements are imprecise due to the possible fluctuation in concentration resulting from physical and nutritional conditions which do not necessarily affect the standing crop similarly. However, chlorophyll a concentrations can lend some insight into the relative amount of the standing crop. Greene, et al, (1975) showed very high correlation between chlorophyll a concentrations and maximum control yields in algal assays performed with *Selenastrum capricornutum*. Strong correlation between chlorophyll a and indigenous alga cell volumes was also reported.

During the September survey, chlorophyll a concentrations were similar at all station locations. Maximum concentrations were recorded from 3-5 meters. Chlorophyll a concentrations recorded for November composite samples were only slightly lower than values recorded for similar samples taken during September. November samples, however, did display a markedly higher OD_{633} ratio (OD = optical density).

The chlorophyll a concentrations reported from both the September and November sampling were very similar to the values reported by EPA (1975) for samples collected from Green Mountain Reservoir during October, 1975. Although sufficient data are not available for regression analyses similar to that reported by Greene, et al, (1975), the data is presented for possible use with additional data collected in the future.

C^{14}

As can be seen from Table 3, primary productivity, as measured using C^{14} methodology, was low at all sampling stations. The maximum one meter C mg/m^3/day value was recorded at station 1b (8.88) while the minimum one meter value was obtained at station 6b (4.13). On the basis of the data collected, primary productivity increased with downstream progression in the reservoir. The data, however, is obviously very limited. Additional data collected during different times of the year is needed to substantiate the possible downstream trend in productivity.

Nelson (1971) reported that Green Mountain Reservoir had the lowest primary productivity values recorded during a study of seven reservoirs associated with the Colorado-Big Thompson Project. Nelson also reported that a well defined peak of maximum productivity was not observed. The primary productivity values reported here for the September, 1976 survey were also low and did not exhibit a defined depth of maximum productivity. The values reported here, however, are consistently lower than the levels reported by Nelson (1971) for similar incubation depths. Variations between the two studies may be due, in part, to the difference in the time of year of the respective studies (i.e., September, 1976 vs. August, 1963) and/or light conditions during incubation, or both. During the September 1976 survey, illumination was less than optimal as skies were consistently overcast during at least a portion of the incubation periods. Additional samples are needed to determine maximum primary productivity during more optimal light conditions.

Table 3. Comparison of primary productivity values obtained during the September, 1976 survey with values reported by Nelson (1971) for Green Mountain Reservoir, August, 1963.

EPA (1976)					Nelson (1971)			
Date	Station	1% Illumination Depth (m)	Sample Depth (m)	C $mg/m^3/day$ 1/	Date	1% Illumination Depth (m)	Sample Depth (m)	C $mg/m^3/day$ 2/
9/16/76	1b	5.5	1.0	8.88	8/1/63	7.5	0.10	10.8
	1b		3.0	7.79			0.10	18.9
	1b		5.4	1.65			1.00	18.0
							1.50	27.0
	3b	5.0	1.0	6.15			3.00	18.0
	3b		3.0	7.83			6.00	9.0
	3b		4.5	5.16			9.00	0.9
9/17/76	3b	4.7	1.0	5.78				
	3b		2.7	4.93				
	3b		4.5	2.61				
	6b	5.0	1.0	4.13				
	6b		2.7	4.04				
	6b		4.8	1.49				

1 Primary productivity values were not converted to C $mg/m^2/day$ because the entire euphotic zone was not adequately defined by the collected samples.

2 Values shown are estimates taken from Figure 12 (Nelson, 1971).

Phytoplankton

Algal counts from aliquots of the November euphotic zone composite samples were extremely low at all stations. Individual genus counts were usually less than 10 cells per ml while total cell counts were less than 100 per ml. *Nitzschia* sp., *Asterionella formosa*, *Fragilaria crotonensis*, and *Stephanidiscus astrea* were the most abundant species. Table 4 shows the composite list of species found at stations 1b, 3b, and 6b. The very low cell counts may be a result of both time of year sampled and the dilution effect of the composite sample. The cell concentrations reported here should not be construed to be indicative of concentrations at specific depthsor during different times of the year. Future sampling should include both individual depth samples and composite samples.

Table 4. List of alga taxa recorded at stations 1b, 3b, and 6b, Green Mountain Reservoir, November, 1976.

Bacillariophyta	Chlorophyta
Achnanthes sp.	*Closterium* sp.
Asterionella formosa	*Cosmarium* sp.
Cocooneis sp.	*Crucegenia* sp.
Cymbella prostrata	*Elakatothrix viridis*
Diatoma hiemale	*Oöcystis* sp.
Fragilaria crotonensis	*Schroderia setigera*
Gomphonema sp.	
Gyrosigma sp.	
Navicula sp.	
Nitzschia sp.	
Nitzschia dissipata	
Nitzschia sigmoidea	
Pinnularia sp.	
Rhoicospenia curvata	
Stephanodiscus astrea	
Synedra sp.	
Tabellaria fenestrata	

TRIBUTARY - PHYSICAL, CHEMICAL, AND MICROBIOLOGICAL CHARACTERISTICS

The complete tabulation of results of physical, chemical, and microbiological parameters collected at each sampling station is given in Appendix C. This data has been summarized in Table 5 showing the 3-day average value for each parameter.

Table 5. Summary of water quality data collected in the lower Blue River drainage.

Parameter[1]	Units	BR-1	SC-1	WC-1	DS-STP	BR-2	RC-1	BC-1	SLC-1	BR-3	BLC-1	OC-1	CC-1	BR-4
Temp	C	7.0	8.5	10.5	12.5	10.5	9.5	10.0	9.5	8.5	10.5	9.5	10.5	12.0
pH	S.U. (median)	6.9	7.0	6.6	6.6	6.7	6.7	6.8	6.8	6.7	6.7	6.8	6.5	6.4
Flow[2]	m^3/s	4.30	0.221	0.161	0.022	4.59	0.331	0.221	0.357	6.57	0.65	0.045	0.161	18.97
Cond	µmhos/cm	170	110	70	390	180	60	60	60	150	<50	130	120	170
DO	mg/l	9.9	8.4	8.0	-	8.6	8.5	8.3	8.1	9.0	8.3	8.3	8.2	5.8
BOD_5	mg/l	<1.0	<1.0	<1.0	2.2	<1.0	1.0	<1.0	<1.0	1.0	<1.0	1.1	<1.0	<1.0
TSS	mg/l	<1.0	6.5	<1.1	7.9	<1.5	1.4	<1.1	1.7	2.1	<2.5	4.7	1.7	2.3
T-Coli	MF#/100ml (Geom Mean)	<2	284	118	949	23	23	12	43	351	193	871	37	18
F-Coli	MF#/100ml (Geom Mean)	<1	64	22	42	11	6	5	32	29	85	597	20	1
Si	mg/l	2.35	4.10	3.02	5.27	2.70	2.42	1.57	1.45	2.85	1.00	6.97	1.30	2.67
T-Mo	µg/l	165	<15	<10	60	135	10	<10	<10	100	<10	<10	<10	85
D-Mo	µg/l	165	15	<10	50	125	<10	<10	<10	100	<10	<10	<10	80
T-Fe	µg/l	40	510	130	100	100	180	200	330	160	180	1020	220	90
D-Fe	µg/l	15	125	70	15	50	90	90	170	40	60	580	150	40
T-Zn	µg/l	75	20	35	75	45	<10	15	20	65	35	15[4]	25	35
D-Zn	µg/l	35	10	10	50	30	<10	10	10	25	10	10	20	50[3]
T-Cu	µg/l	<5	<5	5	5	5	<5	<10	<10	<10	<10	5	<5	5
D-Cu	µg/l	<5	<5	<5	5	<5	5	<5	<5	<10	<5	<5	<5	10[3]
T-Coli	MPN/100ml (Geom Mean)				2027									
F-Coli	MPN/100ml (Geom Mean)				63									

1 All values are 3-day arithmetic averages unless otherwise noted.

2 See the footnotes in Table 8 for an explanation of the computation of mean flows.

3 These dissolved zinc and copper concentrations are thought to be excessive because of sample contamination.

4 This value omits one excessively high concentration of 325 µg/l measured on 9/15/76.

Flow

Flow rates measured during this study averaged slightly less than the 5-year average of the mean September flows at all sampling stations (Table 6). Tributaries to the Blue River contributed 17.3% of the total flow entering Green Mountain Reservoir while direct tributary flow to the reservoir via Black, Otter, and Cataract Creeks comprised only 11.1% of the total. During the National Eutrophication Survey (NES) of Green Mountain Reservoir in 1974-1975 (EPA, 1976b), the above tributaries contributed 20.5% and 13.7% of the total annual flow, respectively. Significant flow variations were observed during the 4-day study period, including a 51% increase in flow from Dillon Reservoir (via the Blue River) and an approximate 50% increase in tributary flow due to sporadic rainfall occurring throughout the study reach. These flow increases made it difficult to calculate representative nutrient loadings, especially since individual stations were sampled on only three out of the four sampling days. The only point discharge in the study area was the Dillon-Silverthorne STP, which discharged at a rate of 0.022 m^3/s during this study. During the September, 1975 portion of the NES study (EPA, 1976b) the STP had averaged 0.020 m^3/s (0.71 cfs). Outflow from Green Mountain Reservoir averaged 18.97 m^3/s (670 cfs) during this study, while total inflow was only 7.39 m^3/s (258 cfs).

General Parameters

Water temperatures measured during this study varied as much as 5 C depending on the time of measurement, but most streams averaged between 8.5 C and 10.5 C. The coldest water was the outflow from Dillon Reservoir (7.0 C) while the warmest water was the outflow from Green Mountain Reservoir (12.0 C).

pH measurements were consistently below 7.0, with median values ranging from 6.4 at the outflow from Green Mountain Reservoir to 7.0 in Straight Creek.

As shown in Table 5, measurements for specific conductance (conductivity) were lower in the tributary streams than in the Blue River itself. The outflow from both Dillon and Green Mountain Reservoirs averaged 170 µmhos/cm.

Mean dissolved oxygen (D.O.) measurements ranged between 8.0 and 9.0 mg/l at all stream stations except immediately below the two reservoirs. The highest mean D.O. concentration recorded was 9.9 mg/l below Dillon Reservoir (BR-1) while the lowest mean D.O. recorded was 5.8 mg/l below Green Mountain Reservoir (BR-4). This relatively low D.O. was likely due to water withdrawal from the lower depths of Green Mountain Reservoir.

Measurements for BOD_5 averaged consistently less than 1.0 mg/l in all streams except Otter Creek (1.1 mg/l). The Dillon-Silverthorne STP (DS-STP) discharge contained only 2.2 mg/l BOD_5.

Table 6. Flow comparisons in the lower Blue River drainage.

Station	Mean Flow* During 9/13-16/76 Study		Five-Year Average of the Mean Sept. Flows[1]	Mean Flows from NES Report (EPA, 1976b) Sept. 1974	Mean Flows from NES Report (EPA, 1976b) 9/74-8/75
BR-1	4.30		4.50	2.94[1]	6.40[2]
DS-STP	0.022		-	0.020	0.026
SC-1	0.215		-		
WC-1	0.161		-		
RC-1	0.348	1.276 (SC-1 to SLC-1)	0.379	0.651[4] (SC-1 to SLC-1)	Adjusted to 2.290 to balance inflow with outflow in Green Mt. Reservoir[4,5]
BC-1	0.215		0.260		
SLC-1	0.337		0.413		
BR-3	6.57		9.40[3]	5.38	9.64
BLC-1	0.629		0.631	0.210	0.862
OC-1	0.045		-	0.028	0.131
CC-1	0.147		0.244	0.059	0.537
BR-4	18.97		13.85	18.07	13.46

* All flow rates are in m^3/s.

1 From USGS Water Resource Reports for Colorado for the years 1970-1974.

2 This value represents mean annual outflow from Dillon Reservoir as stated in the NES Report (EPA, 1976a).

3 Based on data from 1970 and 1971 only.

4 These values include "minor tributaries and immediate drainage" as shown in the NES Report (EPA, 1976b).

5 This annual flow was adjusted to make total annual inflow to Green Mountain Reservoir equal to total annual outflow.

Several streams contributed concentrations of total suspended solids (TSS) in excess of concentrations measured in the mainstem Blue River. Straight Creek (6.5 mg/l) was the most notable contributor, while the DS-STP also contributed significant concentrations (7.9 mg/l).

Microbiological Parameters

The summary data in Table 5 shows that geometric mean concentrations of total coliforms in the Blue River increased from <2 per 100 ml to 351 per 100 ml in the 28 km stream reach between Dillon Dam and the upstream end of Green Mountain Reservoir. In this same reach, fecal coliforms increased from <1 per 100 ml to 29 per 100 ml. The major source of this increase (in terms of concentration) appeared to be the Dillon-Silverthorne STP (T-Coli of 949 and F-Coli of 42 per 100 ml, respectively) but several tributary streams (including Straight, Willow and Slate Creeks) also contributed significant concentrations of total and fecal coliforms. It should be pointed out that most probable number (MPN) concentrations of total and fecal coliforms in the DS-STP effluent averaged approximately 50% and 100% higher, respectively, than the membrane filter (MF) concentrations. Such a difference in results between the membrane filter (MF) and most probable number (MPN) methods of coliform analysis is not unusual since MPN results will commonly be from 10% to 40% higher than MF results, and occassionally as much as 100% higher. The largest measured source of total and fecal coliforms entering Green Mountain Reservoir directly was Otter Creek (geometric mean of 871 total and 597 fecal coliforms per 100 ml, respectively). Coliform die-off was almost complete in Green Mountain Reservoir, as evidenced by concentrations of total and fecal coliform in the outflow of only 18 and 1 per 100 ml, respectively.

Metal and Other Parameters

Average concentrations of molybdenum, iron, zinc, copper, and silica are shown in Table 5 for each sampling location. Concentrations of molybdenum and zinc tended to decrease in the stream reach from Dillon Reservoir to Green Mountain Reservoir, whereas iron (and to a slight extent, copper) concentrations increased in the downstream direction. Average concentrations of molybdenum and zinc in the tributary streams were all less than concentrations measured in the Blue River itself, whereas tributary concentrations of iron were all greater than values measured in the Blue River. Copper concentrations did not reflect any difference between tributary and mainstem sampling locations. Of the three tributary streams entering directly into Green Mountain Reservoir, Otter Creek exhibited concentrations of iron approximately 5 times greater than concentrations measured in Black Creek and Cataract Creek. There were no appreciable differences in molybdenum, zinc, and copper concentrations among these three streams. Silica concentrations in all streams were observed to vary directly with the concentrations of total suspended solids.

Table 5 shows both total and dissolved metal concentrations, and it is evident that dissolved iron and zinc averaged consistently less than total concentrations of these metals. There were no significant differences between toal and dissolved concentrations of molybdenum and copper. Sample contamination on 9/14/76 is thought to be the reason for average dissolved zinc and copper concentrations being higher than total concentrations at BR-4.

Comparison of the metals data with recommended EPA water quality criteria (EPA, 1976c) and proposed Colorado water quality standards (Colorado Department of Health, 1976) (Table 7) indicate that concentrations of total molybdenum, iron, and zinc exceeded one or more of the criteria and/or standards. The recommended criterion of 10 μg/l total molybdenum for use in crop irrigation was exceeded by a factor of 10 in the Blue River at all sampling locations between Dillon and Green Mountain Reservoirs and also in Straight Creek and the Dillon-Silverthorne STP effluent. The likely cause of molybdenum concentrations of this magnitude is the large-scale molybdenum mining operation conducted in the Ten Mile Creek drainage, which drains into Dillon Reservoir. A previous study of Dillon Reservoir (EPA, 1974) identified molybdenum concentrations in the reservoir ranging from 205 μg/l to 465 μg/l. Total iron concentrations also exceeded the proposed Colorado standard of 500 μg/l in Straight Creek (510 μg/l) and Otter Creek (1020 μg/l). Since water hardness in the lower Blue River drainage generally averages less than 100 mg/l as $CaCO_3$ (Britton, 1977), the proposed Colorado standard for total zinc would be 50 μg/l (zinc limits fluctuate with water hardness due to inter-related toxicity effects). This limit was exceeded at two mainstem Blue River locations (immediately below Dillon Reservoir - 75 μg/l, and immediately above Green Mountain Reservoir - 65 μg/l) and in the Dillon-Silverthorne STP effluent (75 μg/l). Both iron and zinc concentrations are considered to be related to natural hydrochemical stream characteristics.

Total Phosphorus Loadings

Computed total phosphorus loadings from both point and non-point sources measured during the September, 1976 survey are shown in Tables 8 and 9.

1. Point Source - The Dillon-Silverthorne STP - the only identified point discharge in the lower Blue River drainage - contributed 12.8% (0.78 kg/day or 1.72 lb/day) of the total phosphorus load entering Green Mountain Reservoir (Tables 8 and 9). This loading compares with the wasteload allocation of 1.42 kg/day (3.13 lb/day) and the average daily load of 0.89 kg/day (1.96 lb/day) determined during the year-long NES Study (EPA, 1976b). Comparison with the NES data in Table 10 shows that the DS-STP contributed a larger percentage of the total phosphorus load during this study, probably due to reduced flows (and related loads) from Dillon Reservoir and all of the tributaries.

2. Non-point Sources - Non-point sources accounted for 87.2% of the total phosphorus entering Green Mountain Reservoir during this study period. As shown in Table 9 this loading consisted of the following contributions: tributaries to the lower Blue River - 15.9%; tributaries to the reservoir itself - 18.6%; unmeasured non-point sources between Dillon and Green Mountain Reservoirs - 16.6%; and the outflow from Dillon Reservoir - 36.1%. If the Dillon

Table 7. Water quality criteria and standards.

Parameter	Units	Recommended EPA Criteria (1976c)	Proposed Colorado Standards (1976)[c]
Temperature	C	-	20
pH	S.U.	6.5-9.0	6.5-9.0
D.O.	mg/l	-	7.0
BOD_5	mg/l	-	5.0
T-Molybdenum	µg/l	10(NAS,1973)	-
D-Molybdenum	µg/l	-	-
T-Iron	µg/l	1000	500
D-Iron	µg/l	300	-
T-Zinc	µg/l	a	50[b]
D-Zinc	µg/l	-	-
T-Copper	µg/l	a	10[b]
D-Copper	µg/l	-	-
T-Coliform	MF#/100ml	-	-
F-Coliform	MF#/100ml	-	200
T-Phosphorus	mg/l as P	0.1	0.1

[a] A 96-hr LC_{50} bioassay test is recommended in order to establish a limit for the particular water body in question.

[b] Proposed standards vary according to water hardness. The limit for soft water (<100 mg/l total hardness as $CaCO_3$) is shown.

[c] The proposed Colorado standards are only preliminary values which may undergo change during future intensive public review. They are shown for comparison purposes only.

Table 8. Total phosphorus loadings in the lower Blue River drainage, Colorado.

Station	9/13/76 Flow* m^3/s	9/13/76 T-P mg/l	9/13/76 T-P kg/day	9/14/76 Flow* m^3/s	9/14/76 T-P mg/l	9/14/76 T-P kg/day	9/15/76 Flow* m^3/s	9/15/76 T-P mg/l	9/15/76 T-P kg/day	9/16/76 Flow* m^3/s	9/16/76 T-P mg/l	9/16/76 T-P kg/day	Ave. T-P Load kg/day	Percent of Total
BR-1	3.09	0.009	2.40	4.16	<0.005	<1.80	4.67	0.006	2.42	5.27	-	-	<2.20	36.1
SC-1[3]	(0.195)	0.017	0.29	0.218[1]	0.008	0.15	(0.252)	0.012	0.26	-	-	-	0.23	3.8
WC-1[3]	(0.142)	0.008	0.10	0.158[1]	<0.005	<0.07	(0.184)	0.005	0.08	-	-	-	<0.08	1.3
DS-STP	-	-	0.78[4]	0.022	0.46	0.87	0.021	0.40	0.72	0.022	0.40	0.76	0.78	12.8
BR-2[5]	(3.40)	0.008	2.35	4.58[1]	0.094[2]	37.20	-	-	-	(5.80)	0.009	4.51	-	-
RC-1	0.258	0.013	0.29	0.311	<0.005	<0.14	0.40	-	-	0.42	0.009	0.33	<0.25	<4.1
BC-1	0.204	0.011	0.20	0.204	0.005	0.09	0.221	-	-	0.252	0.098	2.13	0.14[6]	2.3
SLC-1	0.278	0.008	0.20	0.280	-	-	0.31	0.009	0.24	0.48	0.009	0.37	0.27	4.4
BR-3[5]	4.67[1]	0.008	3.23	-	-	-	(7.05)	0.009	5.48	(7.96)	0.009	6.18	4.96	-
BLC-1	0.538	0.021	0.98	0.57	-	-	0.65	0.009	0.51	0.76	0.007	0.46	0.65	10.7
OC-1[3]	-	-	-	0.040[1]	0.093	0.32	(0.045)	0.102	0.40	(0.054)	0.079	0.37	0.36	5.9
CC-1	0.105	-	-	0.136	<0.005	0.06	0.161	0.005	0.07	0.184	0.015	0.24	0.12	2.0
BR-4	19.14	-	-	19.08	0.008	13.18	19.14	0.006	9.91	18.46	<0.005	<7.97	<10.35	-
Total (BR-3, BLC-1, OC-1, CC-1)													6.09	83.4[7]

* All flows are preliminary mean daily values obtained from the USGS, unless otherwise noted.

1 Instantaneous flow measurement made by EPA.

2 The concentration of T-P at BR-2 on 9/14/76 was influenced by upstream construction activity and should not be considered a typical value.

3 In order to obtain additional flow data to supplement the single EPA flow measurement in Straight, Willow, and Otter Creeks, the average percent change in all USGS-measured tributary flows in the Blue River drainage was calculated each day and the EPA flows adjusted accordingly (as shown in parenthesis).

4 Value shown is the average of the three following days.

5 Except for the one flow measurement made by EPA at BR-2 and BR-3, flows at these stations were estimated (see figures in parenthesis) by adjusting the EPA flow in proportion to the daily change in flow observed at the upstream Blue River station (BR-1).

6 This average load omits the anomolously high value of 0.098 mg/l on 9/16/76.

7 The 16.6% of the total load not accounted for may be partly due to lack of data, but it also reflects the unmeasured non-point T-P loading occurring between Dillon and Green Mountain Reservoirs.

Table 9. Nutrient sources in the lower Blue River drainage, Colorado.

Source*	T-N Load kg/day	Percent of Total	T-P Load kg/day***	Percent of Total
Dillon Reservoir	137	56.6	2.20	36.1
Tributaries to Lower Blue River	30.5	12.6	0.97	15.9
Dillon-Silverthorne STP	17.0	7.0	0.78	12.8
Sub-total	184	-	3.95	-
Blue River at inlet to Green Mt. Reservoir	217	-	4.96	-
Difference in Blue River** Drainage Contributions	33	13.5	1.01	16.6
Direct Tributaries to Green Mt. Reservoir	25.2	10.3	1.13	18.6
Total Entering Green Mt. Reservoir	242	100.0	6.09	100.0

* This table presents only the data actually measured during this study - it does not utilize NES data (EPA, 1976b) for nutrient contributions from septic tanks or direct precipitation, nor does it consider the portion of the Dillon Reservoir nutrient load due to STP discharges within the Dillon Reservoir drainage as point loadings to the lower Blue River drainage.

** This difference may be partly due to a lack of data, but it also reflects the unmeasured non-point nutrient loading occurring between Dillon and Green Mountain Reservoirs.

*** The "less than" symbols (<) shown for average T-P loads in Table 8 are not included in this table in order to facilitate the presentation. The values as shown may be slightly higher than the actual values.

Reservoir load is omitted from the total, the total phosphorus load from non-point sources in the lower Blue River drainage comprises 51.1% of the total entering Green Mountain Reservoir. A tabulation of the total phosphorus loads originating from several of the subdrainage areas is presented in Table 10. Black Creek and Otter Creek had the highest total phosphorus export rates. It should be emphasized that the annual surface loading rates (kg $P/km^2/yr$) are based on only three days of sampling in the Fall and therefore, are representative of seasonal loads only. The values in Table 10 compare to reported annual T-P loadings from well managed pastures and forested lands of 3 to 4 kg $P/km^2/yr$ (Kilmer, undated).

Results of this study have been compared to results of the NES study (EPA, 1976b) in Table 11. It appears that the decreased flow leaving Dillon Reservoir during this study resulted in a lower percentage contribution of total phosphorus from Dillon Reservoir and therefore, higher percentage contributions from most other sources. The large outflow, 18.97 m^3/s (670 cfs), from Green Mountain Reservoir at the time of this study, in combination with a relatively small inflow, 7.39 m^3/s (261 cfs), resulted in a net loss of 3.84 kg/day (8.45 lb/day) total phosphorus out of the reservoir.

Total Nitrogen Loadings

Total nitrogen loadings from both point and non-point sources measured during the September 1976 survey are shown in Tables 9 and 12.

1. Point Sources - The only identified point discharge in the study area was the Dillon-Silverthorne STP (DS-STP) which contributed 7.0% (17.0 kg/day or 37.4 lb/day) of the total nitrogen load entering Green Mountain Reservoir during the study period (Tables 9 and 12).

2. Non-point Sources - The total nitrogen contribution from non-point sources accounted for 93% of the total nitrogen entering Green Mountain Reservoir during the study period (Table 9). Of this total, 12.6% was from tributaries to the lower Blue River (Straight, Willow, Rock, Boulder, and Slate Creeks), 13.5% was due to unidentified sources (including groundwater recharge) in the same reach of the Blue River, 10.3% was from direct tributaries to Green Mountain Reservoir (Black, Otter, and Cataract Creeks), and 56.6% was contributed by the flow from Dillon Reservoir. The actual non-point loading from the lower Blue River drainage itself (omitting the load from Dillon Reservoir) amounted to 36.4% (88.0 kg/day or 194 lb/day) of the total nitrogen entering Green Mountain Reservoir.

   A comparison of nitrogen loadings determined during this study with the loadings determined during the 1974-1975 NES study (EPA, 1976b) is presented in Table 13. For comparison purposes the loadings were tabulated in the same format, which resulted in substantial agreement in percentage contributions from the various sources. This surprisingly good correlation occurred despite the disparity in study durations - the NES study covered a one year period while the present study covered only a one week period. Due to the

Table 10. Total phosphorus export in several subdrainages in the lower Blue River drainage, Colorado.

Stream	Drainage Area[1] km^2	Ave. Flow m^3/s	Ave. T-P Conc. mg/l	kg P/km^2/yr
BR-1	868	4.30	0.007	1.09
RC-1	40.9	0.348	0.009	2.42
BR-3	1323	6.57	0.009	1.41
BLC-1	47.9	0.629	0.012	4.97
CC-1	36.3	0.147	0.008	1.02
OC-1	21.8	0.045	0.091	5.92

[1] Values were taken from EPA, 1976b and USGS, 1971.

Table 11. Comparison of total phosphorus loadings to Green Mountain Reservoir, Colorado, present and NES study.

1. Inputs Source	Present Study kg/day	Percent of Total Load: Present Study	Percent of Total Load: NES Study (EPA, 1976b)
a. Tributaries (non-point load)			
Blue River* (BR-3)	2.54	39.0	58.1
Black Cr. (BLC-1)	0.65	10.0	5.7
Otter Cr. (OC-1)	0.36	5.5	5.2
Cataract Cr. (CC-1)	0.12	1.8	3.1
b. Tributaries to Blue River (non-point load)	0.97	15.0	12.1
c. DS-STP	0.78	12.0	4.9
Indirect load from STP discharges into Dillon Reservoir drainages**	0.66	10.1	8.5
d. Septic Tanks	0.03***	0.5	0.2
e. Direct Precipitation	0.40***	6.1	2.2
Total	6.51	100.0	100.0
2. Outputs (kg/day)			
Reservoir Outlet (BR-4)	10.35		17.51
3. Net T-P accumulation (kg/day)	-3.84		+0.52

* A = B-C-D-E

where A = non-point load contributed by the Blue River itself (2.54 kg/day)
B = total load entering Green Mountain Reservoir at BR-3 (4.96 kg/day)
C = non-point load from tributaries to the Blue River (0.97 kg/day)
D = point load from DS-STP (0.78 kg/day).
E = indirect point load from STP discharges into Dillon Reservoir drainage (0.66 kg/day)

** E = F x G

where E is defined as before

F = load leaving Dillon Reservoir as measured at BR-1 (2.20 kg/day)
G = .301 = 30.1% = the percentage of T-P entering Dillon Reservoir from STP discharges(EPA, 1976b)

*** These values are the estimates shown in the NES Report (EPA, 1976b).
They are included only for the purpose of making valid comparisons between the two studies.

Table 12. *Total nitrogen loadings in the lower Blue River drainage, Colorado.*

Station	9/13/76 Flow** m^3/s	9/13/76 T-N* mg/l	9/13/76 T-N kg/day	9/14/76 Flow** m^3/s	9/14/76 T-N* mg/l	9/14/76 T-N kg/day	9/15/76 Flow** m^3/s	9/15/76 T-N* mg/l	9/15/76 T-N kg/day	9/16/76 Flow** m^3/s	9/16/76 T-N* mg/l	9/16/76 T-N kg/day	Ave. T-N Load kg/day	Percent of Total
BR-1	3.09	0.240	64	4.16	0.453	163	4.67	0.461	186	5.27	-	-	137	56.6
SC-1[3]	(0.195)	0.223	3.8	0.218[1]	0.440	8.3	(0.252)	0.434	9.4	-	-	-	7.2	3.0
WC-1[3]	(0.142)	0.063	0.8	0.158[1]	0.270	3.7	(0.184)	0.235	3.7	-	-	-	2.7	1.1
DS-STP	-	-	17.0[4]	0.022	9.80	18.4	0.021	8.44	15.3	0.022	9.02	17.2	17.0	7.0
BR-2[5]	(3.40)	0.294	86	4.58[1]	3.63[2]	1438[2]	-	-	-	(5.80)	0.468	234	-	-
RC-1	0.258	0.108	2.4	0.311	0.258	6.9	0.40	-	-	0.42	0.352	12.9	7.4	3.1
BC-1	0.204	0.228	4.0	0.204	0.236	4.2	0.221	-	-	0.252	0.338	7.3	5.2	2.1
SLC-1	0.278	0.097	2.3	0.280	-	-	0.31	0.226	6.1	0.48	0.378	15.7	8.0	3.3
BR-3[5]	4.67[1]	0.266	107	-	-	-	(7.05)	0.511	311	(7.96)	0.339	233	217	-
BLC-1	0.538	0.160	7.4	0.57	-	-	0.65	0.386	21.7	0.76	0.415	27.4	18.9	7.8
OC-1[3]	-	-	-	0.040[1]	0.622	2.1	(0.045)	0.362	1.4	(0.054)	0.476	2.2	1.9	0.8
CC-1	*0.105*	-	-	*0.136*	*0.341*	*4.0*	*0.161*	*0.403*	*5.6*	*0.184*	*0.231*	*3.7*	4.4	1.8
BR-4	19.14	-	-	19.08	0.206	339	19.14	0.324	536	18.46	0.376	600	492	-
										Total (BR-3, BLC-1, OC-1, CC-1)			242	86.6[6]

* TKN + NO_2 + NO_3

** All flows are preliminary mean daily values reported by the USGS unless otherwise noted.

1 Instantaneous flow measurement made by EPA.

2 The high concentration of T-N at BR-2 on 9/14/76 was influenced by upstream construction activity and should not be considered a typical value.

3 In order to obtain additional flow data to supplement the single EPA flow measurement in Straight, Willow and Otter Creeks, the average percent change in all USGS-measured tributary flows in the Blue River drainage was calculated each day and the EPA flows adjusted accordingly (as shown in parenthesis).

4 Value shown is the average of the three following days.

5 Except for the one flow measurement made by EPA at BR-2 and BR-3, flows at these stations were estimated (see figures in parenthesis) by adjusting the EPA flow in proportion to the daily change in flow observed at the upstream Blue River station (BR-1).

6 The 13.4% of the total load not accounted for may be partly due to lack of data, but it also reflects the unmeasured non-point T-N loading occurring between Dillon and Green Mountain Reservoirs.

Table 13. Comparison of total nitrogen loadings to Green Mountain Reservoir, Colorado, present and NES study.

1. Inputs Source		Present Study kg/day	Percent of Total Load Present Study	 NES Study(EPA, 1976b)
a. Tributaries (non-point load)				
Blue River* (BR-3)		159	59.6	59.2
Black Creek (BLC-1)		18.9	7.1	6.1
Otter Creek (OC-1)		1.9	0.7	1.2
Cataract Creek (CC-1)		4.4	1.6	3.2
b. Tributaries to Blue River (non-point load)		30.5	11.4	12.2
c. DS-STP		17.0	6.4	6.1
Indirect load from STP discharges into Dillon Reservoir drainages**		10.3	3.8	6.7
d. Septic Tanks		1.1***	0.4	0.2
e. Direct Precipitation		24.2***	9.0	5.1
	Total	267	100.0	100.0
2. Outputs (kg/day)				
Reservoir Outlet (BR-4)		492		1018
3. Net T-N accumulation (kg/day)		-225		+39.5

* A = B-C-D-E

where A = non-point load contributed by the Blue River itself (159 kg/day)
B = total load entering Green Mountain Reservoir at BR-3 (217 kg/day)
C = non-point load from tributaries to the Blue River (30.5 kg/day)
D = point load from DS-STP (17.0 kg/day)
E = Indirect point load from STP discharges into Dillon Reservoir drainage (10.3 kg/day)

** E = F x G

where E is defined as before

F = load leaving Dillon Reservoir as measured at BR-1 (137 kg/day)
G = 0.075 = 7.5% = the percentage of T-N entering Dillon Reservoir from STP discharges(EPA, 1976a)

*** These values are the estimates presented in the NES Report (EPA, 1976b). They are included only for the purpose of making comparisons between the two studies.

relatively large outflow from Green Mountain Reservoir during this study (18.97 m^3/s or 670 cfs) and the small inflow (7.39 m^3/s or 261 cfs) there was a net reduction in total nitrogen in the reservoir of 225 kg/day (496 lb/day).

ALGAL GROWTH POTENTIAL

In order to determine the nutrient limiting algal growth in Green Mountain Reservoir and to assess the possible impact of nutrient addition to the reservoir, laboratory algal assays were performed with euphotic zone composite samples.

Table 14 shows the nutrient concentrations reported for the composite samples (preserved, filtered, and autoclaved and filtered) collected from each sampling location on Green Mountain Reservoir. Increases in total soluble inorganic nitrogen after autoclaving and filtration ranged from 0.009 to 0.017 mg/l N while orthophosphate concentrations changed only slightly.

Figure 6 shows the results of the algal assay performed with autoclaved and filtered water collected from station 1b, Green Mountain Reservoir. Additions of nitrogen, singly (0.32 mg/l dry weight yield) or in combination with EDTA (0.30 mg/l dry weight yield), did not markedly increase dry weight yields from the control level (0.33 mg/l dry weight yield). Additions of phosphorus and phosphorus plus EDTA, however, resulted in significantly larger maximum dry weight yields (1.14 and 1.14 mg/l, respectively).

As can be seen from Figure 6, the largest dry weight yield occurred in the combined phosphorus and nitrogen plus EDTA spike (5.70 mg/l). The dry weight yield of the combined nitrogen and phosphorus spike without EDTA was only 1.85 mg/l. The large observed increase in dry weight with addition of EDTA may be indicative of metal toxicity or secondary micronutrient limitation. Additional algal assays would be required to determine which, if either, of the above hypotheses is correct.

An algal assay with water from station 3b was conducted simultaneously with the algal assay for station 1b. In direct contrast to the responses observed for station 1b, little or no increase in dry weight yield was observed at any of the nutrient spike levels with water from station 3b. Both assays were terminated on day 14. Due to the low dry weight yields at all nutrient spike levels, another algal assay with water from station 3b was conducted, with an assay with water from station 6b conducted simultaneously. After 14 days of incubation under test conditions, little or no increase in growth from the control level was observed for either station 3b or 6b (Figures 7 and 8, first bar of each couplet). Although cell count in the phosphorus-associated spikes had gradually increased during incubation period, the mean cell volume after the first 3-5 days of incubation had remained very low in comparison to the mean cell volumes in the other spikes (Figures 9 and 10). Micronutrient limitation was suspected. Rather than terminate the algal assays on day 14 as planned, each flask was inoculated with 1.0 mg/l of the

Table 14. Nutrient concentrations in euphotic zone composite samples - preserved, filtered only, and autoclaved and filtered, collected from Green Mountain Reservoir, stations 1b, 3b, and 6b, November, 1976.

Parameter	Preserved Only			Filtered Only			Autoclaved and Filtered		
	1b	3b	6b	1b	3b	6b	1b	3b	6b
NH_3	0.011	0.007	0.005	0.011	0.015	0.006	0.012	0.013	0.011
$NO_2 + NO_3$	0.058	0.058	0.053	0.058	0.061	0.061	0.066	0.067	0.064
TKN	0.15	0.12	0.15	0.10	0.12	0.12	0.13	0.11	0.12
TP	0.006	0.006	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
$O\text{-}PO_4$	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
$O\text{-}PO_4$*	0.001	0.001	0.004	0.001	0.001	0.002	0.003	0.003	0.003

* Actual ortho-phosphate values recorded. However, values recorded from 0.00 to 0.004 mg/l P are reported as <0.005 mg/l due to variable precision near the lower limits of detection.

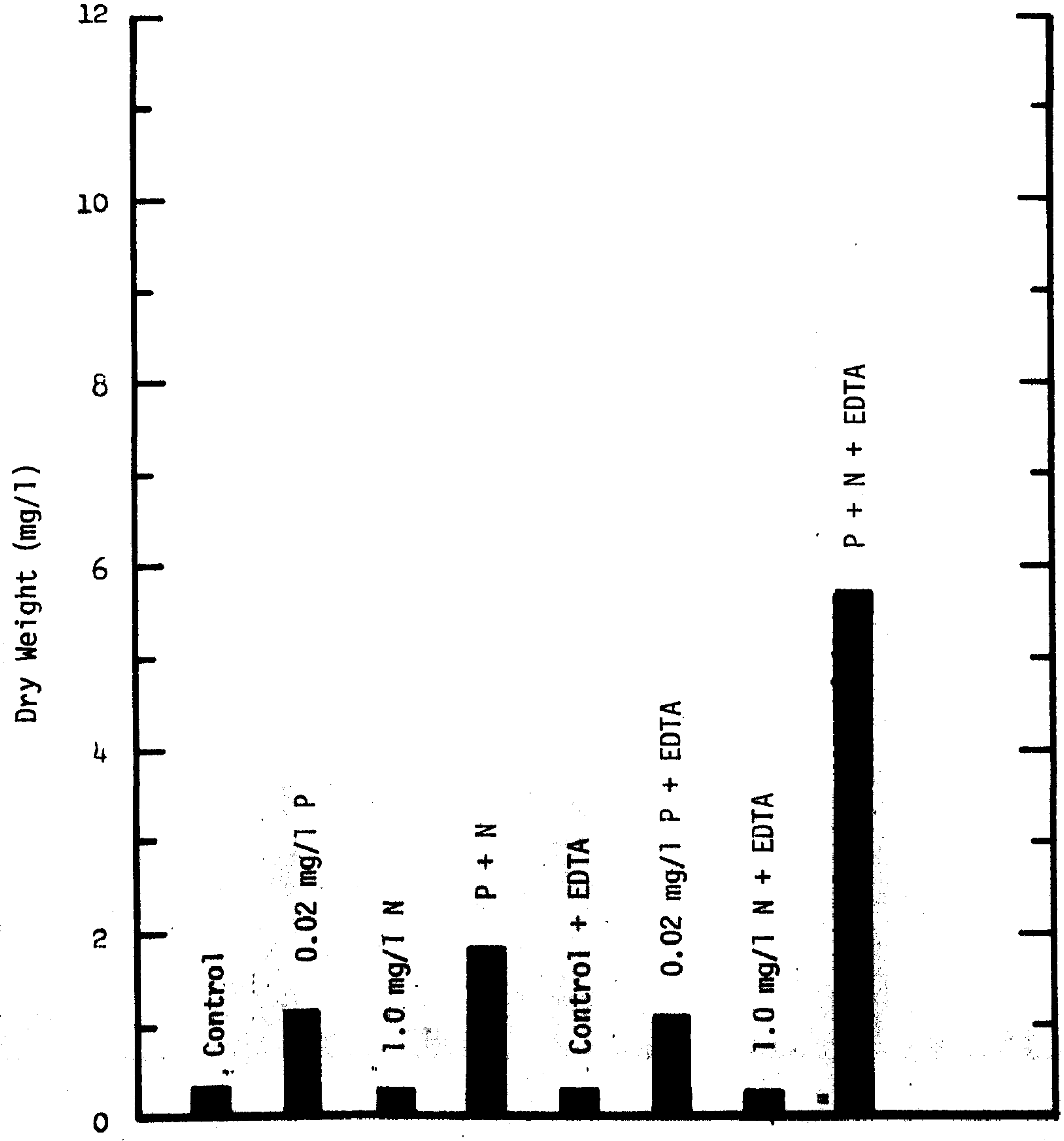


Figure 6. The effects of phosphorus, nitrogen, and phosphorus plus nitrogen, both singly and in combination with EDTA, as compared to the control samples on the growth of Selenastrum capricornutum in autoclaved and filtered water from Green Mountain Reservoir, station 1b.

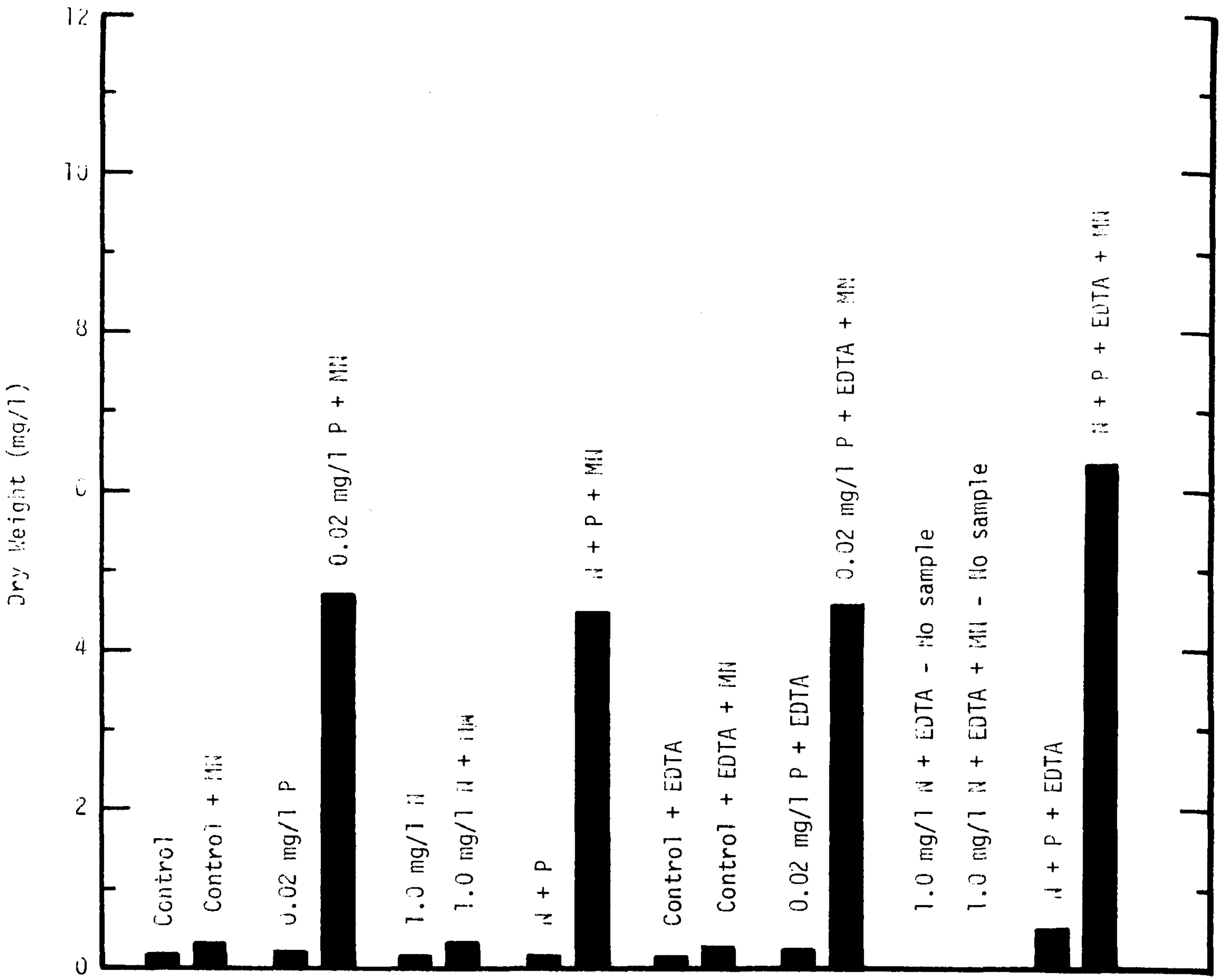


Figure 7. The effects of phosphorus, nitrogen, and phosphorus plus nitrogen, both singly and in combination with EDTA, as compared to the control samples on the growth of *Selenastrum capricornutum* in autoclaved and filtered water from Green Mountain Reservoir, station 3b. The first bar indicates dry weight yield at the end of 14 days incubation. (The second bar indicates dry weight yield after micronutrient (MN) addition on day 14 and an additional two week incubation.)

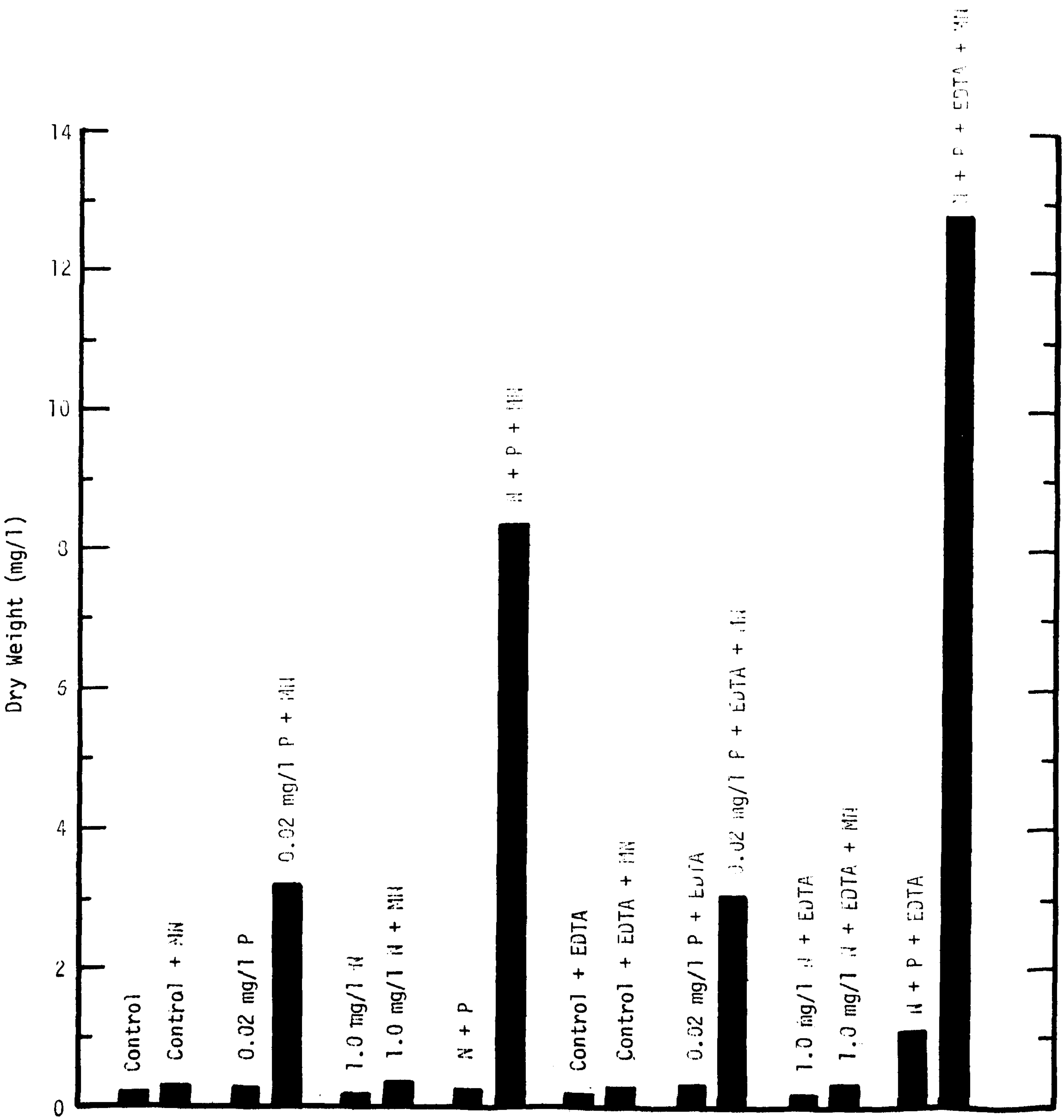


Figure 8. The effects of nitrogen, phosphorus, and phosphorus plus nitrogen, both singly and in combination with EDTA, as compared to the control samples, on the growth of Selenastrum capricornutum in autoclaved and filtered water from Green Mountain Reservoir, station 6b. (The first bar indicates dry weight yield at the end of 14 days of incubation. The second bar indicates dry weight yield after micronutrient (MN) addition on day 14 and an additional two week incubation.)

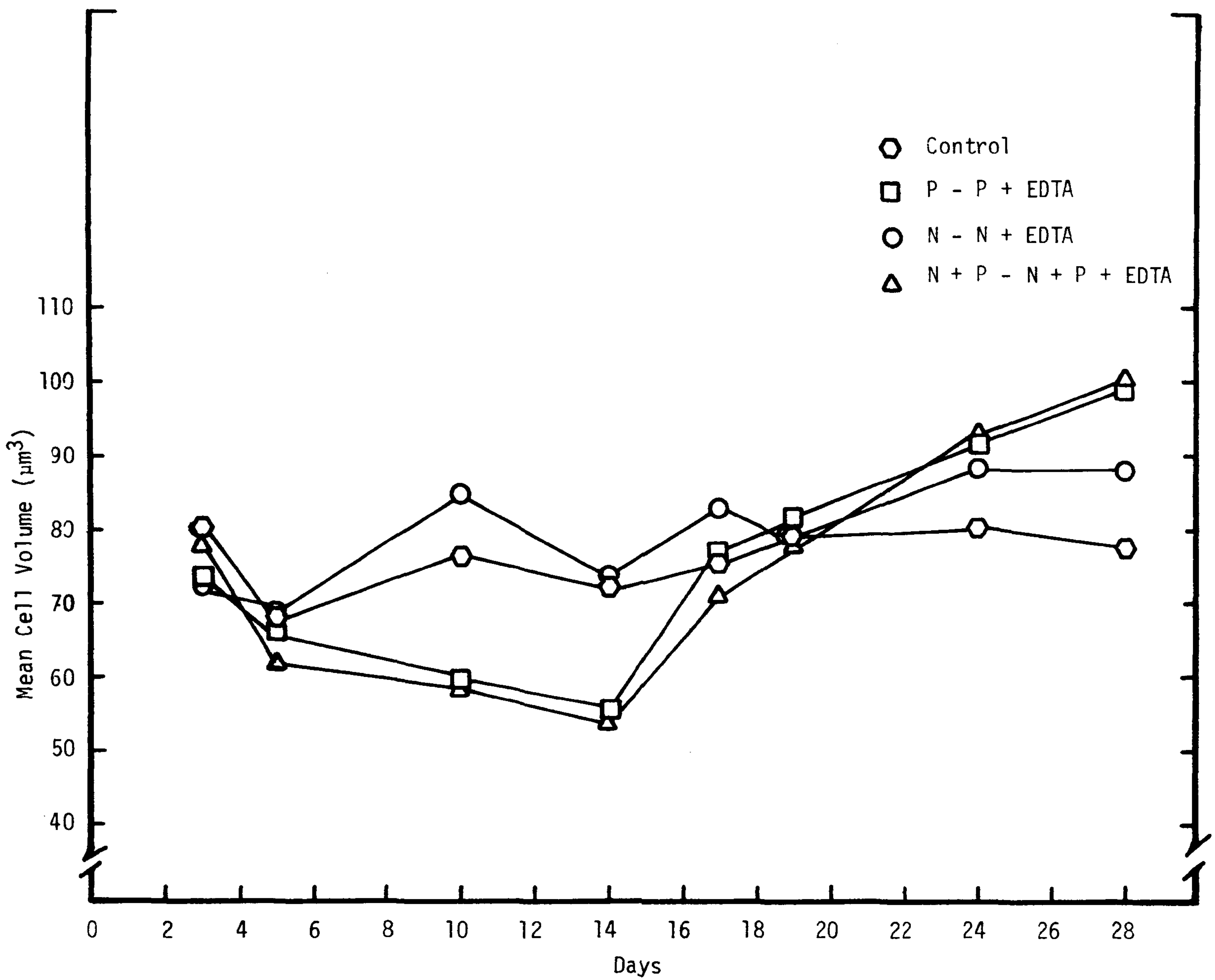


Figure 9. Changes in mean cell volume of Selenastrum capricornutum as a function of time in algal assays conducted with water from station 3b, Green Mountain Reservoir, Colorado. (Data points shown are averages of each spike levels, singly and in combination with EDTA.)

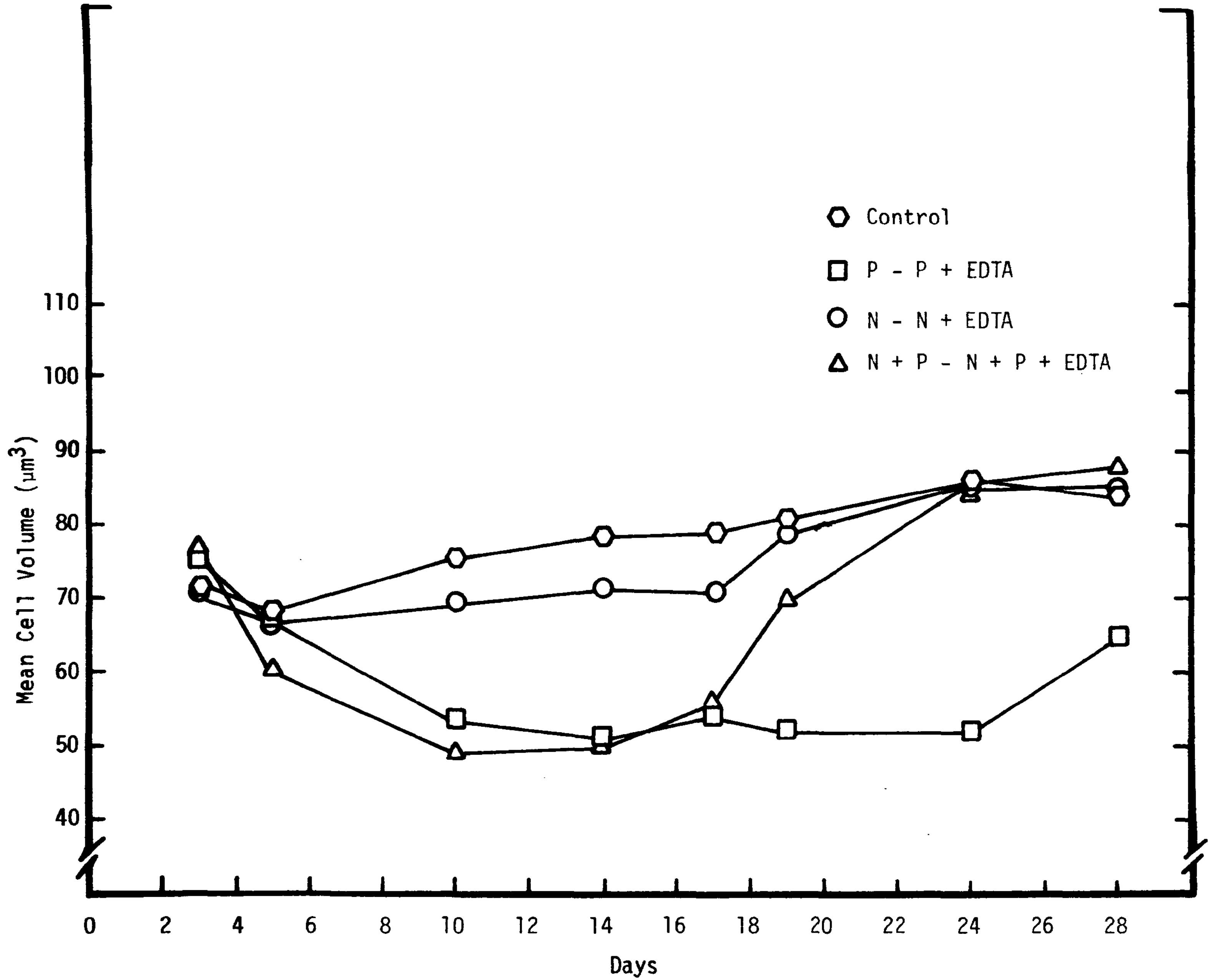


Figure 10. Changes in mean cell volume of *Selenastrum capricornutum* as a function of time in algal assays conducted with water from station 6b, Green Mountain Reservoir, Colorado. (Data points shown are averages of spike levels singly and in combination with EDTA.)

micronutrient stock solution outlined in the Algal Assay Procedure: bottle test (1971). The test flasks were then incubated for an additional 14 days with growth monitored five times during the additional incubation period. If the algal growth in the test waters was limited by micronutrient concentrations a marked increase in growth would theoretically be observed during the additional incubation period.

As can be seen in Figures 7 and 8, algal growth in the water collected from stations 3b and 6b was limited by micronutrient concentration. It is difficult to determine if the micronutrient concentration was the major limiting factor or if a dual limitation of micronutrients and phosphorus existed. Addition of micronutrients to the control and the control plus EDTA resulted in a slight increase in maximum dry weight yield. The small increase in dry weight may represent the growth response to the micronutrient addition and subsequent secondary limitation by phosphorus, or may be solely a result of the additional 14 day incubation. Regardless of whether the micronutrient concentration was the primary limiting factor or a co-limiting factor, both spikes (micronutrient and phosphorus) were required to markedly stimulate algal growth in the test water. Additions of micronutrients to those flasks previously spiked with phosphorus resulted in significant increases in dry weight yield from the levels of the controls. On day 28 of the incubation period (14 days after micronutrient addition) maximum dry weight yields in the control flasks for stations 3b and 6b were 0.33 and 0.33 mg/l, respectively, while maximum dry weight yields in the nitrogen and phosphorus plus EDTA were 6.37 and 12.77 mg/l, respectively. On the basis of the algal assay results, both micronutrient and phosphorus concentrations were limiting algal growth potential at stations 3b and 6b at the time of sampling.

In summary, phosphorus significantly limited potential algal growth at all stations at the time of sampling. In addition, micronutrient concentration also limited algal growth in water collected at stations 3b and 6b. Table 15 shows the t-values for a two-tailed student's t-test of the hypothesis of equal dry weight yields at various spike levels.

After extensive research using S. capricornutum cultured in algal assay media (AAM), Shiroyama, Miller, and Greene (1975) reported that maximum dry weight yields of *Selenastrum capricornutum* could be predicted if the concentrations of nitrogen and phosphorus are known, all other essential nutrients are present, and toxicants are absent. Water containing greater than 0.010 mg/l ortho-P can yield 0.43 mg/l dry weight of test alga per 0.001 mg/l phosphorus while 0.001 mg/l TSIN (total soluble inorganic nitrogen) can yield 0.038 mg/l dry weight of the test alga. In water containing greater than 0.000 mg/l but less than 0.010 mg/l ortho-P, dry weight yields per 0.001 mg/l phosphorus addition will range from 0.1 - 0.43 mg/l (personal communication - William Miller, NERC, Corvallis, Oregon).

Table 16 shows both the actual dry weight yield and the yields predicted on the basis of the reported nutrient concentrations. Although maximum dry weight yields for the phosphorus and phosphorus plus nitrogen were

Table 15. Two sample two-tailed student's t-test of dry weight yields at different nutrient spike levels in water collected from stations 1b, 3b, and 6b, Green Mountain Reservoir, Colorado.

1b	Control	0.02 P	1.0 N	N + P	EDTA + Control	EDTA + 0.02 P	EDTA + 1.0 N	EDTA + N + P
Control		33.56*	0.73	31.10*	1.11	58.45*	2.57	42.95*
0.02 P	33.56*		40.28	13.96*	35.43*	0.16	41.59*	36.24*
1.0 N	0.73	40.28*		32.46*	0.80	172.53*	5.66*	43.26*
N + P	31.10*	13.96*	32.46*		31.73*	15.20*	33.02*	28.96*
EDTA + Control	1.11	35.43	0.80	31.73		66.01	1.34	43.16
EDTA + 0.02 P	58.45*	0.16	172.53*	15.20*	66.01*		178.19*	36.72*
EDTA + 1.0 N	2.57	41.59	5.66	33.02	1.34	178.19		43.48
EDTA + N + P	42.95*	36.24*	43.26*	28.96*	43.16*	36.72*	43.48*	

3b	Control	0.02 P	1.0 N	N + P	EDTA + Control	EDTA + 0.02 P	EDTA + 1.0 N	EDTA + N + P
Control		27.16*	2.41	20.35*	0.21	64.65*	No Sample	13.70*
0.02 P	27.16*		27.41*	1.21	27.16*	0.97		3.09
1.0 N	2.41	27.41*		20.56*	2.80	65.06*		13.80*
N + P	20.35*	1.21	20.56*		20.35*	0.67		3.66
EDTA + Control	0.21	27.16*	2.80	20.35*		64.93*		13.70*
EDTA + 0.02 P	64.65*	0.97	65.06*	64.93*				3.57
EDTA + 1.0 N	No Sample							
EDTA + N + P	13.70*	3.00	13.80*	3.66	13.70*	3.67		

6b	Control	0.02 P	1.0 N	N + P	EDTA + Control	EDTA + 0.02 P	EDTA + 1.0 N	EDTA + N + P
Control		4.10**	2.29	75.69*	1.34	13.29*	3.25	14.28*
0.02 P	4.10**		4.04**	7.70*	4.08**	0.07	4.03**	7.94*
1.0 N	2.29	4.40**		74.81*	1.79	13.06*	0.36	14.23*
N + P	75.69*	7.70	74.81*		75.71*	23.04*	75.00*	3.65
EDTA + Control	1.34	4.08**	1.79	75.71*		13.24*	2.77	14.27*
EDTA + 0.02 P	13.29*	0.07	13.06*	23.04*	13.24*		13.06*	10.32*
EDTA + 1.0 N	3.25	4.03**	0.36	75.00*	2.77	13.06*		14.22*
EDTA + N + P	14.28*	7.94*	14.23*	3.65	14.27*	10.32*	14.22*	

* Significant at $\alpha = 0.01$

** Significant at $\alpha = 0.02$

$H_0: \mu_0 = \mu_1$

$H_a: \mu_0 \neq \mu_1$

where:

μ_0 = any nutrient spike level

μ_1 = any nutrient spike level other than μ_0

Table 16. Comparison of actual vs. theoretical dry weight yields of <u>Selenastrum capricornutum</u> in algal assays performed with water collected from Green Mountain Reservoir, November, 1976.

Station	Day	Actual and Theoretical Dry Weight Yields in mg/l[1]							
		Control	0.02 P	1.0 N	N + P	EDTA + Control	EDTA + 0.02 P	EDTA + 1.0 N	EDTA + N + P
1b	14	0.33(0.30-1.29)	1.14(2.96)	0.32(0.30-1.29)	1.85(9.89)	0.31(0.30-1.29)	1.14(2.96)	0.30(0.30-1.29)	5.70(9.89)
3b	14	0.17(0.30-1.29)	0.19(3.04)	0.17(0.30-1.29)	0.18(9.89)	0.18(0.30-1.29)	0.26(3.04)	No Sample	0.55(9.89)
	28	0.33(0.30-1.29)	4.76(3.04)	0.28(0.30-1.29)	4.45(9.89)	0.33(0.30-1.29)	4.59(3.04)	No Sample	6.18(9.89)
6b	14	0.23(0.30-1.29)	0.34(2.85)	0.20(0.30-1.29)	0.31(9.89)	0.21(0.30-1.29)	0.36(2.85)	0.21(0.30-1.29)	7.09(9.89)
	28	0.33(0.30-1.29)	3.13(2.85)	0.36(0.30-1.29)	8.46(9.89)	0.34(0.30-1.29)	3.08(2.85)	0.37(0.30-1.29)	11.29(9.89)

[1] The first number in each grouping is the actual dry weight yield. Those numbers enclosed with parentheses are the theoretical yields based on the reported available nutrients.

significantly greater than the control, the actual dry weight yields of S. capricornutum in test water from station 1b were less than the predicted yields. In view of the growth response after micronutrient addition to samples from station 2b and 6b, however, it is felt that the difference between actual and theoretical yield for station 1b is likely due to secondary micronutrient limitation.

Dry weight yields for station 3b, after micronutrient addition and an additional 14 day incubation period were, in general, similar to the predicted values. However, dry weight yields for the phosphorus spikes, both singly and in combination with EDTA, were consistently higher than the predicted levels, possibly indicative of a TSIN concentration higher than reported. Also, yields from nitrogen plus phosphorus addition, both singly and in combination with EDTA, did not reach the predicted level, a condition indicative of secondary limitation other than phosphorus, nitrogen, or micronutrient concentration. As stated previously, algal growth in test water from station 3b was primarily limited by phosphorus and micronutrient concentration at the time of sampling.

Dry weight yields for station 6b were very similar to the predicted values. Both actual and predicted dry weight yields indicated strong phosphorus limitation. As previously mentioned, station 6b was also micronutrient limited.

Miller, Maloney, and Greene (1974) defined four productivity groups based on dry weight yields in the control samples of algal assay conducted for 49 lakes; (1) low productivity- 0.00-0.10 mg dry wt. per liter, (2) moderate productivity- 0.11-0.80 mg dry wt. per liter, (3) moderately high productivity- 0.81-6.00 mg dry wt. per liter, and (4) high productivity- 6.10-20.00 mg dry wt. per liter. As reported by the above authors, the productivity values reported reflect only the nutrient content of the water sample at the time of assay and not the entire body of water. The above productivity groupings do, however, allow for comparison of algal assay results from different bodies of water. On the basis of the dry weight yields in the control samples for stations 1b, 3b, and 6b in Green Mountain Reservoir, potential primary productivity was moderate at all stations sampled.

Phosphorus limitation of potential algal growth at all sampling stations is further substantiated by the corresponding N:P ratios reported (TSIN:$O\text{-}PO_4$). Theoretically, water exhibiting a N:P ratio greater than 11.3:1 (38/430) would likely be phosphorus limited, while waters containing a N:P ratio less than 11.3:1 would be nitrogen limited (Shiroyama, et al, 1975; Greene, Soltero, Miller, Gasperino, and Shiroyama, 1975). The N:P ratios of the preserved lake water composite samples from stations 1b, 3b, and 6b (using recorded values of $O\text{-}PO_4$) were 69:1, 65:1, and 14.5:1, respectively. When the reported values (i.e., >0.005 mg/l P) rather than the recorded values of ortho-phosphate are used in computation (Table 14) the N:P ratio still indicate phosphorus limitation at all stations (14:1, 13:1, and 12:1 for stations 1b, 3b, and 6b, respectively).

As can be seen above, N:P ratios are a useful tool in determining the nutrient limiting algal growth in a body of water. However, limiting nutrient assessment based solely on N:P ratios may be of questionable value. In waters of low nutrient content, the N:P ratio may vary greatly with minor changes in reported nutrient concentrations due solely to analytical precision of nutrient analysis (i.e. TSIN = 0.040 mg/l N, O-PO_4 = 0.002 mg/l P, N:P = 20:1 = phosphorus limitation; TSIN - 0.040 mg/l N, O-PO_4 = 0.004 mg/l P, N:P = 10:1 = possible nitrogen limitation). For waters of low nutrient content, N:P ratios must be used in conjunction with other supportive data (i.e. algal assays). Also, N:P ratios obviously do not reflect the possible algal growth potential limitation by factors other than nitrogen or phosphorus.

The results of the algal assays reported here are in agreement with the findings of the Environmental Protection Agency's National Eutrophication Survey (NES) study (EPA, 1976b). Using a depth integrated sample composited from three sampling locations on Green Mountain Reservoir, NES reported that phosphorus was the primary limiting nutrient. The NES report did not mention any possible nutrient limitation other than phosphorus. Secondary micronutrient limitation, however, may have been present,as reported dry weight yields for all spike levels are less than predicted on the basis of the reported nutrient concentrations. The exact reason for the smaller dry weight yields, however, can not be stated on the basis of the available information.

REFERENCES

American Public Health Association. 1975. Standard method for the examination of water and wastewater. 14th ed. A.P.H.A. 1193 pp.

Britton, L.J. 1977. A water quality inventory of surface waters in Eagle, Grand, Jackson, Pitkin, Routt, and Summit Counties, Colorado. U.S. Geological Survey, in cooperation with the Northwest Colorado Council of Governments. (In press.)

Bureau of Reclamation. 1957. Colorado Big Thompson Project. Technical record of design and construction. Vol I. U.S. Gov't. Printing Office, Wash., D.C.

Colorado Dept. of Health. August, 1976. Proposed water quality standards for Colorado. Water Quality Control Commission, Denver, Colorado.

Environmental Protection Agency. 1971. Algal assay procedure: bottle test. Nat'l. Eutrophication Research Program, Corvallis, Oregon. 82 pp.

__________________ 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. Cincinnati, Ohio. EPA-670/4-73-001.

__________________ 1974. Dillon Reservoir - Blue River Study. U.S. EPA, Denver, Colorado. S&A/TIB-28.

__________________ 1976a. Preliminary report on Dillon Reservoir, 1974-1975, National Eutrophication Survey. U.S. EPA, Corvallis, Oregon.

__________________ 1976b. Preliminary report on Green Mountain Reservoir, 1974-1975, National Eutrophication Survey. U.S. EPA, Wash., D.C.

__________________ 1976c. Quality criteria for water. U.S. EPA, Wash., D.C.

Greene, J.C., R.A. Soltero, W.E. Miller, A.F. Gasperino, and T. Shiroyama. 1975. The relationship of laboratory algal assays to measurements of indigenous phytoplankton in Long Lake, Washington. Proc. biostimulation and nutrient assessment. September 10-12, 1975. Utah State University, Logan, Utah. PRWG 168-1.

Hook, R.K. 1974. Water quality management plan, Blue River hydrologic basin. R. Keith Hook and Associates, Colorado Springs, Colorado.

Kilmer, V.J. (Undated manuscript.) Nutrient losses through leaching and runoff. Tennessee Valley Authority. Muscle Shoals, Alabama, as referenced by McElroy, et al, 1976. Loading functions for assessment of water pollution from nonpoint sources. EPA-600/2-76-151. Wash., D.C.

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

National Academy of Sciences - National Academy of Engineering. 1973. Water quality critiera, 1972. EPA-R3-73-033. Wash., D.C.

Nelson, W.C. 1955. Green Mountain Reservoir studies, 1949-1950. Colorado Department of Game and Fish. Ft. Collins, Colorado.

__________ 1971. Comparative limnology of Colorado - Big Thompson Project reservoirs and lakes. Colorado Game, Fish & Parks Dept. F-25-R-1 to 4. Ft. Collins, Colorado.

Patrick, R. and C.W. Reimer. 1966. The diatoms of the United States, Vol. I. Acad. Natural Sci., Philadelphia, Penn. 688 pp.

Schwoerbel, J. 1970. Methods of hydrobiology (freshwater biology). Pergamon Press, New York, N.Y. 200 pp.

Shiroyama, T., W.E. Miller, and J.C. Greene. 1975. The effects of nitrogen and phosphorus on the growth of Selenastrum capricornutum Printz. Proc. biostimulation - nutrient assessment workshop, October 16-18, 1973. U.S. EPA, Corvallis, Oregon. EPA-606/3-75-034.

Smith, G.M. 1950. The fresh-water algae of the United States. McGraw-Hill Publishing Col, New York, N.Y. 719 pp.

Vollenweider, R.A. 1969. A manual on methods for measuring primary production in aquatic environments. Int'l Biol. Programme Handb. 12, Oxford and Edinburgh, Blackwell Sci. Pub. 213 pp.

Ward, H.B. and G.C. Whipple. 1959. Freshwater biology. John Wiley and Sons, Inc. New York - London. 1248 pp.

Weber, C.I. 1971. A guide to the common diatoms at water pollution surveillance system stations. Environmental Protection Agency. Nat'l. Environmental Research Center, Cincinnati, Ohio. 101 pp.

APPENDIX A

CHEMICAL DATA - GREEN MOUNTAIN RESERVOIR

Station: 1-a Transect 1, South 1/4 point

Date	Mo/Day/Yr	9/13/76	9/15/76	9/13/76	9/15/76	9/13/76	9/15/76
Time	Mtly	1400	1735	1455	1732	1350	1730
Depth	Meters	1	1	20	20	27	27
Temperature	Cent.	14.5	13.5	12.5	12.0	12.0	11.5
pH	SU	6.8	7.4	6.6	7.2	6.7	7.3
DO	mg/ℓ	7.6	7.1	5.0	5.2	5.6	5.2
Conductivity	μmhos/cm	170	170	165	170	165	170
NH_3 - N	mg/ℓ	0.005	0.007	0.009	<0.005	0.005	<0.005
TKN - N	mg/ℓ	0.13	0.14	0.16	0.10	0.06	0.12
$NO_2 + NO_3$ - N	mg/ℓ	<0.005	<0.005	0.100	0.097	0.102	0.101
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total - P	mg/ℓ	<0.005	0.009	<0.005*	<0.005	0.007	0.005

* Average of duplicate analyses

Station: 1-b Transect 1, Mid-channel

Date	Mo/Day/Yr	9/13/76	9/15/76	9/13/76	9/15/76	9/13/76	9/15/76
Time	Mtly	1330	1710	1320	1705	1310	1700
Depth	Meters	1	1	20	20	67	64
Temperature	Cent.	14.5	13.5	13.0	12.0	8.5	8.0
pH	SU	6.55	7.4	6.4	7.1	6.3	7.1
DO	mg/ℓ	7.2	7.1	5.0	5.6	4.0	4.25
Conductivity	µmhos/cm	165	165	165	170	190	180
NH_3 - N	mg/ℓ	<0.005	<0.005	<0.005	<0.005	0.011	0.018
TKN - N	mg/ℓ	0.12	0.12	0.13	0.38	0.16	0.12
NO_2 + NO_3 - N	mg/ℓ	<0.005*	<0.005	0.099	0.078	0.199	0.093
Ortho - P	mg/ℓ	0.010*	<0.005	<0.005	<0.005	0.017	0.010
Total - P	mg/ℓ	0.014*	0.006	0.006	<0.005	0.024	0.016

* Average of duplicate analyses

Station: 1-b Transect 1, Mid-channel (continued)

Date	Mo/Day/Yr	11/17/76	11/17/76	11/17/76
Time	Mtly	1000	1020	1040
Depth	Meters	1	12	33
Temperature	Cent.	7.0	7.0	6.5
pH	SU	8.2	8.2	7.7
DO	mg/ℓ	8.6	8.4	8.5
Conductivity	μmhos/cm	165	175	175
NH_3 - N	mg/ℓ	<0.005	0.005	0.008
TKN - N	mg/ℓ	0.11	0.12	0.20
NO_2 + NO_3 - N	mg/ℓ	0.034	0.061	0.057
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.005	0.007	0.008

Station: 1-c Transect 1, North 1/4 point

Date	Mo/Day/Yr	9/13/76	9/15/76	9/13/76	9/15/76	9/13/76	9/15/76
Time	Mtly	1420	1718	1418	1720	1415	1715
Depth	Meters	1	1	20	20	27	27
Temperature	Cent.	14.5	13.5	12.0	12.0	11.5	11.5
pH	SU	6.9	7.3	6.8	7.25	6.7	7.2
DO	mg/ℓ	7.6	7.2	5.1	5.4	5.3	5.4
Conductivity	μmhos/cm	165	165	170	170	170	170
NH_3 - N	mg/ℓ	0.006	<0.005	<0.005	0.033	0.006	<0.005
TKN - N	mg/ℓ	0.08	0.20	0.22	0.07	-	0.10
NO_2 + NO_3 -N	mg/ℓ	0.005	<0.005	0.100	0.090	0.099	<0.005
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.006	0.008*	<0.005	0.005	<0.005	0.006*

* Average of duplicate analyses

Station: 2-a   Transect 2, South 1/4 point

Date	Mo/Day/Yr	9/13/76	9/17/76	9/13/76	9/17/76	9/13/76	9/17/76
Time	Mtly	1555	1255	1550	1253	1545	1250
Depth	Meters	1	1	17	17	30	30
Temperature	Cent.	15.0	14.5	12.5	13.5	11.0	12.0
pH	SU	7.0	7.3	6.8	7.2	6.8	7.2
DO	mg/ℓ	7.4	7.2	5.3	6.1	5.5	5.2
Conductivity	μmhos/cm	170	160	170	160	175	165
NH_3 - N	mg/ℓ	0.008	0.005	<0.005	0.006	0.009	<0.005
TKN - N	mg/ℓ	0.05	0.16*	0.09	0.66	0.04	0.24
NO_2 + NO_3 - N	mg/ℓ	<0.005	0.006	0.095	0.054	0.110	0.124*
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005*
Total - P	mg/ℓ	<0.005	0.009	<0.005	0.005	<0.005	<0.005*

* Average of duplicate analyses

Station: 2-b Transect 2, Mid-channel

Date	Mo/Day/Yr	9/13/76	9/17/76	9/13/76	9/17/76	9/13/76	9/17/76
Time	Mtly	1540	1230	1535	1225	1530	1220
Depth	Meters	1	1	17	17	58	58
Temperature	Cent.	15.0	14.5	12.5	13.0	8.5	9.0
pH	SU	6.85	7.1	6.6	6.9	6.6	6.9
DO	mg/ℓ	7.5	7.2	5.3	6.1	4.1	4.2
Conductivity	μmhos/cm	170	165	170	160	180	180
NH_3 - N	mg/ℓ	<0.005	<0.005	<0.005	-	0.014	0.006
TKN - N	mg/ℓ	0.17	0.22*	0.06	-	0.09	0.21
NO_2 + NO_3 - N	mg/ℓ	<0.005	0.006	0.087	-	0.223	0.260
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	-	0.011	0.010
Total - P	mg/ℓ	0.005	0.007	0.007	-	0.14*	0.014

* Average of duplicate analyses

Station: 2-c Transect 2, North 1/4 point

Date	Mo/Day/Yr	9/13/76	9/17/76	9/13/76	9/17/76	9/13/76	9/17/76
Time	Mtly	1610	1241	No Sample - Too Shallow	No Sample - Too Shallow	1605	1237
Depth	Meters	1	1			14	12
Temperature	Cent.	15.0	14.5			14.0	14.0
pH	SU	7.3	7.1			7.1	7.3
DO	mg/ℓ	7.5	7.1			7.6	6.8
Conductivity	μmhos/cm	170	160			170	165
NH_3 - N	mg/ℓ	<0.005	0.008			<0.005	<0.005
TKN - N	mg/ℓ	0.28	0.24*			0.36	0.17
NO_2 + NO_3 - N	mg/ℓ	<0.005	0.005			<0.005	0.007
Ortho - P	mg/ℓ	0.005	<0.005			<0.005	<0.005
Total - P	mg/ℓ	0.006	0.008			0.007	0.010

* Average of duplicate analyses

Station: 3-a   Transect 3, South 1/4 point

Date	Mo/Day/Yr	9/13/76	9/16/76	9/13/76	9/16/76	9/13/76	9/16/76
Time	Mtly	1705	1012	1700	1010	1655	1005
Depth	Meters	1	1	17	17	26	26
Temperature	Cent.	15.0	13.0	12.5	12.5	12.5	11.5
pH	SU	7.35	7.5	7.2	7.1	7.2	7.1
DO	mg/ℓ	7.5	7.1	5.3	5.7	5.5	5.4
Conductivity	µmhos/cm	170	170	175	170	170	170
NH_3 - N	mg/ℓ	<0.005	0.014	<0.005	<0.005	<0.005	<0.005
TKN - N	mg/ℓ	0.31	0.27	0.26	0.30	0.06	0.34
NO_2 + NO_3 - N	mg/ℓ	<0.005	0.008	0.087	0.075	0.009	0.105
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.007	0.008	0.005	<0.005	<0.005	<0.005

Station: 3-b Transect 3, Mid-channel

Date	Mo/Day/Yr	9/13/76	9/16/76	9/13/76	9/16/76	9/13/76	9/16/76
Time	Mtly	1650	0940	1645	0955	1640	0950
Depth	Meters	1	1	17	17	50	50
Temperature	Cent.	15.0	12.5	13.0	12.0	9.0	8.5
pH	SU	7.25	6.5	7.2	6.7	7.2	6.5
DO	mg/ℓ	7.3	7.1	5.7	5.7	4.5	4.65
Conductivity	μmhos/cm	170	165	170	170	180	180
NH_3 - N	mg/ℓ	<0.005	0.009	0.008	<0.005	<0.005	<0.005
TKN - N	mg/ℓ	0.18	0.41	0.05	0.26*	0.04	0.15
NO_2 + NO_3 - N	mg/ℓ	<0.005	0.009	0.072	0.081	0.194	0.210
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	0.006	0.008
Total - P	mg/ℓ	<0.005	0.009	<0.005	0.005	0.009	0.015

* Average of duplicate analyses

Station: 3-b Transect 3, Mid-channel (continued)

Date	Mo/Day/Yr	11/17/76	11/17/76	11/17/76
Time	Mtly	1115	1135	1155
Depth	Meters	1	12	39
Temperature	Cent.	7.0	7.0	6.75
pH	SU	7.7	7.4	7.9
DO	mg/ℓ	8.7	8.45	8.4
Conductivity	μmhos/cm	200	220	165
NH_3 - N	mg/ℓ	0.010	0.006	0.006
TKN - N	mg/ℓ	0.13	0.12	0.15
NO_2 + NO_3 - N	mg/ℓ	0.057	0.057	0.057
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.006	0.006	0.007

Station: 3-c Transect 3, North 1/4 point

Date	Mo/Day/Yr	9/15/76	9/16/76	9/15/76	9/16/76	9/15/76	9/16/76
Time	Mtly	0935	1050	No Sample - Too Shallow	No Sample - Too Shallow	0920	1040
Depth	Meters	1	1			9	9
Temperature	Cent.	12.5	13.0			12.0	13.0
pH	SU	6.6	6.5			6.5	6.4
DO	mg/ℓ	7.0	7.1			7.1	7.1
Conductivity	μmhos/cm	175	165			220	165
NH_3 - N	mg/ℓ	<0.005	0.015			<0.005	<0.005
TKN - N	mg/ℓ	0.11	0.23			0.25	0.28
NO_2 + NO_3 - N	mg/ℓ	0.007	0.006*			0.008	0.006
Ortho - P	mg/ℓ	<0.005	<0.005			0.005	<0.005
Total - P	mg/ℓ	0.006*	0.010*			0.011	0.009

* Average of duplicate analyses

Station: 4-a Transect 4, South 1/4 point

Date	Mo/Day/Yr	9/15/76	9/17/76	9/15/76	9/17/76	9/15/76	9/17/76
Time	Mtly	1032	1150	1030	1148	1025	1145
Depth	Meters	1	1	18	18	26	26
Temperature	Cent.	13.0	14.0	12.0	13.0	11.0	12.0
pH	SU	7.3	7.2	7.1	7.3	6.9	7.1
DO	mg/ℓ	7.1	7.0	5.8	6.2	5.3	5.2
Conductivity	μmhos/cm	170	160	170	160	180	170
NH_3 - N	mg/ℓ	<0.005	<0.005	0.013	0.012	<0.005	<0.005
TKN - N	mg/ℓ	0.10	0.22	0.08	0.14*	0.15	0.08
NO_2 + NO_3 - N	mg/ℓ	<0.005	0.007	0.064	0.037	0.103	0.112*
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005*
Total - P	mg/ℓ	0.011	0.010	0.006	0.009	<0.005	<0.006*

*Average of duplicate analyses

Station: 4-b Transect 4, Mid-channel

Date	Mo/Day/Yr	9/15/76	9/17/76	9/15/76	9/17/76	9/15/76	9/17/76
Time	Mtly	1017	1105	1010	1125	1005	1120
Depth	Meters	1	1	18	18	40	40
Temperature	Cent.	13.0	14.0	12.5	13.0	11.0	11.0
pH	SU	7.0	6.6	7.2	6.9	6.75	6.7
DO	mg/ℓ	6.9	7.4	6.4	6.1	5.4	5.5
Conductivity	μmhos/cm	170	180	170	160	170	160
NH_3 - N	mg/ℓ	0.009	<0.005	<0.005	0.013	<0.005	0.007
TKN - N	mg/ℓ	0.21	0.21	0.12	0.19	0.08	0.23
NO_2 + NO_3 - N	mg/ℓ	0.006*	0.007	0.035	0.055	0.108	0.142
Ortho - P	mg/ℓ	<0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.010	0.008	0.007	0.007	0.005	0.008

* Average of duplicate analyses

Station: 4-c Transect 4, North 1/4 point

Date	Mo/Day/Yr	9/15/76	9/17/76	9/15/76	9/17/76	9/15/76	9/17/76
Time	Mtly	1050	1128	1045	1125	1040	1130
Depth	Meters	1	1	18	18	26	26
Temperature	Cent.	13.0	14.0	12.5	13.0	11.0	12.0
pH	SU	7.1	7.3	7.0	7.0	7.0	6.8
DO	mg/ℓ	7.0	7.0	6.2	6.5	5.4	5.7
Conductivity	µmhos/cm	165	160	170	160	180	160
NH_3 - N	mg/ℓ	0.005	0.005	0.006	<0.005	<0.005	<0.005
TKN - N	mg/ℓ	0.11	0.34*	0.19	0.22*	0.11	0.13*
NO_2 + NO_3 - N	mg/ℓ	0.008	0.006	0.048	0.042	0.0961	0.108*
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005*
Total - P	mg/ℓ	0.011	0.009	0.007	0.007	<0.005	0.006*

* Average of duplicate analyses

Station: 5-a Transect 5, South 1/4 point

Date	Mo/Day/Yr	9/15/76	9/16/76	9/15/76	9/16/76	9/15/76	9/16/76
Time	Mtly	1150	1558	No Sample - Too Shallow	No Sample - Too Shallow	1145	1555
Depth	Meters	1	1			12	12
Temperature	Cent.	13.5	14.5			13.0	14.0
pH	SU	7.4	7.2			7.4	7.2
DO	mg/ℓ	6.9	7.2			7.1	6.9
Conductivity	µmhos/cm	160	160			170	160
NH_3 - N	mg/ℓ	0.015	<0.005			<0.005	0.027
TKN - N	mg/ℓ	0.20	0.27			0.11	0.25
$NO_2 + NO_3$ - N	mg/ℓ	0.006	0.006			0.006	0.008
Ortho - P	mg/ℓ	<0.005	<0.005			<0.005	<0.005
Total - P	mg/ℓ	0.007	0.007			0.010	0.008

Station: 5-b Transect 5, Mid-channel

Date	Mo/Day/Yr	9/15/76	9/16/76	9/15/76	9/16/76	9/15/76	9/16/76
Time	Mtly	1120	1530	1118	1525	1115	1520
Depth	Meters	1	1	18	18	34	34
Temperature	Cent.	13.5	14.0	12.5	13.0	11.0	12.0
pH	SU	7.3	6.9	7.15	6.5	7.1	6.3
DO	mg/ℓ	7.0	7.0	6.6	6.6	5.2	5.8
Conductivity	µmhos/cm	165	160	170	170	175	170
NH_3 - N	mg/ℓ	<0.005	0.022	0.021	0.023	<0.005	0.009
TKN - N	mg/ℓ	0.23	0.27	0.22	0.33	0.07	0.28
NO_2 + NO_3 - N	mg/ℓ	0.007*	0.007	0.034	0.035	0.118*	0.086
Ortho - P	mg/ℓ	<0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.006	0.012	0.010	0.008	0.006	0.007

* Average of duplicate analyses

Station: 5-c   Transect 5, North 1/4 point

Date	Mo/Day/Yr	9/15/76	9/16/76	9/15/76	9/16/76	9/15/76	9/16/76
Time	Mtly	1135	1545	1130	1543	1125	1540
Depth	Meters	1	1	18	18	26	26
Temperature	Cent.	13.0	14.0	12.5	13.0	11.5	13.0
pH	SU	7.3	6.8	7.1	7.0	7.3	6.6
DO	mg/ℓ	6.9	7.0	6.4	6.9	5.7	5.9
Conductivity	μmhos/cm	170	160	170	165	170	165
NH_3 - N	mg/ℓ	0.007	<0.005	0.011	0.018	0.018	0.022
TKN - N	mg/ℓ	0.25	0.24	0.10	0.47	0.13	0.30
NO_2 + NO_3 - N	mg/ℓ	0.012	0.007	0.035	0.021	0.082	0.080
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.006	0.009	0.008	0.008	0.006	0.007

Station: 6-a Transect 6, South 1/4 point

Date	Mo/Day/Yr	9/15/76	9/16/76	9/15/76	9/16/76	9/15/76	9/16/76
Time	Mtly	1625	1445			1620	1440
Depth	Meters	1	1			7	7
Temperature	Cent.	13.0	14.5	No Sample - Too Shallow	No Sample - Too Shallow	13.0	14.0
pH	SU	7.3	7.5			7.2	7.3
DO	mg/ℓ	7.1	6.9			7.2	6.9
Conductivity	µmhos/cm	165	160			165	170
NH_3 - N	mg/ℓ	0.016	0.020			<0.005	0.005
TKN - N	mg/ℓ	0.09	0.36			0.16	0.32
$NO_2 + NO_3$ - N	mg/ℓ	0.008	0.009			<0.005	0.009
Ortho - P	mg/ℓ	<0.005	<0.005			<0.005	<0.005
Total - P	mg/ℓ	0.008	0.007			0.006	0.007

Station: 6-b Transect 6, Mid-channel

Date	Mo/Day/Yr	9/15/76	9/16/76	9/15/76	9/16/76	9/15/76	9/16/76
Time	Mtly	1550	1422	1540	1420	1545	1410
Depth	Meters	1	1	21	21	24	23
Temperature	Cent.	13.0	14.0	11.5	12.5	11.0	12.0
pH	SU	7.2	7.3	7.2	6.7	7.1	6.6
DO	mg/ℓ	6.9	6.9	7.0	6.9	6.9	6.9
Conductivity	μmhos/cm	165	165	170	170	180	170
NH_3 - N	mg/ℓ	0.010	<0.005	0.005	0.011	0.007	<0.005
TKN - N	mg/ℓ	0.10	0.18	0.19	0.23	0.13	0.14
NO_2 + NO_3 - N	mg/ℓ	<0.005	0.009	0.031	0.023*	0.046	0.035
Ortho - P	mg/ℓ	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total - P	mg/ℓ	0.007	0.007	0.008	0.010	0.014	0.010

*Average of duplicate analyses

Station: 6-b   Transect 6, Mid-channel (continued)

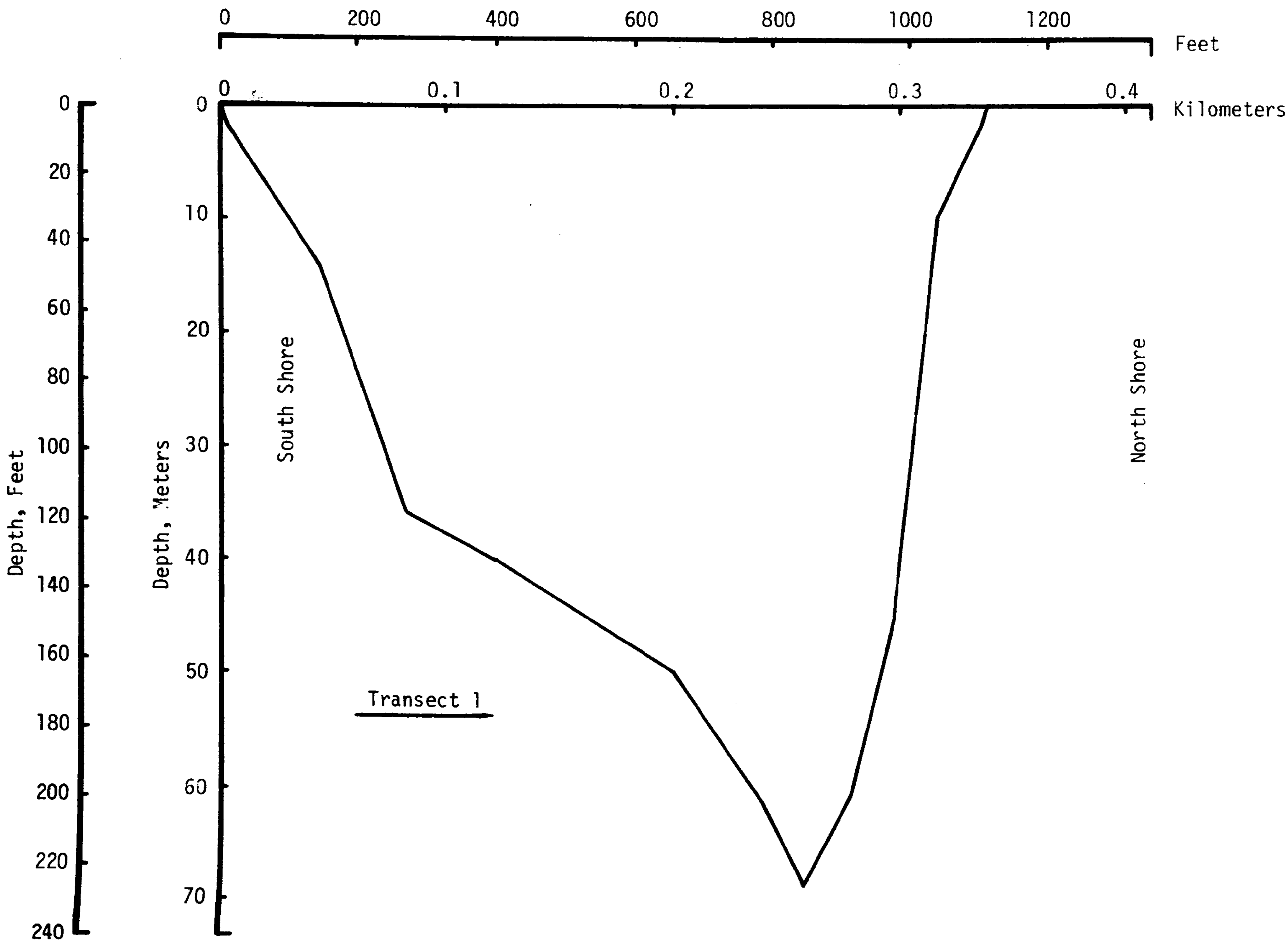
Date	Mo/Day/Yr	11/17/76	11/17/76
Time	Mtly	1215	1250
Depth	Meters	1	6
Temperature	Cent.	7.0	7.0
pH	SU	7.8	7.9
DO	mg/ℓ	9.2	9.2
Conductivity	μmhos/cm	195	180
NH_3 - N	mg/ℓ	0.008	<0.005
TKN - N	mg/ℓ	0.16	0.18
NO_2 + NO_3 - N	mg/ℓ	0.054	0.061
Ortho - P	mg/ℓ	<0.005	<0.005
Total - P	mg/ℓ	0.006	0.008

Station: 6-c Transect 6, North 1/4 point

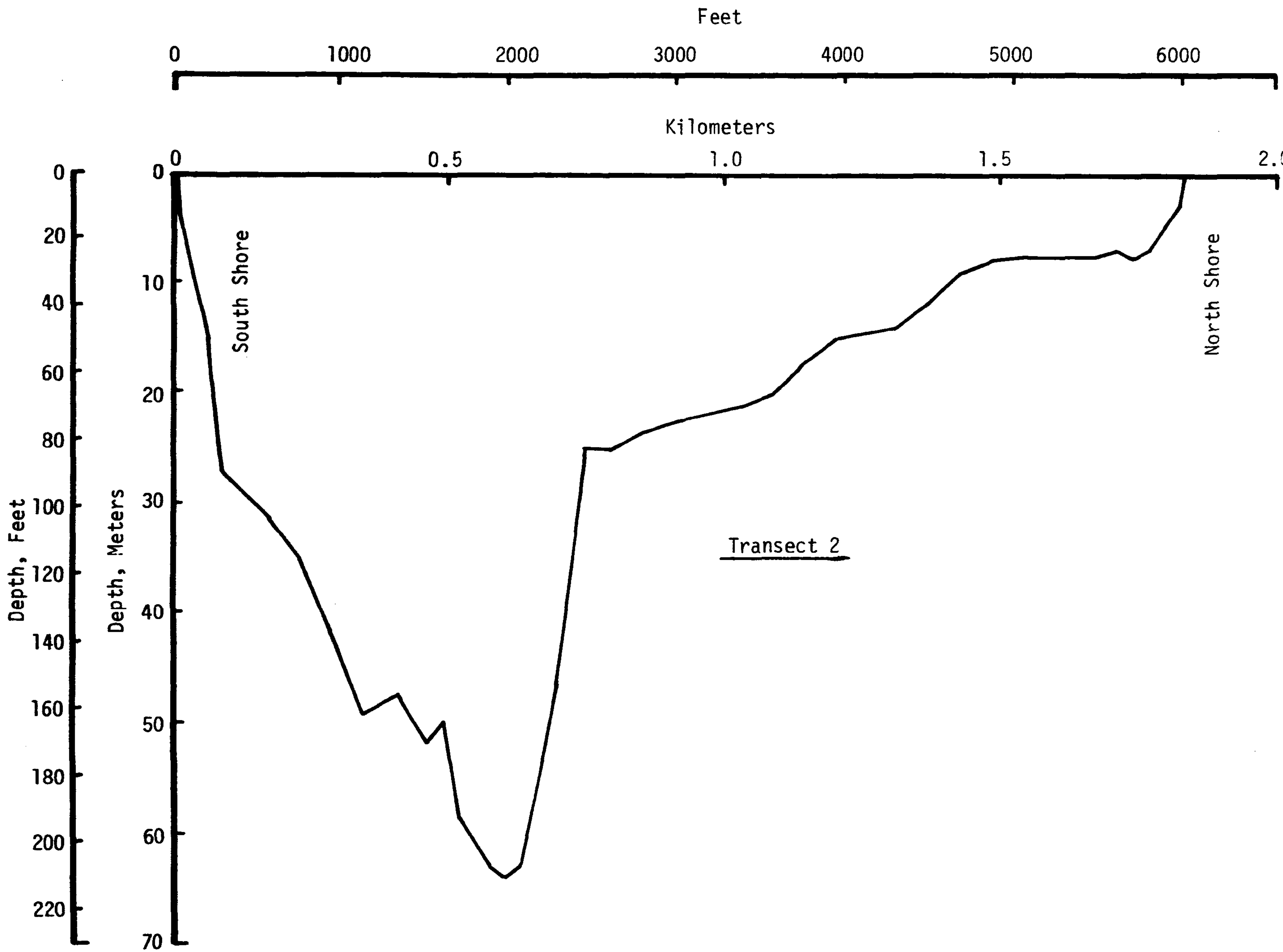
Date	Mo/Day/Yr	9/15/76	9/16/76	9/15/76	9/16/76	9/15/76	9/16/76
Time	Mtly	1600	1435	No Sample - Too Shallow	No Sample - Too Shallow	1615	1430
Depth	Meters	1	1			6	6
Temperature	Cent.	12.5	14.5			13.0	13.5
pH	SU	7.3	7.0			7.2	6.7
DO	mg/ℓ	7.2	6.9			7.1	6.9
Conductivity	μmhos/cm	170	160			170	165
NH_3 - N	mg/ℓ	<0.005	0.008			0.008	0.017
TKN - N	mg/ℓ	0.10	0.38			0.10	0.29
NO_2 + NO_3 - N	mg/ℓ	0.009	0.006			0.010	0.010
Ortho - P	mg/ℓ	<0.005	<0.005			<0.005	<0.005
Total - P	mg/ℓ	0.010	0.005			0.008	0.009

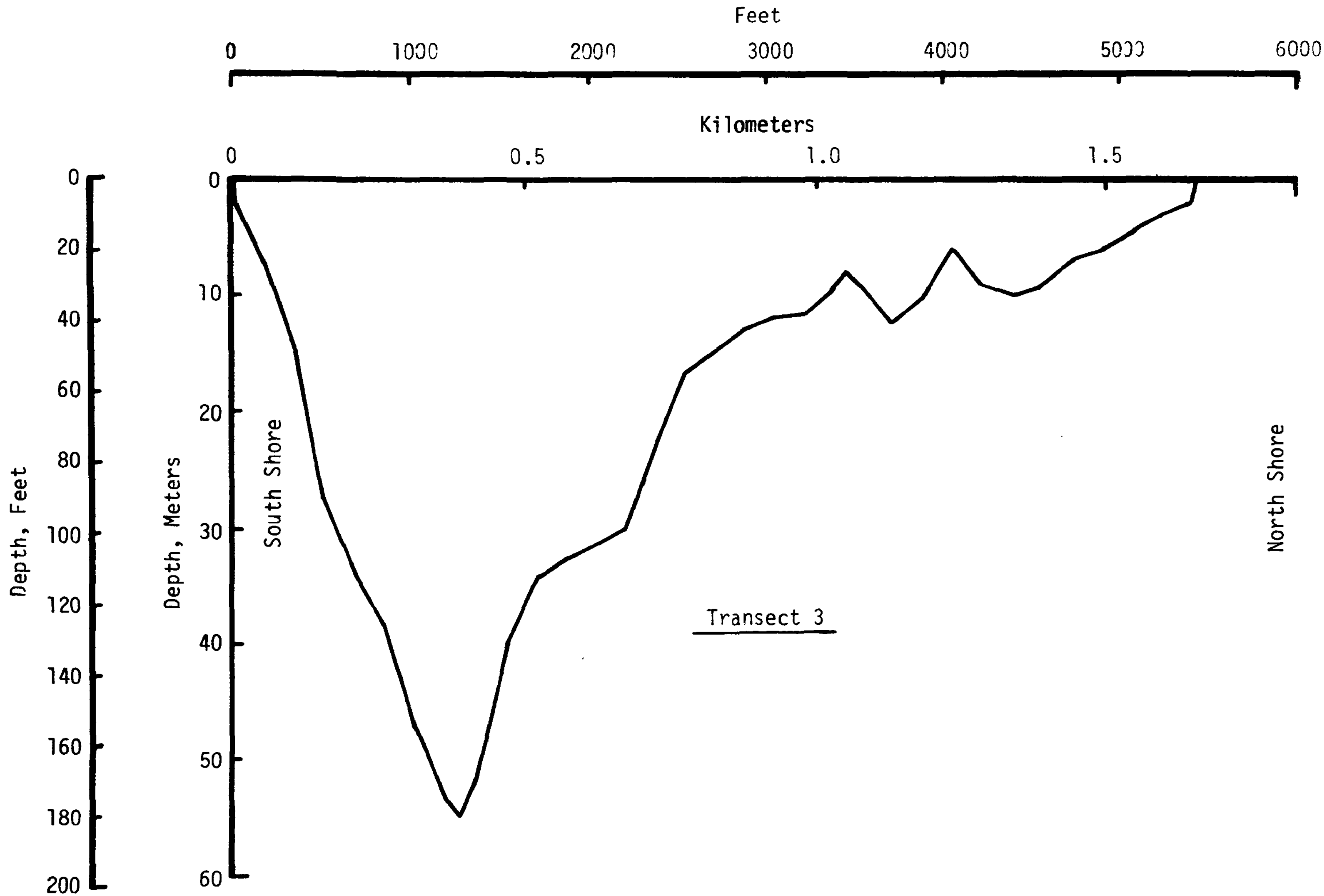
APPENDIX B

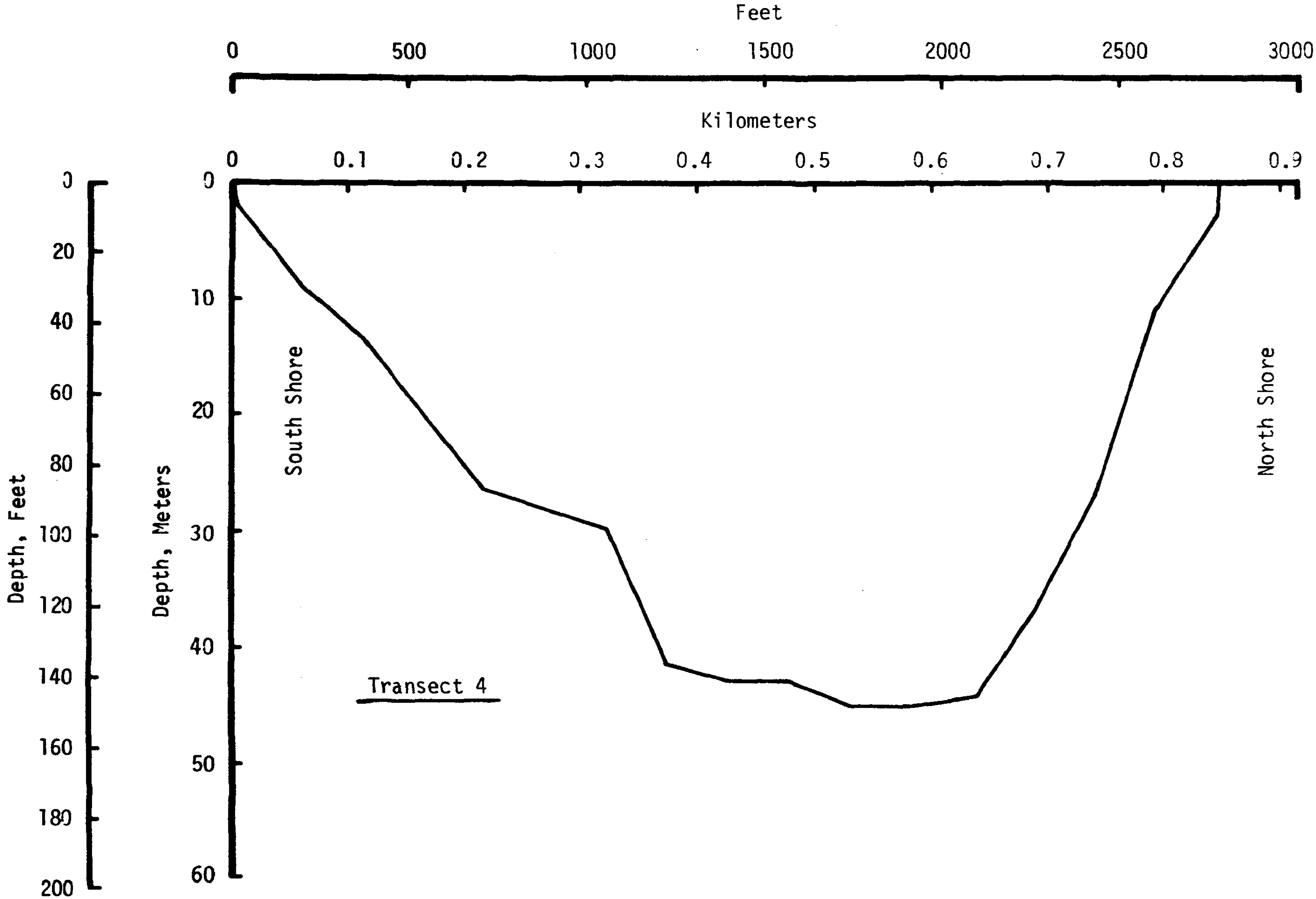
BOTTOM DEPTH PROFILES - GREEN MOUNTAIN RESERVOIR

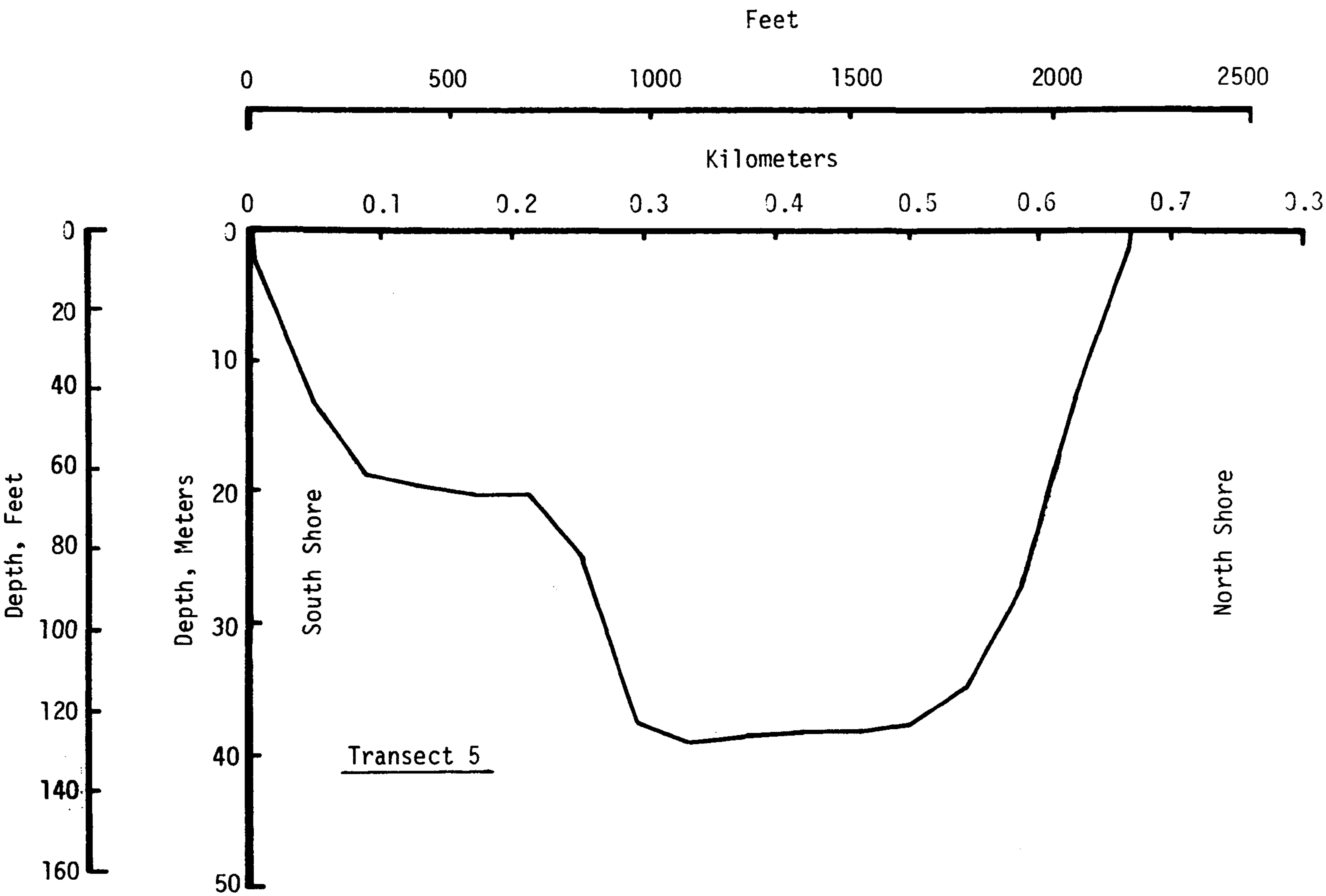


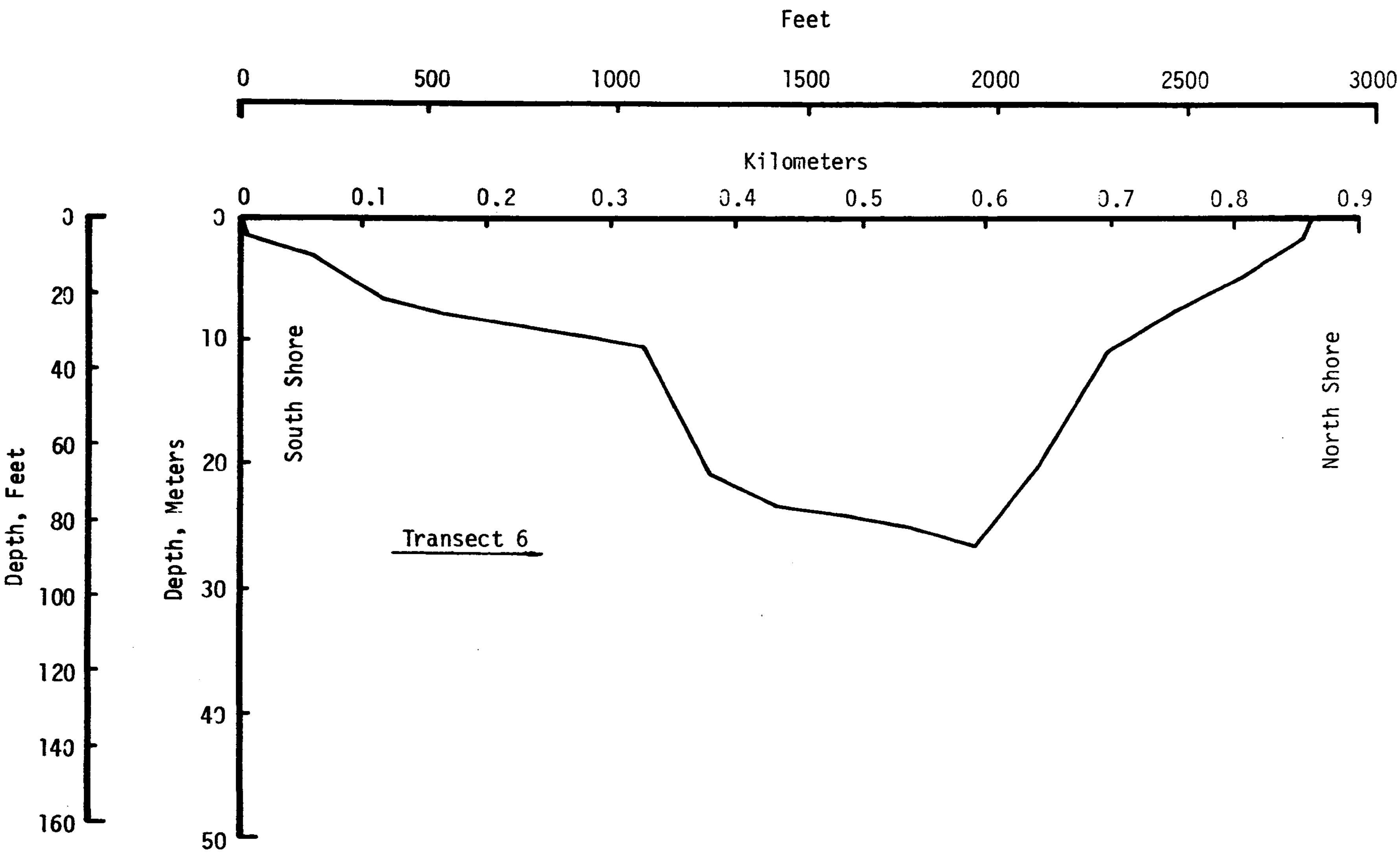
0
200
400
600
800
1000
1200
Feet
0
0.1
0.2
0.3
0.4
Kilometers
Depth, Feet
0
20
40
60
80
100
120
140
160
180
200
220
240
Depth, Meters
0
10
20
30
40
50
60
70
South Shore
North Shore
Transect 1


Feet
0
1000
2000
3000
4000
5000
6000
Kilometers
0
0.5
1.0
1.5
2.0
Depth, Feet
0
20
40
60
80
100
120
140
160
180
200
220
Depth, Meters
0
10
20
30
40
50
60
70
South Shore
North Shore
Transect 2


Feet
0
1000
2000
3000
4000
5000
6000
Kilometers
0
0.5
1.0
1.5
Depth, Feet
0
20
40
60
80
100
120
140
160
180
200
Depth, Meters
0
10
20
30
40
50
60
South Shore
North Shore
Transect 3


Feet
0
500
1000
1500
2000
2500
3000
Kilometers
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Depth, Feet
0
20
40
60
80
100
120
140
160
180
200
Depth, Meters
0
10
20
30
40
50
60
South Shore
North Shore
Transect 4


Feet
0
500
1000
1500
2000
2500
Kilometers
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Depth, Feet
0
20
40
60
80
100
120
140
160
Depth, Meters
0
10
20
30
40
50
South Shore
North Shore
Transect 5


Feet
0
500
1000
1500
2000
2500
3000
Kilometers
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Depth, Feet
0
20
40
60
80
100
120
140
160
Depth, Meters
0
10
20
30
40
50
South Shore
North Shore
Transect 6

APPENDIX C

TRIBUTARY AND STP DATA - LOWER BLUE RIVER DRAINAGE

Station BR-1 Blue River

Date	Mo/Day/Yr	9/13/76	9/14/76	9/15/76
Time	Mtly	1420	1250	1235
Temp	^{o}C	7.5	6.5	6.5
pH	SU	6.85	7.0	6.8
Flow*	m^3/s	3.09	4.16	4.67
Cond	µmhos/cm	180	180	160
DO	mg/l	10	9.8	9.8
BOD_5	mg/l	<1.0	1.0	<1.0
TSS	mg/l	<1	<1	<1.0
T-Coli	#/100ml	<1	<1	8
F-Coli	#/100ml	<1	<1	<1
TKN	mg/l	0.10	0.29	0.26
NO_2+NO_3-N	mg/l	0.140	0.163	0.201
NH_3-N	mg/l	<0.005	<0.005	0.007
T-P	mg/l	0.009	<0.005	0.006
O-P	mg/l	<0.005	<0.005	<0.005
Si	mg/l	2.40	2.30	2.35
T-Mo	µg/l	165	170	155
D-Mo	µg/l	145	185	170
T-Fe	µg/l	40	50	30
D-Fe	µg/l	20	20	10
T-Zn	µg/l	50	60	115
D-Zn	µg/l	25	35	40
T-Cu	µg/l	<5	<5	<5
D-Cu	µg/l	<5	5	5

*** Preliminary data from USGS**

Station SC-1 Straight Creek

Date	Mo/Day/Yr	9/13/76	9/14/76	9/15/76
Time	Mtly	1405	0840	0835
Temp	^oC	12.0	7.0	6.0
pH	SU	6.8	7.0	7.0
Flow	m^3/s	-	0.218	-
Cond	μmhos/cm	110	110	110
DO	mg/l	7.7	8.7	8.9
BOD_5	mg/l	<1.0	1.0	<1.0
TSS	mg/l	9.0	6.0	4.4
T-Coli	#/100ml	180	510	250
F-Coli	#/100ml	34	160	48
TKN	mg/l	0.12	0.32	0.29
NO_2+NO_3-N	mg/l	0.103	0.120	0.144
NH_3-N	mg/l	<0.005	0.007	<0.005
T-P	mg/l	0.017	0.008	0.012
O-P	mg/l	<0.005	<0.005	<0.005
Si	mg/l	4.30	4.00	4.00
T-Mo	μg/l	20	10	10
D-Mo	μg/l	<10	<10	15
T-Fe	μg/l	600	530	400
D-Fe	μg/l	120	110	140
T-Zn	μg/l	30	20	5
D-Zn	μg/l	10	10	10
T-Cu	μg/l	<5	<5	<5
D-Cu	μg/l	<5	5	5

Station WC-1 Willow Creek

Date	Mo/Day/Yr	9/13/76	9/14/76	9/15/76
Time	Mtly	1345	1240	1220
Temp	^oC	11.5	11.0	9.0
pH	SU	6.5	7.1	6.6
Flow	m^3/s	-	0.158	-
Cond	µmhos/cm	75	70	70
DO	mg/l	7.9	7.8	8.4
BOD5	mg/l	<1.0	<1.0	<1.0
TSS	mg/l	1.2	<1.0	<1.0
T-Coli	#/100ml	56	44	660
F-Coli	#/100ml	10	4	260
TKN	mg/l	0.05	0.22	0.19
NO_2+NO_3-N	mg/l	0.013	0.050	0.045
NH_3-N	mg/l	<0.005	0.007	0.010
T-P	mg/l	0.008	<0.005	0.005
O-P	mg/l	<0.005	<0.005	<0.005
Si	mg/l	3.15	2.90	3.00
T-Mo	µg/l	10	<10	<10
D-Mo	µg/l	<10	<10	<10
T-Fe	µg/l	140	120	130
D-Fe	µg/l	70	60	80
T-Zn	µg/l	20	15	75
D-Zn	µg/l	10	10	5
T-Cu	µg/l	5	5	5
D-Cu	µg/l	<5	5	<5

Station DS-STP Dillon-Silverthorne Wastewater Treatment Plant Discharge

Date	Mo/Day/Yr	9/14/76	9/15/76	9/16/76
Time	Mtly	0905	0900	0855
Temp	^oC	14.4	11.5	11.5
pH	SU	6.6	6.6	6.5
Flow	m^3/s	0,022	0.021	0.022
Cond	µmhos/cm	400	360	410
DO	mg/l	-	-	-
BOD_5	mg/l	1.8	3.5	1.2
TSS	mg/l	7.6	9.0	7.0
T-Coli	#/100ml	-	1000	900
F-Coli	#/100ml	-	28	64
TKN	mg/l	1.96	1.58	1.36
NO_2+NO_3-N	mg/l	7.84	6.86	7.66
NH_3-N	mg/l	1.37	1.01	0.94
T-P	mg/l	0.46	0.40	0.40
O-P	mg/l	0.34	0.29	0.28
Si	mg/l	5.65	5.05	5.10
T-Mo	µg/l	50	65	70
D-Mo	µg/l	40	55	50
T-Fe	µg/l	90	140	70
D-Fe	µg/l	10	20	20
T-Zn	µg/l	25	135	60
D-Zn	µg/l	35	35	75
T-Cu	µg/l	5	10	5
D-Cu	µg/l	5	<5	10
T-Coli	MPN/100ml	1400	3500	1700
F-Coli	MPN/100ml	49	79	64

Station BR-2 Blue River

Date	Mo/Day/Yr	9/13/76	9/14/76	9/16/76
Time	Mtly	1300	1200	1230
Temp	^{o}C	11.5	9.5	10.0
pH	SU	6.3	6.9	6.7
Flow	m^3/s	-	4.59	-
Cond	μmhos/cm	180	180	170
DO	mg/l	8.4	8.8	8.7
BOD_5	mg/l	<1.0	<1.0	<1.0
TSS	mg/l	<1.0	2.0	1.6
T-Coli	#/100ml	20	26	24
F-Coli	#/100ml	10	8	16
TKN	mg/l	0.16	0.37	0.29
NO_2+NO_3-N	mg/l	0.134	3.26	0.178
NH_3-N	mg/l	0.009	0.028	<0.005
T-P	mg/l	0.008	0.094	0.009
O-P	mg/l	0.006	0.065	<0.005
Si	mg/l	2.85	2.60	2.65
T-Mo	μg/l	125	145	140
D-Mo	μg/l	110	130	135
T-Fe	μg/l	60	90	160
D-Fe	μg/l	80	20	40
T-Zn	μg/l	30	50	60
D-Zn	μg/l	40	20	25
T-Cu	μg/l	5	5	5
D-Cu	μg/l	5	<5	5

Station RC-1   Rock Creek

Date	Mo/Day/Yr	9/13/76	9/14/76	9/16/76
Time	Mtly	1245	1145	1215
Temp	^oC	10.0	10.0	9.0
pH	SU	6.3	6.95	6.7
Flow*	m^3/s	0.258	0.311	0.425
Cond	μmhos/cm	60	60	60
DO	mg/l	8.4	8.4	8.7
BOD_5	mg/l	<1.0	<1.0	<1.0
TSS	mg/l	1.2	1.6	1.4
T-Coli	#/100ml	12	24	40
F-Coli	#/100ml	4	4	16
TKN	mg/l	0.06	0.17	0.24
NO_2+NO_3-N	mg/l	0.048	0.088	0.112
NH_3-N	mg/l	<0.005	<0.005	<0.005
T-P	mg/l	0.013	<0.005	0.009
O-P	mg/l	0.012	<0.005	<0.005
Si	mg/l	2.60	2.45	2.20
T-Mo	μg/l	10	15	10
D-Mo	μg/l	<10	<10	15
T-Fe	μg/l	170	180	180
D-Fe	μg/l	110	90	70
T-Zn	μg/l	<5	10	15
D-Zn	μg/l	10	5	10
T-Cu	μg/l	<5	<5	<5
D-Cu	μg/l	5	5	5

* Preliminary data from USGS

Station BC-1 Boulder Creek

Date	Mo/Day/Yr	9/13/76	9/14/76	9/16/76
Time	Mtly	1210	1135	1200
Temp	^oC	10.5	10.5	9.0
pH	SU	6.2	6.8	6.8
Flow*	m^3/s	0.204	0.204	0.252
Cond	μmhos/cm	60	60	60
DO	mg/l	8.2	8.2	8.4
BOD_5	mg/l	<1.0	<1.0	<1.0
TSS	mg/l	<1.0	<1.0	1.2
T-Coli	#/100ml	12	16	8
F-Coli	#/100ml	2	12	4
TKN	mg/l	0.20	0.18	0.25
NO_2+NO_3-N	mg/l	0.028	0.056	0.088
NH_3-N	mg/l	<0.005	<0.005	<0.005
T-P	mg/l	0.011	0.005	0.098
O-P	mg/l	0.008	0.005	0.094
Si	mg/l	1.60	1.50	1.60
T-Mo	μg/l	<10	10	<10
D-Mo	μg/l	<10	<10	10
T-Fe	μg/l	210	220	160
D-Fe	μg/l	70	90	120
T-Zn	μg/l	10	<5	25
D-Zn	μg/l	10	5	10
T-Cu	μg/l	5	<5	10
D-Cu	μg/l	5	<5	5

* Preliminary data from USGS

Station SLC-1 Slate Creek

Date	Mo/Day/Yr	9/13/76	9/15/76	9/16/76
Time	Mtly	1150	1130	1145
Temp	^oC	11.0	9.0	9.0
pH	SU	6.8	6.8	6.3
Flow*	m^3/s	0.278	0.311	0.481
Cond	µmhos/cm	70	60	60
DO	mg/l	7.75	8.2	8.4
BOD_5	mg/l	<1.0	<1.0	1.0
TSS	mg/l	1.2	1.6	2.4
T-Coli	#/100ml	22	34	110
F-Coli	#/100ml	14	28	80
TKN	mg/l	0.08	0.17	0.24
NO_2+NO_3-N	mg/l	0.017	0.056	0.138
NH_3-N	mg/l	<0.005	0.006	<0.005
T-P	mg/l	0.008	0.009	0.009
O-P	mg/l	<0.005	<0.005	<0.005
Si	mg/l	1.60	1.40	1.35
T-Mo	µg/l	<10	<10	<10
D-Mo	µg/l	<10	<10	<10
T-Fe	µg/l	370	310	320
D-Fe	µg/l	170	170	170
T-Zn	µg/l	10	30	25
D-Zn	µg/l	15	10	10
T-Cu	µg/l	<5	10	10
D-Cu	µg/l	<5	<5	<5

* Preliminary data from USGS

Station BR-3 Blue River

Date	Mo/Day/Yr	9/13/76	9/15/76	9/16/76
Time	Mtly	1100	1110	1125
Temp	^oC	9.5	8.0	8.5
pH	SU	6.0	6.7	6.8
Flow	m^3/s	4.67	-	-
Cond	µmhos/cm	140	180	140
DO	mg/l	8.8	9.1	9.1
BOD_5	mg/l	1.0	1.0	1.0
TSS	mg/l	1.6	1.2	3.4
T-Coli	#/100ml	270	240	670
F-Coli	#/100ml	12	75	28
TKN	mg/l	0.16	0.24	0.13
NO_2+NO_3-N	mg/l	0.106	0.271	0.209
NH_3-N	mg/l	0.007	0.018	0.005
T-P	mg/l	0.008	0.009	0.009
O-P	mg/l	<0.005	<0.005	<0.005
Si	mg/l	3.00	2.75	2.80
T-Mo	µg/l	90	100	100
D-Mo	µg/l	85	120	100
T-Fe	µg/l	140	150	180
D-Fe	µg/l	40	40	40
T-Zn	µg/l	25	115	55
D-Zn	µg/l	20	20	30
T-Cu	µg/l	<5	10	5
D-Cu	µg/l	5	5	10

Station BLC-1 Black Creek

Date	Mo/Day/Yr	9/13/76	9/15/76	9/16/76
Time	Mtly	1015	1100	1110
Temp	^oC	10.5	10.5	11.0
pH	SU	6.2	6.8	6.7
Flow*	m^3/s	0.54	0.65	0.76
Cond	µmhos/cm	<50	50	<50
DO	mg/l	8.4	8.2	8.3
BOD_5	mg/l	<1.0	<1.0	1.0
TSS	mg/l	2.2	<1.0	4.4
T-Coli	#/100ml	250	100	290
F-Coli	#/100ml	78	60	130
TKN	mg/l	0.10	0.32	0.30
NO_2+NO_3-N	mg/l	0.060	0.066	0.115
NH_3-N	mg/l	<0.005	0.008	<0.005
T-P	mg/l	0.021	0.009	0.007
O-P	mg/l	0.008	<0.005	<0.005
Si	mg/l	1.10	0.90	1.00
T-Mo	µg/l	<10	<10	<10
D-Mo	µg/l	<10	10	<10
T-Fe	µg/l	220	120	210
D-Fe	µg/l	50	60	70
T-Zn	µg/l	10	65	35
D-Zn	µg/l	15	5	10
T-Cu	µg/l	<5	10	10
D-Cu	µg/l	<5	<5	5

* Preliminary data from USGS

Station OC-1 Otter Creek

Date	Mo/Day/Yr	9/14/76	9/15/76	9/16/76
Time	Mtly	1050	1045	1100
Temp	^oC	11.0	9.0	8.0
pH	SU	6.8	6.3	6.9
Flow	m^3/s	0.040	-	-
Cond	µmhos/cm	130	140	130
DO	mg/l	7.9	8.4	8.7
BOD_5	mg/l	1.1	1.3	1.0
TSS	mg/l	4.8	3.6	5.6
T-Coli	#/100ml	1100	1000	600
F-Coli	#/100ml	800	720	370
TKN	mg/l	0.46	0.32	0.36
NO_2+NO_3-N	mg/l	0.162	0.042	0.116
NH_3-N	mg/l	0.005	<0.005	0.012
T-P	mg/l	0.093	0.102	0.079
O-P	mg/l	0.078	0.084	0.063
Si	mg/l	7.00	7.30	6.60
T-Mo	µg/l	<10	<10	<10
D-Mo	µg/l	<10	<10	<10
T-Fe	µg/l	1200	950	900
D-Fe	µg/l	600	620	530
T-Zn	µg/l	15	325*	20
D-Zn	µg/l	5	10	10
T-Cu	µg/l	5	10	5
D-Cu	µg/l	<5	<5	<5

* This value appears to be an outlier.

Station CC-1 Cataract Creek

Date	Mo/Day/Yr	9/14/76	9/15/76	9/16/76
Time	Mtly	1035	1030	1045
Temp	^oC	12.0	10.0	9.5
pH	SU	6.8	6.5	6.5
Flow*	m^3/s	0.136	0.164	0.184
Cond	μmhos/cm	120	120	120
DO	mg/l	7.9	8.3	8.4
BOD_5	mg/l	<1.0	<1.0	<1.0
TSS	mg/l	2.0	1.2	1.8
T-Coli	#/100ml	36	56	26
F-Coli	#/100ml	16	28	18
TKN	mg/l	0.30	0.35	0.16
NO_2+NO_3-N	mg/l	0.041	0.053	0.071
NH_3-N	mg/l	<0.005	<0.005	0.006
T-P	mg/l	<0.005	0.005	0.015
O-P	mg/l	<0.005	<0.005	0.011
Si	mg/l	1.30	1.30	1.30
T-Mo	μg/l	15	<10	<10
D-Mo	μg/l	<10	15	<10
T-Fe	μg/l	230	210	210
D-Fe	μg/l	220	120	120
T-Zn	μg/l	20	15	35
D-Zn	μg/l	40	5	10
T-Cu	μg/l	<5	5	5
D-Cu	μg/l	10	<5	<5

* Preliminary data from USGS

Station BR-4 Blue River

Date	Mo/Day/Yr	9/14/76	9/15/76	9/16/76
Time	Mtly	1015	1010	1025
Temp	^oC	12.0	12.5	12.0
pH	SU	6.6	6.3	6.4
Flow*	m^3/s	19.08	19.14	18.46
Cond	µmhos/cm	170	160	180
DO	mg/l	5.7	5.8	5.8
BOD_5	mg/l	<1.0	<1.0	<1.0
TSS	mg/l	2.0	2.4	2.6
T-Coli	#/100ml	8	6	120
F-Coli	#/100ml	<1	2	<1
TKN	mg/l	0.06	0.17	0.22
NO_2+NO_3-N	mg/l	0.146	0.154	0.156
NH_3-N	mg/l	<0.005	0.005	<0.005
T-P	mg/l	0.008	0.006	<0.005
O-P	mg/l	<0.005	<0.005	<0.005
Si	mg/l	2.60	2.70	2.70
T-Mo	µg/l	95	80	85
D-Mo	µg/l	75	80	85
T-Fe	µg/l	110	100	60
D-Fe	µg/l	70	20	40
T-Zn	µg/l	15	65	20
D-Zn	µg/l	120**	10	20
T-Cu	µg/l	5	10	<5
D-Cu	µg/l	25**	5	<5

* Preliminary data from USGS

** The only plausible explanation for these high concentrations of dissolved zinc and copper is that the sample may have inadvertently been contaminated during sampling.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-908/2-77-003	2.
3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE Green Mountain Reservoir - Lower Blue River Study, Colorado, September, 1976	5. REPORT DATE
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Ronald M. Eddy, Robert L. Fox	8. PERFORMING ORGANIZATION REPORT NO. S&A/TIB-30
9. PERFORMING ORGANIZATION NAME AND ADDRESS Technical Investigations Branch, Surveillance & Analysis Division, U.S. Environmental Protection Agency - Region VIII, Denver, Colorado 80295	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES	

16. ABSTRACT During September, 1976, a study was conducted by the Environmental Protection Agency, Region VIII, to determine existing nutrient and organic loadings to Green Mountain Reservoir, present trophic status of the reservoir, and possible effects of increased nutrient addition on algal growth potential. Sampling was conducted during a four day period, with additional samples collected in November, 1976.

Samples in Green Mountain Reservoir were collected at quarter points along six transects, three depths per sampling site. Samples were also collected from the Dillon-Silverthorne STP, the mainstem Blue River, and eight tributaries in the lower Blue River drainage.

Of the computed total phosphorus and total nitrogen loadings to the reservoir, 12.8% and 7.0%, respectively, were attributable to the Dillon-Silverthorne STP. Non-point loadings from the lower Blue River drainage (omitting the discharge from Dillon Reservoir) comprised 51.1% of the total phosphorus and 36.4% of the total nitrogen entering Green Mountain Reservoir. Results of the laboratory algal assays indicated phosphorus limitation at all stations with micronutrient limitation also evident at stations 3b and 6b. On the basis of chlorophyll a and primary productivity values, Green Mountain Reservoir, at the time of sampling was oligotrophic. Dry weight yields in the algal assays indicated that potential primary productivity was moderate at the time of sampling.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT Release to the Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 39
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

A REQUEST

Date of request 3-Mar-92 Not needed after: n/a Requester's order no. ILL2146

CALL NO.

EG&G Lake Arbor Library
6272 W. 91st Ave.
Westminster, CO 80030
Attn: Interlibrary Loan

For use of G Porter Status RFP Dept.

Book author: OR periodical title, vol. and date

Environmental Protection Agency - Denver, CO.
Technical Investigation Branch

Book Title, edition, place, year series: OR periodical article author, title, pages. ☐ This edition only

Dillon Reservoir - Blue River Study. Colorado
June, July, August 1973. 1974.

Verified in: OR: item cited in

ISBN, OR ISSN, or LC card, or OCLC, or other number if known ________

If non-circulating, & cost does not exceed $ ________ please supply ☐ Microfilm ☐ Hard copy

EPA Region 8 Library
999 18th
Denver, CO

Request complies with
☐ 108(g)(2) Guidelines (CCG)
☐ other provisions of copyright law (CCL)

AUTHORIZED BY: (full name) Robert Pride

TITLE Information Specialist

Request for ☒ LOAN or ☐ PHOTOCOPY
According to the A.L.A. Interlibrary Loan Code

REPORTS: Checked by

SENT BY: ☐ Library rate ☐ ________

Charges $ 0 Insured for $ ________

Date sent 3/5

DUE 4/2

RESTRICTIONS: ☐ For use in library only

☐ Copying not permitted ☐ ________

NOT SENT BECAUSE: ☐ In use ☐ Not Owned

☐ Non Circulating

☐ Request of ________

Estimated Cost of: ☐ Microfilm ________ ☐ Hard copy ________

BORROWING LIBRARY RECORD:

Date received 3/6/92

Date returned 3/19/92

By ☐ Library rate ☐ ________

Postage enclosed $ ________ Insured for $ ________

RENEWALS: ☐ No renewals

Requested on ________

Renewed to ________ (or period of renewal)

Note. The receiving library assumes responsibility for notification of non-receipt.

A REQUEST

Date of request 3-Mar-92 Not needed after: n/a Requester's order no. ILL2147

CALL NO.

EG&G Lake Arbor Library
6272 W. 91st Ave.
Westminster, CO 80030
Attn: Interlibrary Loan

For use of G Porter Status RFP Dept.

Book author; OR periodical title, vol. and date

Eddy, Ronald M & Robert L Fox
Environmental Protection Agency, Denver CO

Book Title, edition, place, year series: OR periodical article author, title, pages. ☐ This edition only

Green Mountain Reservoir - Lower Blue River Study
September 1976. 1977.

Verified in: OR: item cited in

ISBN, OR ISSN, or LC card, or OCLC, or other number if known ________

If non-circulating, & cost does not exceed $ ________, please supply ☐ Microfilm ☐ Hard copy

EPA Region 8 Library
999 18th
Denver, CO

Request complies with
☐ 108(g)(2) Guidelines (CCG)
☐ other provisions of copyright law (CCL)

AUTHORIZED BY: (full name) Robert Pride

TITLE Information Specialist

Request for XX LOAN or ☐ PHOTOCOPY
According to the A.L.A. Interlibrary Loan Code

REPORTS: Checked by

SENT BY: ☐ Library rate ☐ ________

Charges $ 0 Insured for $ ________

Date sent 3/5

DUE 4/2

RESTRICTIONS: ☐ For use in library only

☐ Copying not permitted ☐ ________

NOT SENT BECAUSE: ☐ In use ☐ Not Owned

☐ Non Circulating

☐ Request of ________

Estimated Cost of: ☐ Microfilm ________
☐ Hard copy ________

BORROWING LIBRARY RECORD:

Date received 3/6/92

Date returned 3/19/92

By ☐ Library rate ☐ ________

Postage enclosed $ ________ Insured for $ ________

RENEWALS: ☐ No renewals

Requested on ________

Renewed to ________
(or period of renewal)

Note: the receiving library assumes responsibility for notification of non-receipt.