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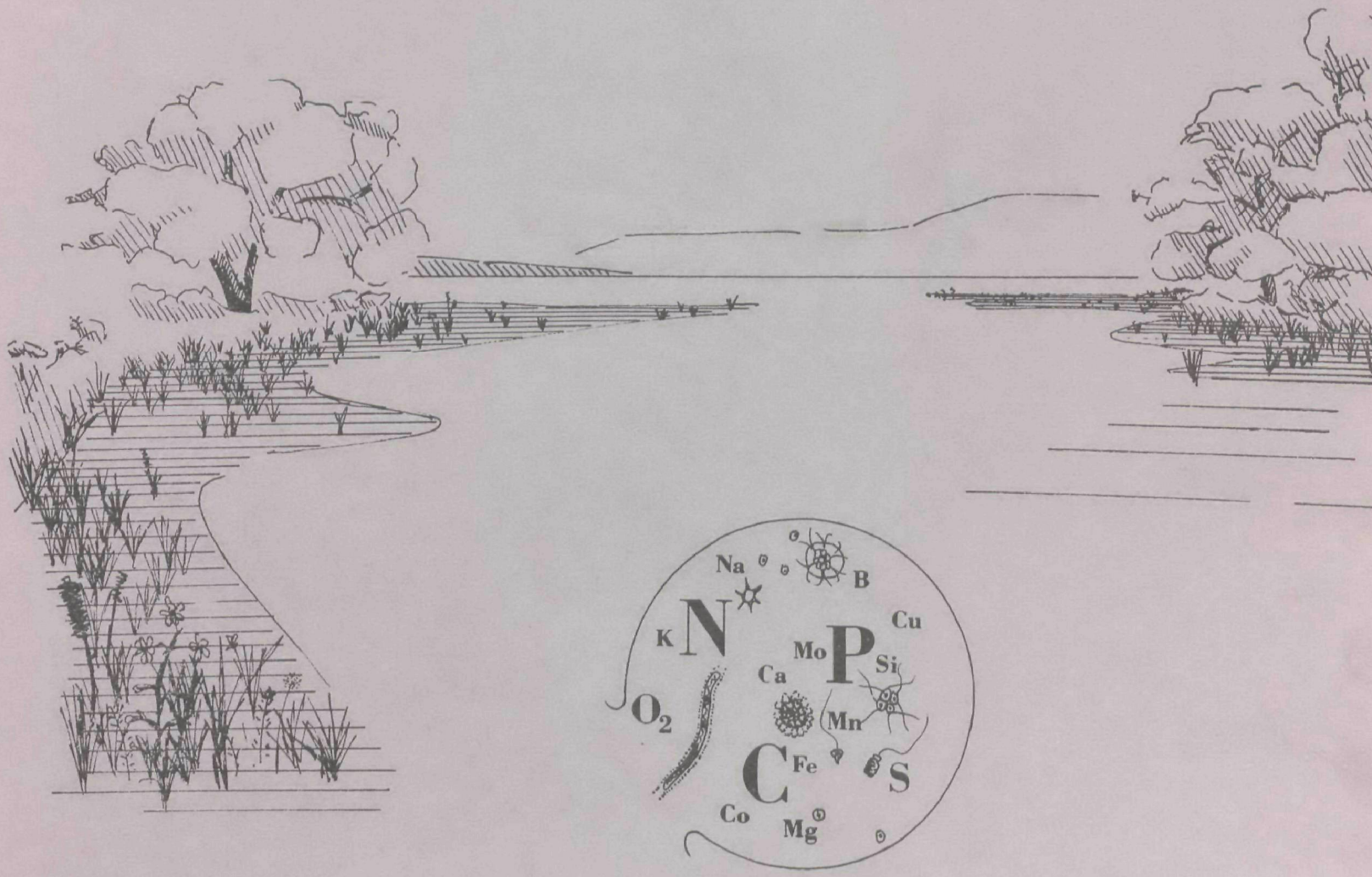
EUTROPHICATION OF SURFACE WATERS—LAKE TAHOE INDIAN CREEK RESERVOIR



U.S. ENVIRONMENTAL PROTECTION AGENCY

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EUTROPHICATION OF SURFACE WATERS – LAKE TAHOE
INDIAN CREEK RESERVOIR

by

Lake Tahoe Area Council
South Lake Tahoe, Calif., 95705

for the

ENVIRONMENTAL PROTECTION AGENCY

Project Nos. 16010 DNY

16010 DSW

July 1971

EPA Review Notice

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ABSTRACT

During the years 1969 to 1971 field and laboratory studies were made to determine the temporal changes and relationships between the water quality characteristics of Indian Creek Reservoir and those of reclaimed water from the South Tahoe Public Utility District, which comprised 70 percent of the annual input to the reservoir.

Reclaimed water contained 0.01 to 0.04 mg/ℓ phosphorus and more than 15 mg/ℓ ammonia. Initially the reservoir would not support fish life, but as the reservoir matured, ammonia levels declined to less than 4 mg/ℓ and by 1970 the reservoir was an excellent trout fishery. Approximately 70 percent of the ammonia nitrogen was lost to the atmosphere by nitrification-denitrification in the system. Good biological productivity of the reservoir indicated access to other sources of phosphorus, probably soil and surface runoff.

Bioassays showed the growth stimulating ability of the reservoir water to exceed that of the reclaimed water. Various parameters showed that the reservoir responds to more complex factors than those measurable in the reclaimed waste water, thus raising the question of the optimum degree of treatment of water destined for recreational impoundments.

This report was submitted in fulfillment of Demonstration Grants No. 16010 DSW and 16010 DNY under the sponsorship of the Water Quality Office, Environmental Protection Agency.

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SECTION I

CONCLUSIONS

Based on the results of physical, chemical, and biological observations of Indian Creek Reservoir during the period March 1969 to May 1971, the following conclusions and evaluations are made.

1. The water impounded at Indian Creek Reservoir during the period of study was approximately one-third surface runoff and direct precipitation on the reservoir surface, and two-thirds reclaimed water exported from the South Tahoe Public Utility District's plant.

2. Because the drainage area above the reservoir is small (1700 acres) it may be expected that as the volume of exported water increases, the quality of impounded water will increasingly be influenced by the reclaimed water.

3. Estimates of runoff and evaporation rates previously reported to the STPUD by its engineering consultants appear to be sufficiently valid to permit reasonable water budget estimates for Indian Creek Reservoir.

4. Infiltration rates in the reservoir in mid-1969 were estimated to average about 0.035 ft of water per day; a reasonable value for the type of soil in the area. During 1970-71 the estimated rate was 0.028 ft of water per day. The decrease is reasonable considering the expected clogging of soil pores as the reservoir matures.

5. The clarity of Indian Creek Reservoir water during the period of observation was typical of shallow impoundments of relatively good quality water. During the period June 1969 through April 1971 Secchi disk readings varied from 0.8 to 6.5 meters.

6. Water temperatures in the upper stratum of the reservoir, where light and other environmental factors are most favorable to plankton growth, reach an 18°-22°C range also favorable to biological activity. In winter they fall below the lower limit for biological activity.

7. With only minor exceptions, the observed data on physical characteristics of the reservoir are in line with typical and explainable phenomena, although not in sufficient detail to permit statistical evaluations.

8. Chemical analyses of impounded water show that there was little difference in conservative chemical quality from top to bottom, indicating that the reservoir water was generally well mixed.

9. Throughout the period of study the pH of the impounded water varied from 7.7 to 8.5, as compared to 7.4 to 8.8 in the influent reclaimed water. The average pH of the impounded water remained close to 8.0, indicating that Indian Creek Reservoir was in a healthy condition limnologically.

10. There is evidence that iron in the influent water is utilized in the biological cycle of the reservoir, although there was no evidence that it is a limiting element.

11. In terms of conductivity and chemical components the water impounded at Indian Creek Reservoir is of good quality for irrigation water.

12. Differences in concentration of conservative quality factors such as chlorides in influent reclaimed and impounded water in the reservoir was clearly the result of dilution and evaporation.

13. Substantial evidence was found that bicarbonate alkalinity was used as a source of carbon by the biota of the reservoir during the period of study.

14. There is a tendency for the COD of Indian Creek Reservoir water to be higher in the growing season when algae are present.

15. The excess of suspended solids in impounded water over that in influent reclaimed water is most evident during the growing season.

16. Wind movement across the reservoir has an important effect on mixing of the impounded water.

17. Prior to September 1969 the impounded water was poorly mixed. Thereafter dissolved oxygen indicated that mixing was occurring due to natural causes. The installation of a mechanical aerator in June 1970 resulted generally in a good vertical oxygen profile, although it did not completely forestall a repetition of the oxygen depression which appeared each July.

18. Correlation coefficients for suspended solids versus the reciprocal of clarity were found by the computer to be 0.88. When more than 50 percent of the suspended solids were volatile solids, the correlation coefficient increased to 0.93.

19. Phosphorus was considered the limiting nutrient in Indian Creek Reservoir. Average N/P ratios in the influent reclaimed water were of the order of 150:1. In the impounded water the ratio averaged 140:1 during 1969-70 but increased to 300:1 in 1970-71, probably as a result of increased efficiency of phosphorus removal in the STPUD plant.

20. With but little effect of dilution the ammonia concentration changed from more than 15 mg/ℓ in the influent water to generally less than 4 mg/ℓ in the impounded water. Nitrogen balance and microbiological studies showed that nitrogen is being lost from the reservoir and that nitrification-denitrification is the major mechanism.

21. Two estimates made from different independent approaches place the total nitrogen lost from the reservoir during two years in the range of from 61,000 to 84,000 kg; more than 60 percent of the influent nitrogen.

22. Apparently there is a slight tendency for nitrate and ammonia concentrations to increase with time. Should this prove to be real rather than apparent the reservoir would eventually become untenable to trout.

23. Biologically, Indian Creek Reservoir showed important changes over a two-year period of observation. From an initial situation in 1969 in which it apprently would not support fish life, it developed in 1970 into an excellent trout fishery.

24. Evidence that with time the reservoir increased rather than decreased in biological health was found in an increase in the diversity of benthic invertebrates from 1969-70 to 1970-71. In October 1969 dipterous larvae averaged 428 per square foot, whereas in October 1970 the value was only 280 per square foot. Nevertheless the low oxygen tolerant types which predominated in 1969 were far less evident in 1970.

25. Although the diversity of benthic organisms is lower than might be expected in a mature reservoir it is continuing to increase as the reservoir continues to stabilize. However, the benthic standing crop is decreasing with time, hence the amount of food available from the benthos to the fish population may be decreasing.

26. Changes in the contents of the stomachs of trout from 1969 to 1971 indicate that some changes took place in the limnological condition of the reservoir. Chironomids predominated in 1970; Daphnia in the spring of 1971; and snails in the summer of 1971.

27. Apparently several annual cycles have been established in Indian Creek Reservoir. An annual spring phytoplankton bloom appears to start in February. This is followed by an April-May bloom of Daphnia. It is concluded, however, that additional seasonal data are necessary before it can be said with certainty that the reservoir has stabilized.

28. Plankton surveys made in 1969, 1970, and 1971 indicate good biological productivity of Indian Creek Reservoir water.

29. Vascular plants in Indian Creek Reservoir affected the dissolved oxygen resource of the impounded water to a marked degree, although their importance to the nutrient balance was minimal.

30. Five or six varieties of vascular plants are increasingly profuse in the reservoir during the summer and could conceivably become a nuisance in future years.

31. Bioassays of impounded water showed limited growth rates of test algae, probably because of a prior tieup of nutrients, particularly of phosphorus, in the standing crop of aquatic organisms in the impounded water.

32. Growth rates in bioassays of impounded water were inversely related to the biological growth cycle of the reservoir.

33. Water impounded in Indian Creek Reservoir, although supporting biota, was nevertheless more capable of stimulating growth in bioassays than was the influent reclaimed water.

34. Unquestionably the factors controlling the behavior of Indian Creek Reservoir are far more complex than can be predicted by merely analyzing its major influent waters.

35. Observation of Indian Creek Reservoir over a period of time may make it possible to design water reclamation processes capable of producing a water of balanced quality suited to a broad spectrum of recreational or other uses.

36. The STPUD water reclamation plant is a highly efficient system for removing phosphorus, and Indian Creek Reservoir is a good system for removing nitrogen.

SECTION II

RECOMMENDATIONS

It has been shown in the work herein reported that Indian Creek Reservoir has changed in quality characteristics from an initial condition in which it closely resembled the influent reclaimed water from the STPUD, to a system clearly more complex and capable of supporting biota which at first could not live in it. Should this trend continue it may be that in time the reservoir will become excessively eutrophic regardless of the quality of exported water, just as lakes have done under normal inputs from precipitation and runoff. Should this occur, much of the purpose of tertiary treatment of waste water becomes questionable. To clarify this question it is recommended that a program of monitoring of the Indian Creek Reservoir be continued and the data analyzed annually.

Less comprehensive objectives of the recommended monitoring program include: 1) determining whether the ability of Indian Creek Reservoir to support aquatic life is increasing or decreasing, and 2) observing whether the suspected slow increase in nitrate and ammonia is in fact occurring. This will give information as to the importance of nitrogen removal as a treatment process.

It is recommended that studies beyond the scope of the Indian Creek Reservoir study herein reported, but suggested by its findings, be conducted for the purpose of determining: 1) the feasibility of utilizing intermediate size ponds to reduce the nitrogen content of a phosphate-stripped water, and 2) the optimum nutrient levels and relationships for impoundments to be used for recreational or other specific benefits, with the intent of establishing more rational parameters of treatment plant design.

SECTION III

INTRODUCTION

ORIGIN OF INDIAN CREEK RESERVOIR

Indian Creek Reservoir is the terminus of a system designed to export from the Lake Tahoe Basin the final effluent from the domestic waste water treatment facilities of the South Tahoe Public Utility District (STPUD). The concept that sewage should be removed from the Tahoe Basin developed during the early nineteen sixties. At that time it was becoming widely apparent throughout the U.S.A. that the growing population pressure on the nation's water resources was leading to overfertilization of surface waters, with consequent algal blooms that interfered with normal beneficial use of such resources. In many instances losses were identifiable in economic terms as well as in depreciated aesthetic and recreational values.

In the specific case of Lake Tahoe, discharge of waste water effluents directly into the lake had never been considered an acceptable alternative. However, prior to about the year 1960 disposal on land within the basin was generally considered adequate to overcome the public health and aesthetic objections to discharge into surface waters of the region. Nevertheless, it was recognized by water quality control authorities and others that the clarity and beauty of Lake Tahoe was a consequence of an extremely low productivity resulting from its oligotrophic (nutrient poor) characteristics. Moreover, it was evident that the Lake Tahoe Basin is essentially a closed system subject to human imports of nutrients but to only limited export of nutrients, principally via the Truckee River and some selective logging. Thus the lake is the ultimate nutrient sink in the basin. In such a situation in 1960, sewage disposal was considered the most critical unsolved problem.

Under a grant from the Max C. Fleischmann Foundation of Reno, Nevada, the Lake Tahoe Area Council conducted a comprehensive study on protection of the water resources in the Lake Tahoe Basin through management of wastes. The resulting report [1] recommended export as one of the three feasible alternatives. At about the same time (1961) the STPUD retained consulting engineers to develop a long-range permanent solution to its disposal problems.

The idea of export as a practical solution to the waste management problem of the Lake Tahoe Basin, however, developed slowly. No community was willing to be the terminus of any waste export scheme. The concept that water is forever "sewage" once it has been used to transport wastes proved to be too deeply ingrained in the minds of citizens to be overcome by simple persuasion. "If it is not good enough for you, it is not good enough for me" was the ultimate attitude. This rationale precluded both export by way of the Truckee River and by pipeline as well, although the latter offered more possible alternatives.

Matters were finally brought to a head as a result of a growing national concern over eutrophication. This initiated a review of water quality criteria that has increasingly led in the direction of nutrient removal as an obligatory objective of waste water treatment. A series of demonstration grants to the STPUD were made under the Advanced Waste Water Treatment program of the series of federal agencies which culminated in the Environmental Protection Agency. These grants led to the development on a plant scale of processes for nutrient removal and for upgrading waste water in quality to drinking water standards. Thereafter to make export feasible it was only necessary for people to understand that what constitutes acceptable high quality water almost anywhere is not adequate to protect Lake Tahoe from eutrophication because of the lake's sensitivity to nitrogen at levels far below those acceptable for drinking water.

The Indian Creek Reservoir site was selected as a logical place to impound reclaimed water because it offered an agricultural use of water without release to surface streams.

CHARACTERISTICS OF INDIAN CREEK RESERVOIR

Indian Creek Reservoir is located in Alpine County, California on the eastern side of the Sierra Nevadas on a tributary of Indian Creek in Diamond Valley. Figure 1 shows its general relationship to Lake Tahoe, Luther Pass, and other geographical features of the area, as well as the profile of the 27-mile reclaimed water export line from South Lake Tahoe.

The reservoir was formed in 1968 by the construction of a rockfill dam, 68 feet in height, across the tributary to Indian Creek, together with a smaller saddle dam of the same type to prevent overflow of the reservoir into a shallow and little used impoundment known as Stevens Lake. In preparing the reservoir site the original vegetation, comprising mostly scrub brush and pinon pine, was removed and the existing shallow soil stripped down to a stratum of quite impervious hardpan and rock which characterizes the area. In this manner it was intended to minimize the organic matter initially present on the bottom of the reservoir which might subsequently become a nutrient for organic growth in the overlying water.

The spillway crest of the main dam was established at an elevation of 5600 feet above mean sea level. Thus it is about 625 feet below the water surface elevation of Lake Tahoe and some 2100 feet below the summit of Luther Pass. At maximum water surface elevation (5600 feet) the surface area of the reservoir is approximately 160 acres, or about 9 percent of the 1700 acres of drainage area above the dam. The maximum volume of impounded water is about 3130 acre feet.

Although the reclaimed water from the STPUD is essentially of drinking water quality, its disposal to the Carson River system is not permitted under standards established to preserve the exceptionally low dissolved solids content of the West Carson River. Therefore the reservoir is operated without overflow by releasing to irrigated agriculture during the growing season the water impounded during the previous winter. This results in a maximum variation in water surface elevation between 5600 and 5582 feet and a volume variation between 3130 and 1000 acre feet. Such an extreme variation, however, is not expected to occur until after the year 2000, at which time the anticipated export from South Lake Tahoe will approach the 14,000 acre feet of water that agriculture in the immediate area can probably accept at its full potential. Thus it is evident that the operational schedule of Indian Creek Reservoir will have some seasonal effects on the quality of the impounded water.

Other factors governing the quality of stored water, beyond the degree of treatment of the water exported by the STPUD, include the climatological and hydrological characteristics of the reservoir area. As shown in Figure 2 (Section IV) the long axis of the reservoir lies along the meridian. Thus it parallels roughly the adjacent Sierra Nevadas to the west. The mountain range in turn protects the reservoir from the prevailing winds but guides local winds along the axis of the reservoir on a generally south to north path. Cover on the drainage area varies from pinon pine on the east to a stand of timber intermingled with scrub brush on the west. This cover varies in density from quite heavy brush to isolated stands of timber. Slopes are steepest on the west; on the order of 10 to 20 percent at lakeside. To the east the slopes are more moderate, averaging about one-half the values cited.

The climate of the Indian Creek area is typical of that of the eastern or "rain shadow" side of the Sierras at altitudes in the 5000 to 6000 foot range. Average annual precipitation at the reservoir is reported [2] to be about 20 inches, with 70 percent of this total occurring during the winter, November through April, season of the year. Although snowfall is substantial during the winter, rainfall accounts for much of the precipitation. Average monthly records from the U. S. Weather Bureau gage at Woodfords, California, some 3 miles northwest of Indian Creek Reservoir, show a variation from 0.34 inches in the months of July and August, to 4.28 inches in January, when prevailing storms occur. In spite of the small amount of summer rainfall it is likely to be intense. Rapid rise of heated air up the face of the mountains occasions thunderstorms and, because the soil in the Indian Creek area is shallow and on appreciable slopes, some of the summer precipitation

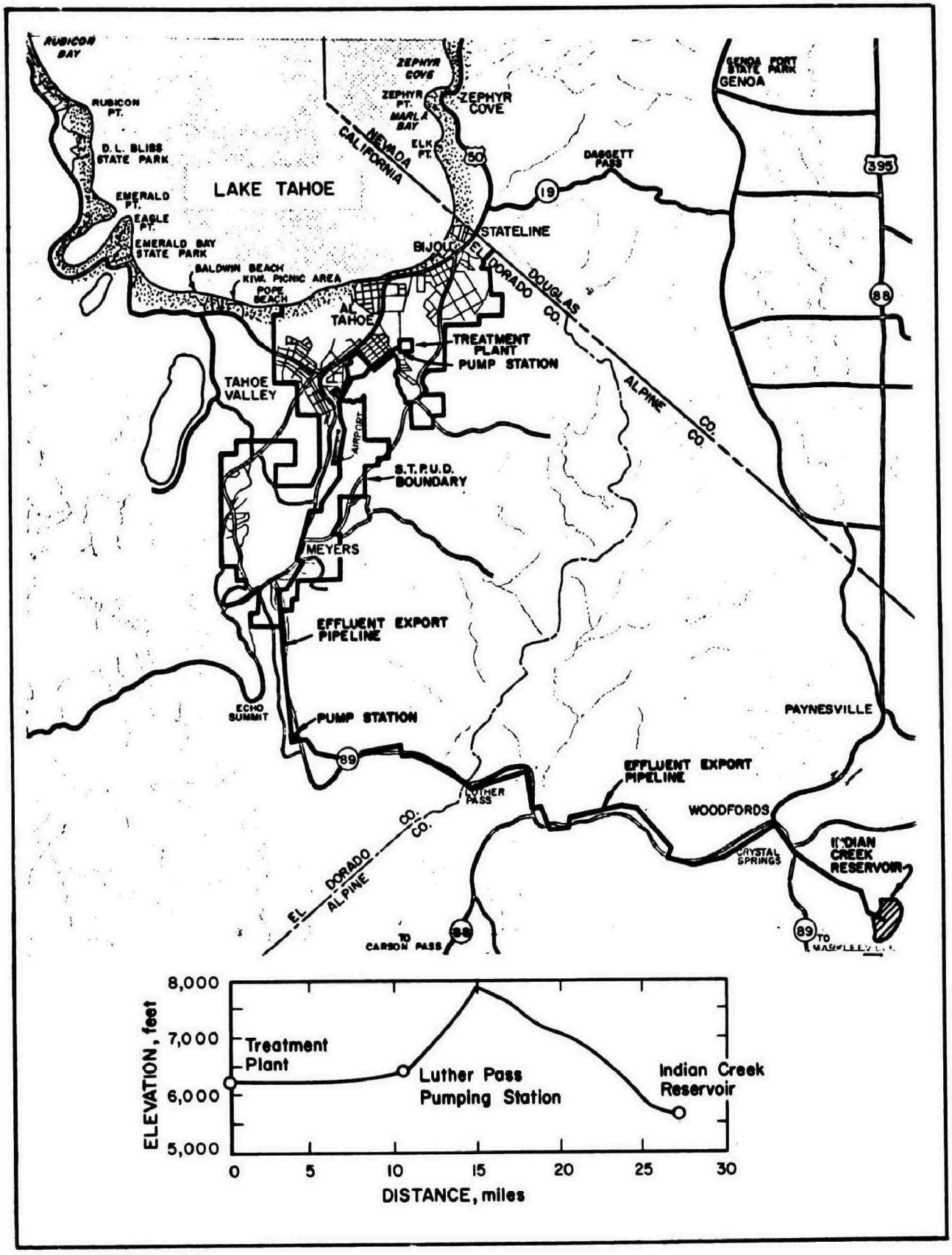

FIGURE I. GEOGRAPHICAL RELATIONSHIPS, INDIAN CREEK RESERVOIR AND EXPORT LINE FROM LAKE TAHOE BASIN (2,3)

can be expected to run off into the reservoir. At times of more seasonal rainfall or of snowmelt on frozen ground, however, considerably more input of meteorological water is to be expected. In contrast with natural runoff, inputs to the reservoir through the export pipeline of the STPUD are continuous the year round, being greatest during the summer season when the transient population of the Lake Tahoe Basin is greatest. Thus the effect of surface runoff on the nature of water reaching the reservoir is less in summer than would normally result from climatological variation in the Indian Creek area. An estimate of the nature of this variation reported in 1970 [4] is as follows:

1. Maximum monthly runoff of surface water to reservoir, approximately 49 times the minimum.

2. Maximum input of reclaimed water: approximately 6.4 times the minimum.

3. Minimum ratio of reclaimed water to surface runoff: 1/2.66 (January).

4. Maximum ratio of reclaimed water to surface runoff: 118/1 (July, August, September).

5. Anticipated composition of impounded water on annual basis:
   Meteorological water ------ 30 percent
   Reclaimed water ---------- 70 percent

Evaporation from the surface of Indian Creek Reservoir is a factor in water quality. Rates of evaporation in the area are greatest during the period, May to October. At this time the daytime temperatures are highest, leading to a convective rise of air mass up the face of the adjacent Sierra Nevadas which rise to elevations of from 7800 to more than 9000 feet. Nighttime cooling of the air mass at higher elevations due to back-radiation through the relatively thin atmospheric cover contributes to a subsidence of cool air at night, resulting in a day to night temperature change which may range from 25 to 40 degrees. Thus although the reservoir is sheltered from prevailing winds, there is a considerable movement of air which scavenges the water surface of its overlying blanket of moist air and so encourages evaporation. Evaporation losses during the four warmest months may average some 24 inches, 7 inches of which occurs in July. During the period of study herein reported the annual evaporative loss from Indian Creek Reservoir is estimated at 40 inches.

Because of the relatively small percentage of surface water in comparison with reclaimed water and the operating schedule which calls for withdrawing by discharge to irrigation and by evaporative and percolative losses the entire reservoir input each year, it may be expected that the water impounded in Indian Creek Reservoir will resemble reclaimed water more closely as time goes on.

NEED FOR STUDY

Need for the study herein reported has both utilitarian and practical scientific aspects. In as much as the process of tertiary treatment of waste water is far from its ultimate technological and economic optimum, the creation and utilization of Indian Creek Reservoir raised a number of important questions, including:

1. How effective is tertiary treatment at present levels of development in controlling algal growth in impoundments of effluents from such treatment?

2. What limnological developments in impounded tertiary effluents will affect beneficial uses of such impoundments?

3. What degree of treatment would be necessary to permit retention of reclaimed water in the Lake Tahoe Basin without posing a threat to the quality of Lake Tahoe water?

4. Given recreational or other beneficial uses as objectives of water reclamation, what treatment processes are required to produce water of optimum quality characteristics?

Answers to the first two of these questions are badly needed in order to evaluate the processes currently classed as "advanced" or "tertiary" treatment in relation to their objectives.

The third question should be answered because it may not be assumed that tradeoffs between exports from Lake Tahoe via the Truckee River and via pipelines will not some day have to be adjudicated; nor that present social, cultural, and aesthetic attitudes toward reclaimed water will endure forever. Conceivably, water of a quality equal to that of Lake Tahoe may eventually be produced routinely from waste water and be in demand by people living in the Basin at that point in time.

The fourth question is of particular importance in the economic management of the environment. In contrast with the current practice of adding new unit processes to waste treatment as rapidly as they are developed in the belief that the more the treatment the less the pollution, this question envisions the possibility that an optimum balance of water quality factors might be established for the specific beneficial uses desired and waste water treatment processes tailored to produce that desired product.

Interwoven in the need to answer questions such as the foregoing is the need, and the opportunity, to trace the biological and ecological history of an impoundment of highly treated waste water created on previously vegetated dry land. The manner in which such an impoundment matures with time is all important to answering the four questions cited. Moreover, it affords an opportunity never before presented to collect scientific data of exceptional pertinence to the problem of control of eutrophication of surface waters.

OBJECTIVES OF STUDY

The general objective of the study was to collect and evaluate data needed in answering questions such as outlined in the Need For Study. Specific objectives included:

1. To relate the biological, physical, and chemical characteristics of Indian Creek Reservoir to the corresponding characteristics of reclaimed water from the STPUD Wastewater Reclamation Plant.

2. To trace the seasonal and temporal changes in the biological, physical, and chemical characteristics of Indian Creek Reservoir.

3. To relate the observed characteristics of the reservoir water to the nutrient concentrations and biostimulatory characteristics of the influent reclaimed water.

4. To evaluate the relative contribution of biostimulants contributed by the reclaimed water and by exchange from the underlying soil and sediments.

NATURE AND SCOPE OF REPORT

The report herein presented covers work done on the Indian Creek Reservoir pursuant to the objectives of the study during the period December 1, 1968 through May 31, 1971 under a combination of Demonstration Grants No. 16010 DSW and 16010 DNY. In as much as the former of these two grants included objectives other than those related to Indian Creek Reservoir, many of its findings are published separately [5]. The report draws also upon findings of other cooperating agencies (see Section VII Acknowledgments) which are either published elsewhere or included herein in the Appendix (Section XI).

Because the work was conducted over two consecutive grant periods which ended on May 31 of each year, the data were analyzed and evaluated at the end of each of two study periods (April 1969 through March 1970, and April 1970 through May 1971). In preparing the report the results of these two study periods were compared for the

reason that filling of the reservoir and acclimating of the newly inundated land occurred during the first year, whereas normal operating plans were in effect during the second. Thus the results obtained during 1969-70 might reveal important limnological factors in the development of the reservoir which might become either more or less critical in the more established impoundment of 1970-71. Such a consideration is especially important wherever averages are used in the report to describe the physical, chemical, or biological responses of the reservoir.

The report draws upon and extends figures and tables previously published in a First Progress Report [4]. It is therefore intended to stand as a final report, although its findings may later be combined with subsequent data if the project continues through future years.

SECTION IV

PROJECT DESIGN AND METHODOLOGY

PROJECT DESIGN

The project was designed around a program of sampling, analysis, and evaluation and interpretation in terms of the objectives of the study. The scope and details of the sampling and analytical aspects were designed to determine, within budgetary and climatological limitations, 1) the amount of nutrients entering the reservoir; 2) the effect of such nutrients on the level of productivity of the reservoir; and 3) the environmental fate of these nutrients. It was particularly desired to learn whether nutrients are sequestered in the reservoir sediments or biota, escape to the surrounding environment via the atmosphere, or pass through the reservoir with outflowing water.

Sampling stations were chosen at the locations indicated in Figure 2. Initially, the reclaimed water influent to the reservoir (herein designated by the symbol, III) was sampled at the inlet to the pressure outfall line at the STPUD plant, some 27 miles from Indian Creek Reservoir. Beginning in July 1969, however, this influent sampling was made at the Luther Pass pumping station (see Figure 1, Section III), some 10 miles closer to the reservoir. Discharge from the reservoir (herein designated by the symbol, B) was sampled and measured in rate at a valved outlet pipe in the main dam from which water is discharged in significant amounts during the irrigation season. At other times continuous leakage occurs at a rate of about 15 gallons per minute due to poor seating of the valve. By June 1970 it was evident from analytical results that the chemical quality of the discharge (B) was no different than that of the reservoir water because of the high degree of mixing of the impounded water. Therefore sampling of the discharge was discontinued. A composite sample of the impounded water (herein designated by the symbol, C) was made up of several portions collected around Station 1 (Figure 2). Comparison of analyses of samples from this and other stations in the reservoir showed that Station 1 yielded a good estimate of the levels of nutrients and other constituents of the impounded reservoir water.

SAMPLING PROGRAM AND METHODS

Beginning in April 1969 the influent (III) and composite sample (C) of the reservoir were collected in one-gallon lots as often as weather conditions permitted, but generally on approximately a weekly schedule. Normally, reservoir sampling was made by use of a trailer-mounted 12-foot aluminum outboard motor boat. Of necessity this equipment had to be stored at the Lake Tahoe Area Council Laboratory some 60 miles from the reservoir, hence when road conditions made transfer of the boat difficult, a one-man inflatable rubber boat was used to collect reservoir samples.

During the 1969-70 season vertical sampling at Stations 1, 2, and 3 (Figure 2) were made over a 24-hour period at different seasons of the year in order to define variations in the horizontal and vertical distribution of various quality constituents of the impounded water. During these 24-hour sampling studies personnel camped overnight at the reservoir, using a gasoline-powered generator to provide electrical power for lighting and for operating analytical equipment such as pH meters and magnetic stirrers. When it was established that the reservoir was well mixed, the 24-hour schedule was discontinued as a routine procedure. Thereafter (1970-71) sampling in depth was made in a vertical section at Station 3 only, on each sampling date.

Bottom sediments, benthic invertebrates, phyto- and zooplankton were sampled at intervals to study the aquatic community of Indian Creek Reservoir. A composite sample of the soil from 20 stations around the impoundment was collected in the

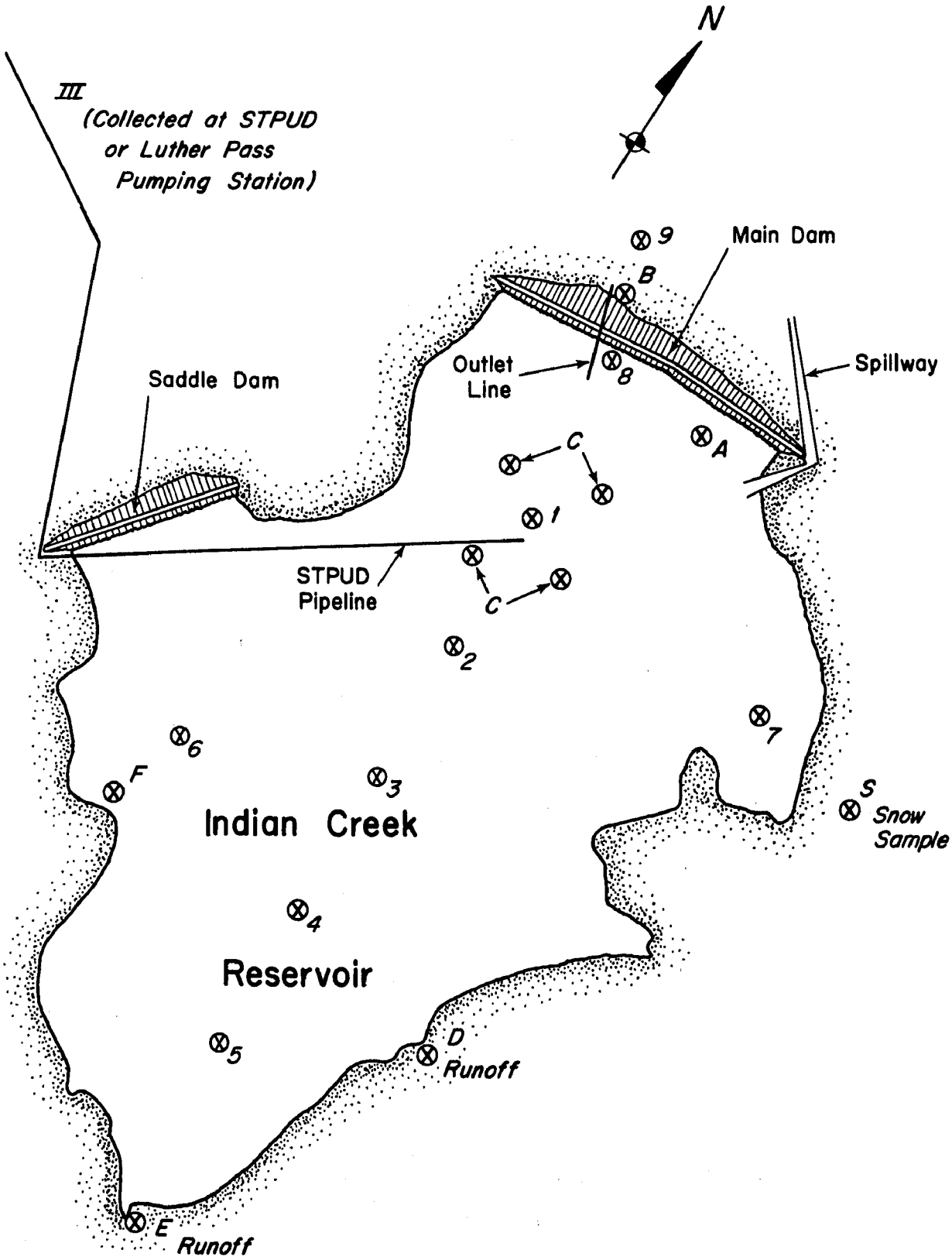

FIGURE 2. LOCATION OF SAMPLING STATIONS AT INDIAN CREEK RESERVOIR

zone above the water line from which vegetation had been stripped in preparing the site in order to get some idea of the probable organic content of the reservoir bottom initially.

Temperatures were measured using a laboratory thermometer (-10° to 110°C). Light readings were taken with a Gossen Tri-Lux C light meter with a 20x translucent filter. The Secchi depth was determined as the average point of disappearance for an ascending and descending 8 inch diameter white, flat, circular, metal plate. Reservoir depth was read from a staff gage installed at the main dam.

The influent, discharge, and reservoir composite water samples were collected directly in polyethylene bottles used as sample containers. Samples at different depths below the water surface were collected with either an all plastic-latex rubber, Van Doren water sampler or a plastic Kemmerer sampler and transferred to polyethylene bottles. Bottom sediments were sampled by means of an Ekman dredge. Although rocks and sticks interfered with operation of the dredge in some shoreline areas, it was generally not too difficult to collect adequate lake sediment (as opposed to the soil stratum constituting the reservoir bottom). Usually a depth of 1-2 inches of silty-clay was collected at each sampling site. This was screened (U. S. No. 30) when collection and analysis of benthic invertebrates was the objective, or mixed and placed in a sample container for later chemical analysis. Phytoplankton samples were collected as water samples. Zooplankton were counted directly in water samples or collected by either surface tows or vertical tows (bottom of reservoir to surface) using a Wisconsin Style Plankton net (No. 20 mesh nylon) and bucket.

Records of climate and of the flora and fauna observed in the Indian Creek Reservoir basin were also collected during the sampling trips to Indian Creek Reservoir. For example, wind direction and speed, cloud cover, and unusual climatological conditions were recorded regularly in a permanent log book. Also, visitations to the lake of deer and migratory waterfowl (principally, ducks and grebes) were observed and recorded. The location of developing vascular plant communities, floating algal material, and similar phenomena which would be expected to indicate changes in the reservoir conditions were noted. Data on the developing fish population were obtained, principally from the Department of Fish and Game.

In addition to the regular program of sampling of influent and impounded waters, samples of surface runoff were collected when such runoff was observed. However, because of the dry environment, very little runoff occurred during the summer months. As a rule summer precipitation takes place during a relatively short period of time and is rapidly absorbed or drained into the reservoir. This decreased the likelihood of personnel being on the site to obtain samples when runoff occurred.

Data obtained from studies conducted by the Environmental Protection Agency, the California Department of Water Resources and of Fish and Game, and the South Tahoe Public Utility District were also used to supplement direct observations made by the project staff.

TREATMENT OF SAMPLES

Methods of field and laboratory treatment, as well as storage, of sample were designed to maintain continuity of the work load in the laboratory without sacrificing accuracy of the results of analyses for such characteristics as: DO, COD, BOD, SS, VSS, nitrogen series, orthophosphate, total phosphorus, iron, chlorides, calcium, alkalinity, pH, conductivity, and the biostimulatory properties of various concentrations of the sample.

Water samples were normally transported to the laboratory and stored overnight in a refrigerator (< 5°C) for chemical analysis the following day. When it was not possible to begin analysis on such a schedule, the water samples were filtered and the filtrate frozen for analysis at a later time. Analysis for DO and BOD were begun in the field (reagents added up to and including the concentrated H_2SO_4).

Initially pH and alkalinity were determined in the field; however, no differences due to the time involved in transporting samples to the laboratory were observed and so all other analyses of the regular weekly water samples were performed in the laboratory. However, with the overnight sampling studies of the vertical and horizontal variations of chemical components during a 24-hour period, measurement of DO, temperature, pH, and alkalinity were made as soon as possible after collection. Samples were then composited for the different depths and stations and returned to the laboratory for further chemical analysis.

Phytoplankton were placed in brown glass jars and preserved in the field in a 5 percent Na_2CO_3 neutralized formalin solution. Zooplankton were preserved in 5-10 percent neutralized formalin in brown glass jars. The benthic invertebrates were placed in glass jars after having been screened and rinsed with reservoir water and 15 percent neutralized formalin was added for preservation. Bottom sediment samples were placed in brown glass jars and brought back to the laboratory for later analysis.

ANALYTICAL PROCEDURES

Preparation of Samples

Preliminary preparation of samples for physical and chemical analyses and bioassays varied somewhat depending on the specific method chosen for each assay. Water samples selected for flask bioassays, including Lake Tahoe water used for dilution, were filtered through Whatman glass fiber filters (GF/C) and finally through Millipore(R) filters (HA, 0.45 μ pore size). They were then stored in tightly stoppered polyethylene containers and frozen, unless the test was to begin within five days. For chemical analyses aliquots of the samples, both the unfiltered and those passed through the previously described glass fiber and Millipore(R) filters, were kept in tightly capped 2-ℓ polyethylene containers and stored in a refrigerator at temperatures approaching 0°C until all chemical determinations were completed. It was determined that no significant difference existed between chemical analyses of nutrients measured in unfiltered or filtered samples.

Chemical Assays

Chemical analyses of the filtered and unfiltered water samples were made according to Standard Methods [6] in determining biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, alkalinity, organic nitrogen, ammonia, chlorides, total phosphorus, calcium, and conductivity. Methods described by Strickland and Parsons [7] were considered more suitable for iron, nitrite, nitrate, and reactive inorganic phosphorus at the low concentrations prevailing in the Tahoe samples. Details of individual analyses are presented in Appendix G [4]. All laboratory chemical determinations were subjected to replicate analyses on aliquots of the same sample [8,9] to determine the precision of results attainable by the project staff by the analytical procedure used. The results showed that with the exception of organic nitrogen and total phosphorus in Lake Tahoe water, where concentrations are extremely small, the chemical analytical work is of good precision in terms of the coefficient of variation. A statistical analysis of the two methods of laboratory filtration (0.45 μ HA Millipore and GF/C Whatman glass fiber filter paper) indicated that there is no essential difference in the accuracy of the two methods.

Sediment chemical composition on a dry weight basis (available P, organic carbon, total N, and particle size) was determined according to methods described by Porcella, Kumagai, and Middlebrooks [10].

The technique for measuring total suspended solids (SS) and volatile suspended solids (VSS) was patterned from a combination of the procedures outlined in Standard Methods [6]; Strickland and Parsons [7]; and Maciolek [11]. Whatman glass fiber filters (GF/C) were used in solids preparation. The filters were prepared by soaking in distilled water to wash the fibers free of salts. They were then placed in a 103°C hot air oven overnight. Thereafter they were placed in a muffle furnace for

30 minutes at 450°C to destroy any organic matter present without fusing the glass fibers. After cooling, the filters were dried in a hot air oven at 103°C and tared quickly on a Mettler semimicro balance, to avoid error due to the hydroscopic nature of the dried filter. In making the solids determinations the sample was applied to the filter until the volume of sample had passed through, or until the filter was completely clogged. The volume of filtrate was then recorded. The filters with their load of suspended solids were dried overnight at 103°C and the dry weight recorded to the nearest 0.01 mg. To determine the VSS present in suspended solids the loaded filters were then redried and reweighed to verify the SS value. They were then ignited at 450°C for 2 hours, soaked with a few drops of distilled water to rehydrate the mineral matter, dried overnight at 103°C and weighed. The loss in weight was recorded as VSS in mg/ℓ.

In some cases it was necessary to revise the suggested methods in order to expand the scope of the analysis to encompass the wide range of nutrient concentrations encountered in the various samples assayed. The procedure was to prepare two standard curves for the Beckman Model B spectrophotometer, one using a 1-cm pathway cuvette and the other a 5-cm cuvette. The range of concentration for N, P, and Fe using the two pathway cells was from 1 μg/ℓ to 200 μg/ℓ. Samples in which the level of the constituent exceeded the maximum range of concentration were diluted to the concentration range of the cells by a calibrated volume of deionized water.

Flask Bioassays

Samples of STPUD effluent (III), impounded water (C), and reservoir discharge (B), as well as some selected shoreline samples, were assayed by the flask bioassay technique [8,9] both undiluted and diluted to 10% and 1% concentrations in Lake Tahoe water.

In making the assay the filtered sample was first diluted to the desired concentration with filtered Lake Tahoe water. One hundred and fifty mℓ of this solution was then placed in each of five sterile 250 mℓ Erlenmeyer flasks. Glassware used in assays was dry heat sterilized. Cells of a species of Selenastrum in good physiological condition were centrifuged and washed twice in Lake Tahoe water to minimize the chance of nutrient carry over from the stock culture to the test flasks. An equal volume of the suspended cells was then added to each test flask, so that the concentrations of cells in the 150 mℓ of liquid was approximately 50 cells/mm^3.

Loose fitting plastic beakers were inverted over the tops of the inoculated test flasks, prior to being placed in a 20°C constant temperature room and incubated on a gently moving (30 cycles/min) shaker table for a period of five days. Illumination of approximately 550 ft-c (5920 lux) intensity was provided by four 40 watt G. E. fluorescent lamps, No. F40-CW, Coolwhite, four ft in length.

The cell concentration in the test flasks were determined by cell counts at the end of 1, 3, and 5 days during the five week period of incubation. After the final counts were completed, suspended solids and pH measurements were made on a composite of the liquid in the five replicate flasks.

Test Organism

The alga Selenastrum gracile (Reinsch) was originally selected and utilized as a test organism for assays on the basis of consideration of characteristics of an ideal test organism and of favorable results reported by Skulberg [12] with the same genus. It has the disadvantage of producing large cells under rich nutrient conditions. In addition, newly formed cells tend to remain attached; but because they rarely exceed four in a group, cells are easily distinguished by "hand" counting with a microscope. These limitations were considered minor for the conditions prevailing at Tahoe when the hand procedure was used. However, in July 1969 a Model B "Coulter" counter was purchased to improve the efficiency and accuracy of cell counting. The Coulter counter functions on the principle that as each particle passes through an

orifice, it displaces its own volume of diluent within the orifice and thus momentarily changes the resistance value between the electrodes positioned on each side of the orifice. A cell count is recorded each time the resistance is changed. Thus, the attached newly formed S. gracile cells would be counted as a single cell instead of the multiple number they represent. For this reason the closely related organism Selenastrum capricornutum which has the same approximate advantages as S. gracile, but do not remain attached after division, was substituted in studies in which the Coulter counter was used.

The basic culture of the two Selenastrum species were maintained at a constant growth rate by the continuous culture method (θ = 5 days) using a nutrient solution of 10 percent Skulberg's medium (Appendix B) [4], which is specifically designed for culturing Selenastrum. The purity of the Selenastrum species was checked periodically by microscopic examination and contamination with other organisms was normally nonexistent. On one occasion this normal finding led to inadequate vigilance and a contamination of the basic culture with a "Chlorella type" organism developed between two successive microscopic checks. Consequently, the purity of the basic culture used in the assays for a period of approximately six weeks in the fall of 1969 is in question. The results of the contaminated assays are discussed in later sections.

Counting Procedures

As noted in the previous section (Test Organism) two basic methods were used to count the alga cells; the hand counting method up to July 1969 and the Coulter counter method thereafter.

The hand counting procedure was initiated by removing a 10 mℓ aliquot from each flask after an incubation time of one, three, and the final five days and centrifuging the aliquot for 10-15 minutes at 2000 rpm (approximately 800 times gravity). After centrifugation, 8-9 mℓ of the supernatant were removed with a Pasteur pipette and the pellet of cells resuspended in the remaining liquid medium. A drop of the suspension was then put on a Spencer Bright-Line hemocytometer for counting under the microscope. Duplicate counts were made for each flask and five replicates were performed for each concentration; thus a total of 30 counts were made for each concentration of sample tested. The duplicate counts for each flask were averaged, and the resulting values were then averaged to obtain a mean count for the five replicates constituting the assay.

The method used in the Coulter counter technique involved removing a 10 mℓ aliquot from each flask. The aliquot was then diluted with a saline solution so that the final concentration was from a maximum of 50 percent to the concentration that will provide a final count of less than 100,000 particles (counting capacity of the Coulter counter) for a 0.5 mℓ diluted sample. The maximum time required for each count is 13 sec. As was done in the hand count method a mean value was obtained for the five replicates.

Reliability, Sensitivity, and Precision of Cell Counting

Accurate cell counting techniques are imperative for meaningful kinetic studies of algal growth. A comparison of the results of the conventional hand counting technique versus the Coulter counter for the same samples was made. The results of the hand counting technique varied somewhat with the magnification used, but mainly with the ability of the individual doing the counting to judge representative cell concentration areas, superimposed cells, attached cells, etc. The Coulter counter, however, when in proper operating order, records each time a particle passes between the two electrodes. A coincidence correction coefficient is multiplied by the number of particles recorded by the Coulter counter, thereby, providing a statistical correction for the possibility of superimposed cells passing between the electrodes at the same time. Thus it is obvious that the Coulter counter should provide a much higher degree of sensitivity and reliability as well as the added benefit of a considerable

time saving over the hand counting technique. The reliability of the Coulter counter was emphasized when the same sample was introduced to the Coulter counter several times in succession and the difference in the numerical results were found to be insignficant (< 1 percent coefficient of variation).

Computer Analysis of Data

The computer was utilized to analyze the data more efficiently, especially to obtain values of maximum growth rate, $\hat{u}$; log maximum growth rate, $\hat{u}_\ell$; mean maximum cell concentration at the end of the growth period, $\hat{X}$. The computer was also utilized to determine the mean, coefficient of variation, range of 95 percent confidence levels, and correlation factors. These determinations and their significance are discussed in sections which follow.

SECTION V

RESULTS OF STUDY

INTRODUCTION

Pursuant to the objectives and the program outlined in Section III, physical, chemical, and biological observations were made of the progressive changes in the water budget and in water quality in Indian Creek Reservoir (ICR). The results of these observations are hereinafter presented and discussed; and further evaluated in Section VI. The data presented and analyzed were collected by members of the project staff; by the South Tahoe Public Utility District and the U. S. Weather Bureau as a part of their normal operating procedures. Estimates by Clair A. Hill and Associates for the STPUD [2] were also used in computing the water budget of the reservoir.

PHYSICAL OBSERVATIONS

Water Budget of ICR

Filling of Indian Creek Reservoir was begun on March 31, 1968. Table 1 summarizes the input of reclaimed water and withdrawals of stored water from the reservoir as reported monthly by the STPUD during the subsequent three years (April 1968 through April 1971), together with calculations which permit some preliminary conclusions concerning the water budget of the reservoir.

Columns 1 through 4 of Table 1 represent data taken directly from the STPUD reports, converted to ac-ft units. Column 5 represents the volume of water in ac-ft which would have been in the reservoir at the end of each month were there no inflow from surface runoff, or loss of water through evaporation to the atmosphere and infiltration into the soil underlying the reservoir. It may be noted that in some instances these theoretical values exceed the actual 3130 ac-ft capacity of the reservoir. Overflow, however, did not in fact occur because of actual losses and lack of overriding inputs by surface runoff. Column 6 reports estimates of the actual reservoir volume based on depth gage readings and a cumulative capacity curve [2,4] in ac-ft.

From Table 1 it is noteworthy, though to be expected, that during the winter of 1968-69 the volume of water impounded in the reservoir increased rapidly in comparison with the reclaimed water input. For example, by the end of April 1969 the actual volume of impounded water was 2280 ac-ft as compared with 1327 ac-ft pumped to the reservoir from South Lake Tahoe. The difference, 953 ac-ft, therefore represents the accumulation due to surface runoff after all infiltrative and evaporative losses have been charged off. Subsequently, during the summer of 1969 the withdrawal of 522 ac-ft in August and September did not change the volume of water impounded in the reservoir. Consequently this value may be taken as a rough estimate of the net input to the reservoir during a two-month period from sources other than reclaimed water. Similar estimates of the net inflow during 1970 and 1971 may be derived from the data presented in Table 1.

Data from Table 1 for each of two 12-month periods are utilized in Table 2 in developing a water budget for Indian Creek Reservoir. These data are designated by the symbols I, D, and ΔS in the table. Other values for use in the water balance equation, $E + P_O = I + RO + P_L - D - V_O - \Delta S$, were estimated as hereinafter outlined. Definition of each symbol in the equation is noted in column 3 of Table 2.

TABLE 1

SUMMARY OF RECLAIMED WATER INPUTS TO INDIAN CREEK RESERVOIR
(April 1968 – April 1971)
(STPUD Monthly Reports)

1	2			3		4	5	6
Year and Month	Daily Flow to Indian Creek Reservoir (mgd)			Total Inflow For Month		Widthdrawn for Irrigation	Cumulative Total (Input Minus Withdrawn)	Total in Indian Creek Reservoir Observed or Computed
	Maximum	Minimum	Average	(mgd)	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)
1968								
Apr	2.4	0.9	1.84	55.1	169	0	169	
May	2.4	1.9	1.96	60.77	186	0	355	
Jun	3.1	0.0	2.4	66.9	205	0	560	
Jul	3.3	1.8	2.7	82.8	254	302	512	
Aug	2.7	1.9	2.5	76.7	235	369	378	
Sep	3.6	0.0	1.7	51.6	158	414	122	
Oct	1.8	1.1	1.6	48.0	147	0	269	280
Nov	2.2	0.2	1.52	37.9	116	0	385	
Dec	2.5	0.8	1.6	49.8	153	0	538	
1969								
Jan	4.1	1.1	2.2	69.0	212	0	750	
Feb	2.5	1.4	1.9	53.9	165	0	915	
Mar	3.8	1.6	1.9	57.5	176	0	1091	
Apr	3.3	2.2	2.6	76.8	236	0	1327	2280
May	3.0	1.0	2.1	63.9	196	0	1523	2200
Jun	3.8	2.0	2.67	81.0	249	0	1772	2300
Jul	2.8	2.2	2.5	75.9	233	0	2005	2350
Aug	3.0	1.9	2.7	82.3	253	319	1939	2150
Sep	2.6	1.8	2.1	61.9	190	203	1926	2100
Oct	2.0	1.5	1.8	56.4	173	0	2099	2150
Nov	2.04	1.07	1.67	50.18	154	0	2253	2100
Dec	3.37	1.28	2.06	63.93	196	0	2449	2300
1970								
Jan	5.40	1.74	2.80	86.97	267	0	2716	
Feb	3.16	2.10	2.34	65.52	201	0	2917	3080
Mar	3.01	1.87	2.31	58.19	178	0	3095	
Apr	2.32	1.06	2.05	61.55	189	0	3284[a]	3100
May	3.04	1.89	2.14	66.49	204	4	3484[a]	3080
Jun	3.22	2.05	2.51	75.45	232	152	3564[a]	3000
Jul	3.26	2.32	2.75	85.29	262	629	3197[a]	2700
Aug	3.36	2.70	3.01	93.57	287	951	2533	1940
Sep	3.37	1.96	2.47	74.12	227	614	2146	1540
Oct	2.35	1.77	2.06	64.04	197	0	2343	1520
Nov	2.77	1.62	2.06	61.96	190	0	2533	1620
Dec	3.24	1.52	2.28	70.70	217	0	2750	1820
1971								
Jan	3.9	1.2	2.36	73.2	225	0	2975	2080
Feb	3.6	1.5	2.49	70.0	215	0	3190[a]	2260
Mar	3.3	2.1	2.56	79.2	243	98	3335[a]	2410
Apr	3.4	2.5	2.8	84.5	259	25	3569[a]	2600

[a]Exceeds 3130 ac-ft, capacity of Reservoir.

TABLE 2

WATER BUDGET, INDIAN CREEK RESERVOIR

1	2	3	4
Time Period	Symbol	Item	Quantity (ac-ft)
April 1969 through March 1970	E	Evaporation from reservoir surface	387
	P_o	Percolation through reservoir bottom	2426
	I	Influent reclaimed water from STPUD	2674
	RO	Sub-basin drainage into reservoir	1145
	D	Water discharged from reservoir	522
	P_L	Precipita directly on reservoir	340
	V_o	Leakage through reservoir outlet valve	24
	ΔS	Change in volume of impounded water during period shown in column 1	+800
April 1970 through March 1971	E	Evaporation from reservoir surface	450
	P_o	Percolation through reservoir bottom	1375
	I	Influent reclaimed water from STPUD	2687
	RO	Sub-basin drainage into reservoir	815
	D	Water discharged from reservoir	2448
	P_L	Precipitation directly on reservoir	225
	V_o	Leakage through reservoir outlet valve	24
	ΔS	Change in volume of impounded water during period shown in column 1	-570

Evaporation from the reservoir surface (E) was computed from the reservoir water surface corresponding to the average gage height observed for each month of the year, multiplied by the average evaporation rate for free water surfaces in the Indian Creek area for the corresponding month. Depth-Area and Monthly Evaporation Curves developed by Clair A. Hill and Associates [2,4] were used in this computation.

Precipitation on the ICR drainage area, and directly on the reservoir suface (P_L), was taken from the U. S. Weather Bureau records at Woodfords which showed 28.02 inches for the 1969-70 12-month period. For the 1970-71 period the long-term average value of 20 inches [2,4] was used.

Runoff (RO) was computed from monthly precipitation values (observed or average) multiplied by monthly runoff factors estimated by Clair A. Hill and Associates [2,4].

Leakage through the reservoir outlet (V_o) was determined by measurements made by the project staff, which showed about 15 gallons per minute as an average value.

Percolation losses through the reservoir bottom (P_o) were obtained by differences, using the water balance equation. Thus the value for percolation reported in column 4 of Table 2 represents actual percolative losses from the reservoir, plus or minus the net error in assumption in evaluating other items in the water balance equation.

In exploring the inherent error resulting from the foregoing approach it was previously reported [4] that during the summer months of 1969-70 the apparent loss of

water by percolation was around 0.035 feet of water per day. Such a value has been shown [13] to be within the range which might be expected in tight soils continuously inundated for more than a year. The apparent percolative losses for the full 1969-70 and 1970-71 years of Table 2 are about 0.048 and 0.028 feet per day, respectively. Neither of these values take into consideration the greater percolative capacity of soils that are drained when the depth of water in the reservoir is decreased during discharge – a refinement that is impossible to achieve with the available data. Nevertheless, the values are reasonable and consistent with the well-known fact that the rate of infiltration into a continuously inundated soil decreases with time. Consequently they support the general conclusion that the water balance shown in Table 2 is a reasonable estimate. From column 4, however, it may be seen that the estimated annual input to the reservoir from runoff and direct precipitation is of the order of 24 to 34 percent, as compared to the anticipated average annual value of 30 percent (Section III).

Physical and Environmental Parameters of ICR

Weekly observations of several physical parameters of Indian Creek Reservoir reported in Table 13 (Appendix) are summarized in Table 3 for the period of study. Results of similar 24-hour observations appear in Table 14 (Appendix). Such detailed data as clarity (Secchi), air and water temperature variations throughout the day and with depth below the water surface are of particular importance in evaluating the quality of water in the reservoir and its relationship to observed biological changes. In the context of the physical characteristics of the reservoir, however, Table 3 is adequate to reveal the magnitude and variation in water and air temperatures, and in the clarity of the water as measured by the Secchi disk.

Clarity of Water. During the period May 1969 to May 1971 the clarity of the water in Indian Creek Reservoir varied from 2.27 to 21.5 feet (0.8 to 6.5 meters). Figure 3 summarizes the Secchi disk data reported in Tables 3 and 13 (Appendix). It shows that as the reservoir became more mature there was a marked tendency for the clarity to increase. For example, during 1969 the maximum clarity occurred in December when the Secchi disk reading exceeded 11 feet. However, in 1970 values in the 19 to 21-foot range appeared in April and July, and again in the October to December period. In both years a period of high clarity appeared in the month of July, with minimum values occurring in February and March. It is difficult to document the exact causes of the winter decline in clarity. The greatest surface runoff occurred in December 1969. This might be expected to bring in appreciable suspended solids from surface wash. Considerable algal growth occurred in the February-March period in both years, giving a green cast to the water and quite obviously reducing its clarity. However, it might be said in general that the clarity of Indian Creek Reservoir was typical of shallow impoundments of good quality water.

Temperature. From Table 3 it is evident that water temperature in the surface zone followed ambient air temperature in a normal manner, with less response to transient climatological phenomena. Of greatest significance to the water quality and biological productivity of the reservoir is the fact that the near-surface water temperature maintained levels in the 18-22°C range over essentially a four-month period each year. Figure 4 shows that the water temperature pattern for the 1969-70 year was essentially repeated in the 1970-71 period. Data presented in Table 13 (Appendix) show that some thermal stratification was evident from late May to mid-July 1970 at which time the temperature drop from surface to bottom of the water was of the order of 3 to 7.5°C. In September 1969 and again in September 1970 there was no temperature difference between the surface and the 14-meter level, indicating good vertical mixing. That this was not simply the effect of the aeration turnover system is evidenced by the thermal profile which existed in previous months under similar aeration.

Environmental Factors. Although no daily observations are available at Indian Creek reservoir to identify the environmental factors of climate some general observations are reported in column 8 of Table 3. Clear weather prevailed throughout the report period. Wind direction seems to be heavily influenced by the adjacent mountain

TABLE 3

WEEKLY OBSERVATIONS OF ENVIRONMENTAL DATA, INDIAN CREEK RESERVOIR
(MAY 1969 – May 1971) .

1	2	3	4	5	6	7	8
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)[a]	Air Temp. (°C)	Light Intensity (ft-c)	Remarks
May 1969							
29	-	1.68	49.75	17	-	-	-
Jun							
4	-	1.17	49.8	18	-	-	-
19	-	0.91	50.1	18	-	-	-
24	-	2.18	50.4	18	-	-	-
Jul							
1	-	2.05	50.5	18	-	-	-
10	-	1.47	-	19	-	-	-
17	1140	2.22	50.7	22	-	6600	Clear, sunshine, slight westerly breeze, 2"-4" chop, water slightly turbid
22	1430	1.81	50.7	23.1	29.4	-	Cloudy, thunderstorm in distance, septic odor detected near reservoir outlet
29	0945	3.12	50.85	22.2	22.8	4900	Very clear, few small clouds, southerly wind strong at times
Aug							
5	1030	2.68	50.85	20.8	25.5	5400	Clear skies, northerly wind
12	0930	1.50	50.95	20.3	25	4600	Skies crystal clear, water surface like glass
19	1030	1.75	50.25	20	21.7	5200	Clear skies, winds northwesterly
Sep							
2	1530	2.69	49.34	21	31	4600	Cloudy, wind constant from southwest, water surface choppy
10	1545	1.95	49.5	20.5	29.5	4600	Clear, few small clouds, wind calm to breeze from west, water surface glassy to rippled
15	1245	1.22	49.6	19	22.6	5600	Strong west winds 15-20 mph, 20-30 mph at 1645 hr, waves 6"-10"
25	1245	1.40	48.2	17	25	5500	Clear, slight winds fron northwest, ripples on water surface
Oct							
2	1420	1.12	49.2	16	20.5	5200	Thin clouds, wind northerly, water near dam appeared extremely dark
8	1400	-	48.6	14	-	2200	Storm clouds, northerly winds 30-40 mph, waves 18" amplitude
16	1320	1.27	48.6	9.5	12	4000	Patchy clouds, winds southwesterly strong at times, water rough but no whitecaps
24	1050	1.88	48.7	9	13.5	1340	Cumulus cloud, overcast, slight breeze from southwest, water surface calm
30	1015	2.18	48.75	9	11.3	4400	Clear, sunny, no waves
Nov							
13	1150	2.80	48.83	8.5	16	4200	Clear and sunny, water calm
19	1125	2.80	49.0	6.5	11	5000	Clear skies, thin clouds, slight northwest breeze, water surface ripples
26	1125	3.04	49.1	5	9	4000	Clear skies, light clouds
Dec							
3	1055	3.46	49.2	4	11	4000	Clear, thin clouds, water surface like glass
16	1100	2.64	49.8	3	11	4600	(Dec 15 no wind) Dec 16 southwest wind too strong for sampling all stations, wave amplitude 2-3 ft
Jan 1970							
5	1410	2.80	50.8	4	-0.5	2800	Clear blue skies, slight southwest breeze, lake frozen over except small area to west, ice 5" at sampling station
Feb							
5	1315	0.81	54.1	4.2	10	2000	Cloudy, overcast, wind slight southwest
18	1310	0.85	54.6	4	5	6400	Sky blue to partly cloudy, clouds large dark, wind slight and northerly
Mar							
3	1211	0.99	54.75	5	8	6400	Bright sunny, southwesterly winds strong, wave amplidude 8-10"
18	1200	0.86	55.5	6.8	4.2	6400	Clear and bright, few clouds, light breeze, waves 2-3"
26	1145	0.84	55.2	8.2	12	5200	Clear to partly cloudy, slight northerly wind, waves 2-3"

*NOTE: Subsequently in April and May 1970 readings increased to 4.0-5.8 m.

[a]At one ft below water surface.

TABLE 3 (Continued)

1	2	3	4	5	6	7	8
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)	Air Temp. (°C)	Light Intensity (ft-c)	Remarks
Apr 15	1200	5.89	55.5	10.0	7.0	-	Partly cloudy, numerous mosquito-like insects on water surface.
23	1100	5.83	55.6	10.5	9.5	-	Snow, partly cloudy, floating chunks of algae observed near shore.
30	1230	5.80	55.6	9.5	11	-	Clear sky, partly cloudy, slight ripple, approximately 75-100 water fowl.
May 7	1250	4.88	55.8	14.0	18.0	-	Clear sky, numerous fishermen, floating chunks of algae all over surface.
19	1115	4.12	55.5	13.4	15.7	-	Partly cloudy, windy, well mixed, few swallows, black birds on shore.
27	1220	1.65	55.5	16.5	16.5	-	Partly cloudy, several fishermen, slight breeze gusting at times.
Jun 4	1225	3.75	55.3	19.5	26.5	-	Clear sky, partly cloudy, approximately 25 fishermen, 2 boats, lake smooth, outlet open.
16	1240	2.53	54.9	15.5	19.5	-	Clear sky, cloudy, numerous campers and fishermen, 2 boats.
25	1230	3.97	54.8	20.5	23.5	-	Cloudy, 8 fishermen, approximately 25 water fowl, 4 cows grazing.
Jul 1	1145	5.22	54.4	18.5	23.5	-	Clear sky, numerous sportsmen, black snails noted near dam.
7	1235	5.47	54.0	21.0	23.0	-	Clear sky, partly cloudy, slight northerly, 15 to 20 fishermen.
16	1245	4.27	53.8	21.0	17.4	-	Clear sky, outlet open, moderate south westerly, 6" to 8" waves.
21	1420	3.24	53.6	22.5	26.0	-	Clear sky, partly cloudy, brisk westerly, numerous fisherman, one boat.
30	1150	1.89	50.7	20.8	23.0	-	Clear sky, white precipitate on dam indicating water level drop, decrease on south end indicated by algae and mud.
Aug 7	1400	1.56	49.2	20.8	26.8	-	Clear sky, black algal crust on bouys, strong south westerly.
14	1330	2.16	48.0	21.7	27.0	-	Clear sky, "no overnight camping" signs posted, few gulls, 6 ducks.
18	1315	2.62	47.4	21.8	27.0	-	Clear sky, partly cloudy, light wind from the south, 24 hr sampling trip.
19	1330	2.41	47.2	21.3	27.5	-	Clear sky, partly cloudy, water level low exposing considerable benthic plants.
26	1235	2.26	46.9	20.0	23.0	-	Clear sky, partly cloudy, approximately one dozen 10" to 16" catch observed from boat, fishermen, 100+ water fowl of various species, 3 boats.
Sep 4	1230	2.04	44.7	17.7	25.0	-	Clear sky, few fishermen, no boats, strong southerly approximately 30+ mph.
10	1415	2.93	43.9	18.2	28.0	-	Clear sky, slight to moderate southerly, few fishermen.
17	1230	4.15	44.0	16.3	23.0	-	Clear sky, flying insects a nuisance, Daphnia noted in DO samples.
23	1300	5.43	44.1	15.0	25.0	-	Clear sky, approximately 10 fishermen, 2 boats, small flock of water fowl, Daphnia still noted.

TABLE 3 (Continued)

1	2	3	4	5	6	7	8
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)	Air Temp. (°C)	Light Intensity (ft-c)	Remarks
Oct 1	1230	5.62	43.5	14.3	23.0	-	Clear sky, surface glassy, thousands of black snails, approximately .60 mm dia. collected in dredge.
9	1235	5.83	44.0	13.0	21.5	-	Clear sky, partly cloudy, approximately 10 fishermen, observed several catch 12" to 14".
14	1215	6.13	44.0	13.0	19.0	-	Clear sky, approximately 200 coots, numerous fishermen, 1 boat, numerous Daphnia.
22	1225	4.06	44.2	9.5	9.5	-	Clear sky, partly cloudy, strong southerly, 8" to 10" waves, 4 or 5 fishermen.
28	1200	6.53	44.4	7.5	14.0	-	Clear sky, partly cloudy, large Daphnia at 8 m, approximately 6 vehicles, 2 rubber rafts, 1 motor boat.
Nov 6	1230	3.51	44.9	7.0	6.0	-	Rain, snow, strong south westerly, appears to be well mixed.
11	1335	4.27	45.0	7.4	11.0	-	Partly cloudy, strong south westerly, 8" to 12" waves, approximately 15 vehicles with fishermen.
18	1200	5.50	45.1	6.8	8.5	-	Clear sky, partly cloudy, fishing season closed, coot population diminished considerably.
24	1300	-	45.3	7.8	19.0	-	Clear sky, partly cloudy, strong south westerly, too windy to launch, grab samples taken.
Dec 9	1400	3.54	46.7	2.8	6.0	-	Clear sky, several fish jumping, numerous deer tracks along road, 2 hunters.
15	1145	4.58	46.9	2.7	12.0	-	Clear sky, partly cloudy, 1/2" ice in middle of lake, aerators just turned on.
Jan 1971 6	1215	5.19	48.0	2.9	-3.0	-	Clear sky, entire lake frozen, approximately 7" ice, aerators not working, numerous deer tracks.
27	1150	5.50	49.6	4.0	9.5	-	Clear sky, lake approximately 50 percent frozen with approximately 1" ice, slight northerly wind.
Feb 10	1315	1.83	50.0	5.5	17.0	-	Clear sky, extremely green cast over entire lake, no wind.
22	1215	1.53	50.6	5.0	6.0	-	Cloudy, green cast over entire lake, wind southwest at approximately 5 mph.
Mar 9	1300	1.22	51.0	4.5	11.0	-	Cloudy, 6" to 8" waves, approximately 50 coots.
15	1255	1.07	51.6	4.9	10.0	-	Clear sky, partly cloudy, 2" to 3" waves, no water fowl observed.
24	1250	0.92	51.7	4.9	11.0	-	Partly cloudy, green cast over lake, several species of birds and water fowl, 3" to 5" waves.
Apr 5	1130	0.79	52.1	10.0	19.5	-	Clear sky, partly cloudy, green cast over lake, two ducks observed.
19	1140	1.65	52.5	10.2	15.5	-	Clear sky, slight ripple, approximately 50 ducks, numerous flying chironomus near shore.
May 5	1155	5.98	53.0	12.0	16.0	-	Partly cloudy, approximately 10 anglers, approximately 25 water fowl, slight ripple.
17	1230	-	53.2	14.0	16.0	-	Clear sky, numerous birds of several varieties, several fishermen.

[a]At one ft below water surface.

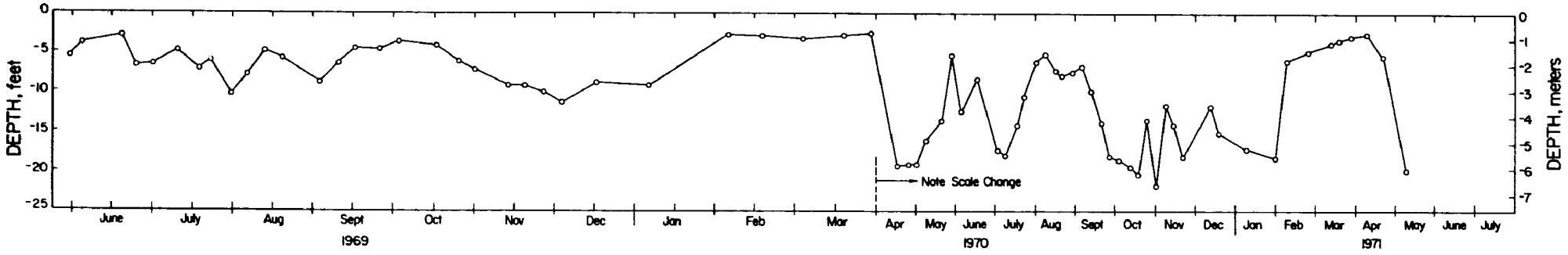

FIGURE 3. CLARITY OF INDIAN CREEK RESERVOIR, (SECCHI DISK)

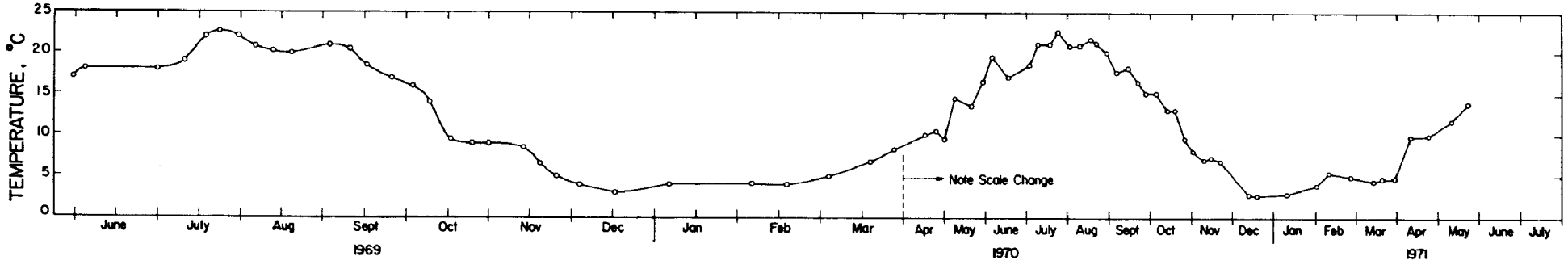

FIGURE 4. VARIATION IN SURFACE WATER TEMPERATURE (TOP 1/2 METER), INDIAN CREEK RESERVOIR

range, with southwesterly or northwesterly winds most common. Only on rare occasions was the water surface free of ripples or waves due to wind, a fact which undoubtedly reduced the clarity as measured by the Secchi disk. The roughest water observed resulted from strong southwesterly winds in October and December, and from northerly winds in March.

Wind movement across the reservoir undoubtedly has an important effect on mixing of the reservoir. From Figure 2 (Section IV) it may be seen that a southerly wind roughly parallels the long axis of the reservoir, moving from the shallowest water towards the dam. Waves induced by such wind action then tend to stir up sediments in the shallows and, if of any duration, to pile up water at the deepest end of the reservoir. Subsequent movement of water is therefore from the reclaimed water inlet (near the dam) to the shallow southerly end of the pool. A northerly wind, of course, develops a seiche that results in a return flow to the dam when calm is restored. Southwesterly winds blow toward the lake shore northeast of the dam (see Figure 2) and, because of the protection of a high ridge at the west abutment of the dam, can be expected to initiate a counterclockwise movement of surface water in the reservoir. This should have a mixing effect, at least in the deeper portion of the impoundment north of an east-west line passing through the saddle dam. It is concluded that the well mixed condition found to exist in Indian Creek Reservoir is to no small degree a result of wind movement and direction.

Some more general environmental factors of ICR were presented in Section III. Initially the reservoir site was remote from human activity, with only cattle and deer grazing in what is now its shallowest portion. Such domestic and wild animals continue in the area, but as noted in Table 3 the reservoir has proven extremely attractive to fishermen and harbors various species of wildfowl.

CHEMICAL OBSERVATIONS

Daily observations of the chemical and bacteriological quality of reclaimed water exported to Indian Creek Reservoir by the South Tahoe Public Utility District were compiled by the District from the beginning of export March 31, 1968 and reported on a monthly basis thereafter. Analyses of the impounded water were begun by the LTAC Laboratory on October 3, 1968, prior to the beginning of the EPA Indian Creek Reservoir Demonstration Grant, as a part of ongoing studies of eutrophication of surface waters likewise supported by the EPA [5]. Beginning in April 1969, analysis of the exported reclaimed water was made also by the LTAC Laboratory as a part of its weekly sampling program at Indian Creek Reservoir. Analysis of surface and ground waters in the vicinity of the reservoir made by the California Department of Water Resources have been reported [4].

BOD and COD

From results of BOD analyses obtained during the first year of study [4] it was evident that the Biochemical Oxygen Demand of the reclaimed water exported to Indian Creek Reservoir (III) was extremely low, averaging only about one mg/ℓ. Therefore routine BOD examinations of reservoir influent were discontinued in March 1970.

Values of COD in the influent and impounded water of ICR are reported in Table 13 of Appendix. Due to an imperfection in laboratory technique, COD data collected prior to June 1970 are considered unreliable and are therefore not summarized in Figure 5. From the figure it is evident that there was little difference in influent and impounded water in terms of COD. There is, however, a slight tendency for the impounded water to be higher in Chemical Oxygen Demand, especially during the spring growing season when, as noted in relation to clarity (Figure 3), the presence of algae in the impounded water was evident.

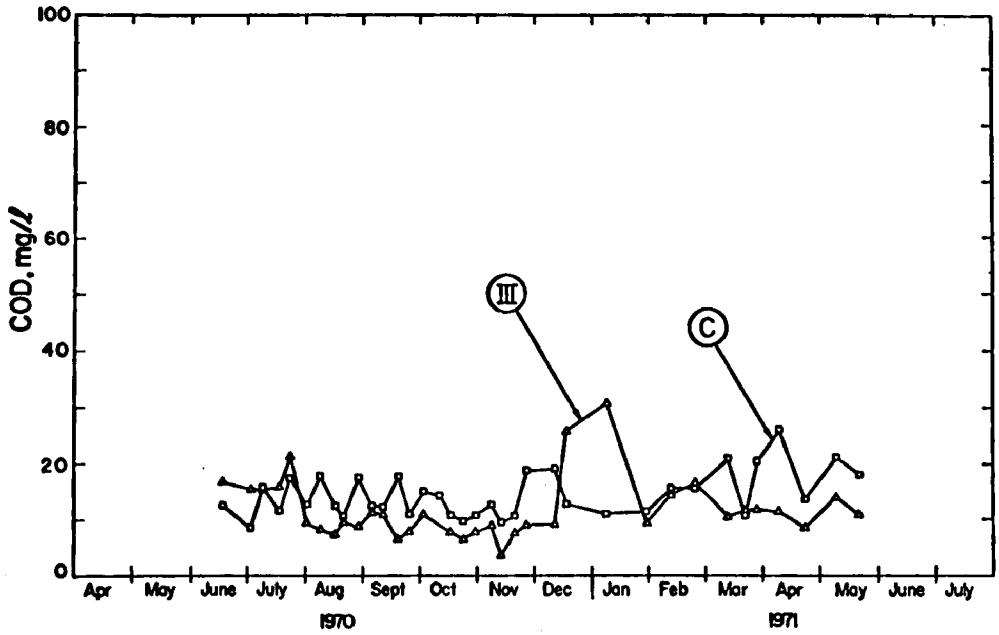

FIGURE 5. VARIATION IN COD, INDIAN CREEK RESERVOIR

Suspended Solids (SS)

Results of the suspended solids analysis reported in Table 13, Appendix, were analyzed both in terms of clarity versus SS and variation in SS with time and season. In Figure 6 are plotted Secchi disk readings in relation to suspended solids in the impounded ICR water at the time of reading. Although there is a variability in clarity at any given SS value, which is explainable in terms of water surface disturbance and other variables, the general curve takes the form to be expected of a clarity-turbidity relationship. At levels of SS below about 2 mg/ℓ this relationship is no longer evident. However, considering the nature and limitations of the Secchi disk test it is perhaps surprising that the relationship continues to be evident at such low concentrations as appear in Figure 6. Comparison of Figure 3 with Figure 7 reveals the expected inverse relationship between water clarity and suspended solids in the impounded water, the lowest Secchi disk reading appearing at times when peaks occurred in the SS curve.

The correlation coefficient for suspended solids versus reciprocal clarity was found to be 0.88 and the regression coefficient was 25 mg SS/ℓ/ft Secchi disk depth. When the data on SS were segregated into two groups (> 50% VSS, and < 50% VSS) it was found that although the correlation coefficients were comparable (0.93 and 0.87, respectively), the regression coefficients were quite different, varying from 31 mg SS/ℓ/ft for the > 50% VSS material to 21 mg SS/ℓ/ft for the < 50% VSS material. Thus considerable effect of the presence of algae as VSS on the relationship between SS and Secchi depth occurs, probably because of the absorption of the longer wave lengths of light (red) by green algae.

Figure 7 presents the suspended solids data on a time sequence for the period of study. As previously noted, the general similarity of impounded water (C) and reservoir discharge (B) justified dropping the latter from the sampling schedule in March 1970. As might be expected, the reclaimed water tended to be reasonably constant in suspended solids content except for an occasional peak. Nevertheless, during the period April 1970 to May 1971 it varied from a low of 0.43 mg/ℓ to a high of 4.43 mg/ℓ. During this same period the SS concentration in the impounded water varied from 0.66 mg/ℓ to 9.07 mg/ℓ.

The excess of SS in impounded water over that in reclaimed water is most impressive in the early growing season (January to March) of each year. The effect of climatological factors on the suspended solids in the reservoir is evident in the data for October 1969 and again in November 1970. In the first instance (see Table 3) heavy

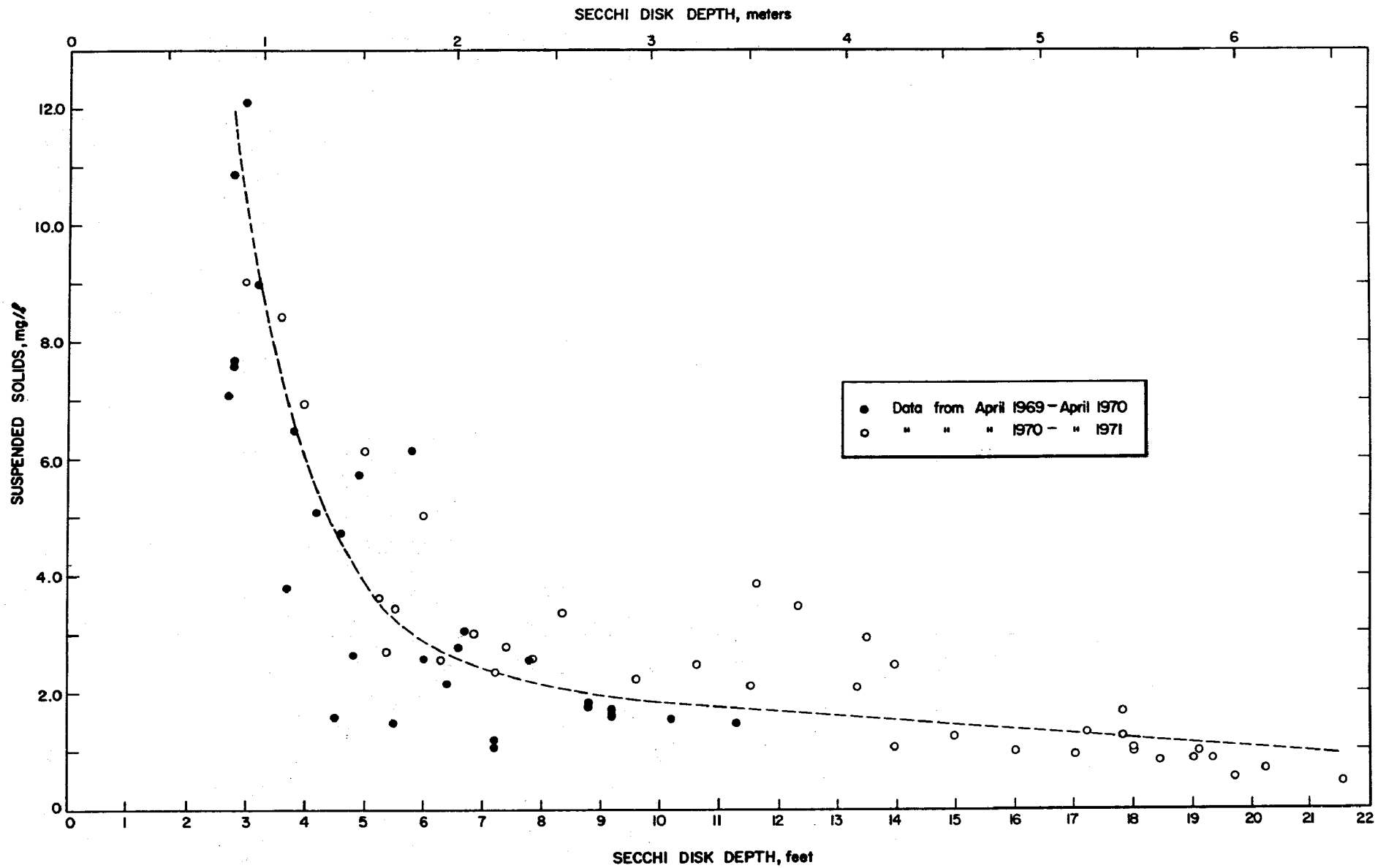

FIGURE 6. CLARITY OF WATER (SECCHI DISK) AS A FUNCTION OF SUSPENDED SOLIDS

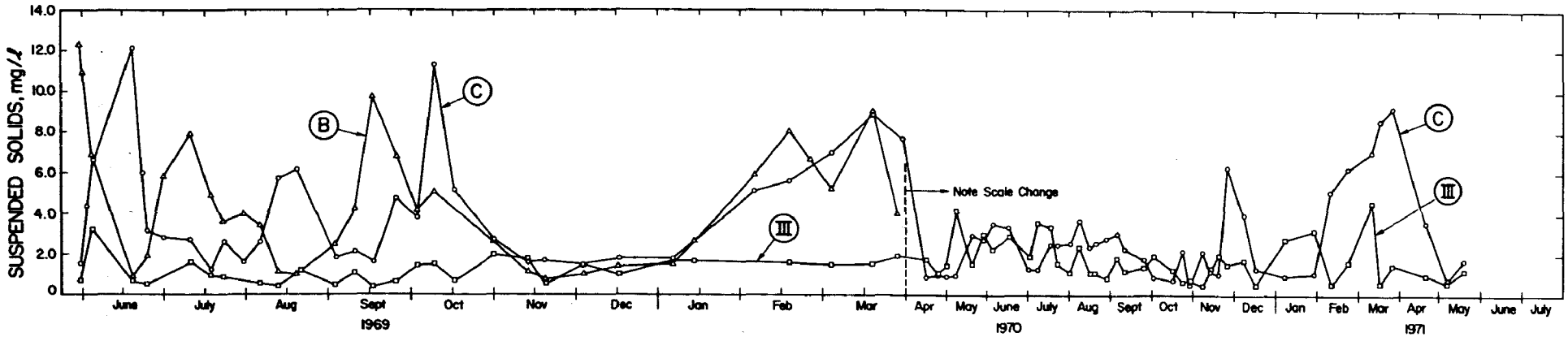

FIGURE 7. VARIATION IN SUSPENDED SOLIDS, INDIAN CREEK RESERVOIR

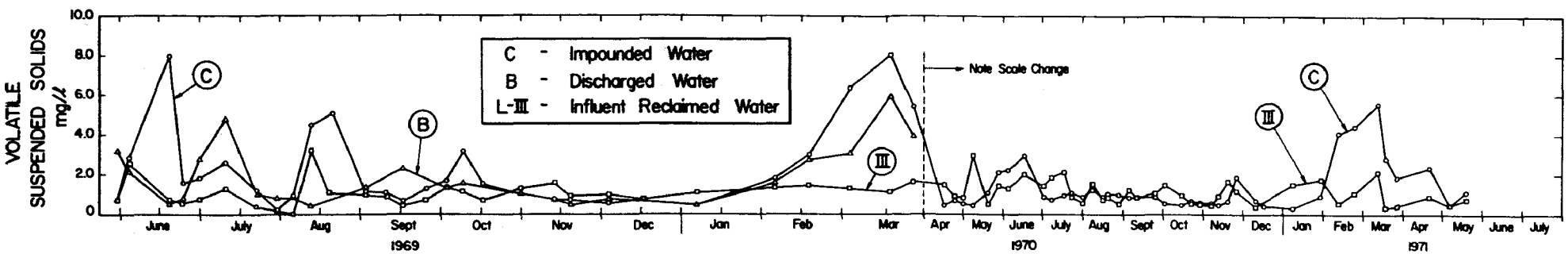

FIGURE 8. VARIATION IN VOLATILE SUSPENDED SOLIDS, INDIAN CREEK RESERVOIR

winds prevailed at the reservoir. In the latter instance winds were too strong to permit launching of the sampling boat and data had to be taken from a grab sample obtained near the shore.

Volatile Suspended Solids (VSS)

Figure 8 shows a tendency for the VSS in the impounded water to be like that of the influent reclaimed water except during the spring growing season and on a few other less obviously explainable occasions. Thus VSS, as might be expected in a situation such as Indian Creek Reservoir, tends to follow the same pattern as the total suspended solids (SS). A comparison of Figure 8 with Figure 7 shows this generally to be the case. However, a careful analysis of Table 13 (Appendix) shows that on several occasions the SS/VSS ratio was greater than normal (e.g., 3 to 1). Reasons for this variation are not fully documented nor self-evident. It may well be that wind disturbance, together with pulses in the aquatic community, are the principal factors. At any rate on 8 of 13 occasions when the SS/VSS ratio exceeded 3 to 1 strong winds were blowing at the time of sampling. On three other occasions the winds were light; and on two occasions no apparent cause was identified. In as much as wind conditions at Indian Creek Reservoir are unpredictable and no continuous wind records are available, and the VSS levels involved are only in the 1 to 2 mg/ℓ range, there is nothing implausible about the observed variation in SS/VSS ratio although its causes are not fully identified.

Iron

The iron content of influent reclaimed water averaged higher than that of the impounded water. Because iron was measured in filtered samples, such a condition could result from the taking up of influent iron by living cells or by precipitation of iron from the impounded water. The former would indicate that iron is an important factor in the production of biota in the reservoir, whereas the latter would be of little significance. Further evidence may be derived from a study of Figure 9.

Figure 9 shows that the concentration of iron in influent and impounded water was variable, particularly on a seasonal basis, being higher during the summer months when the visitor load on the Lake Tahoe Basin is greatest. Analysis of raw sewage at the STPUD plant [14] in 1968-69 shows clearly that the waste water is much more concentrated in summer than in winter. For example, total nitrogen on June 25, 1968 was 42 mg/ℓ. On January 18, 1969 it was but 17 mg/ℓ. Similar reductions were observed in other constituents of the raw sewage.

From June to November 1969 there was a tendency for the impounded (C) and discharge water (B) curves to parallel each other, but little tendency to follow the pattern of influent iron (III). The greatest concentration of iron in the reservoir water was observed in June 1969 coincident with similar high concentrations in SS and VSS. Again in the spring and summer of 1970 the concentration of iron tended to follow the same pattern as that of suspended solids. This indicates that the presence of iron was related to the solids. However, because iron was measured in a filtered sample it could not have been incorporated in algal cells, although it may have been in the recycling process.

After June 1969 there was a pronounced tendency of iron to decrease when SS and VSS increased. This suggests that iron may have been an important factor in the production of biota in the reservoir during the growing season. During the winter of 1969-70 it is not clearly evident where the iron was located in the system. Most likely the summer input of iron was tied up in dead cells on the reservoir bottom and the impounded water reflected the influent iron concentration unchanged for lack of biological activity at the low temperatures of winter. Thus there is evidence that iron in the influent water is utilized in the biological cycle of Indian Creek Reservoir, although there is no evidence that it is a limiting element.

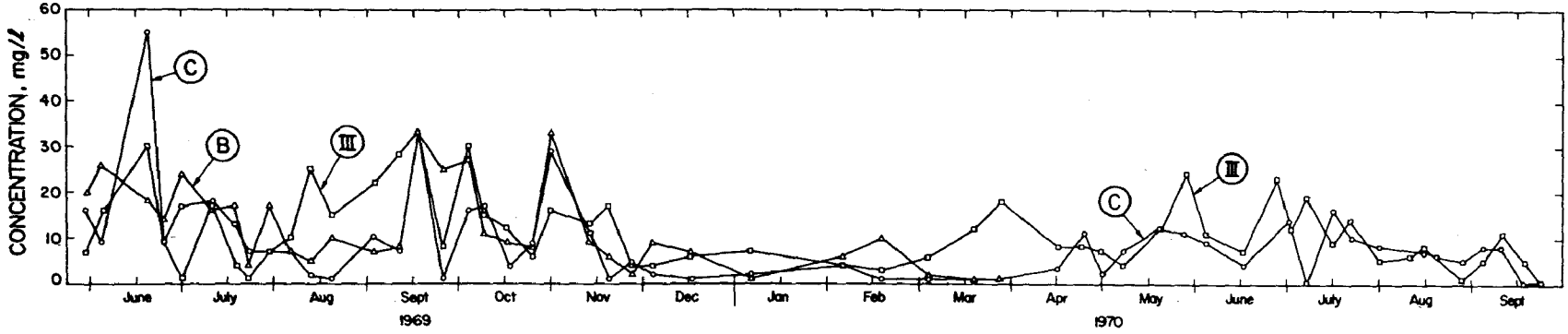

FIGURE 9. VARIATION IN IRON CONCENTRATION, INDIAN CREEK RESERVOIR

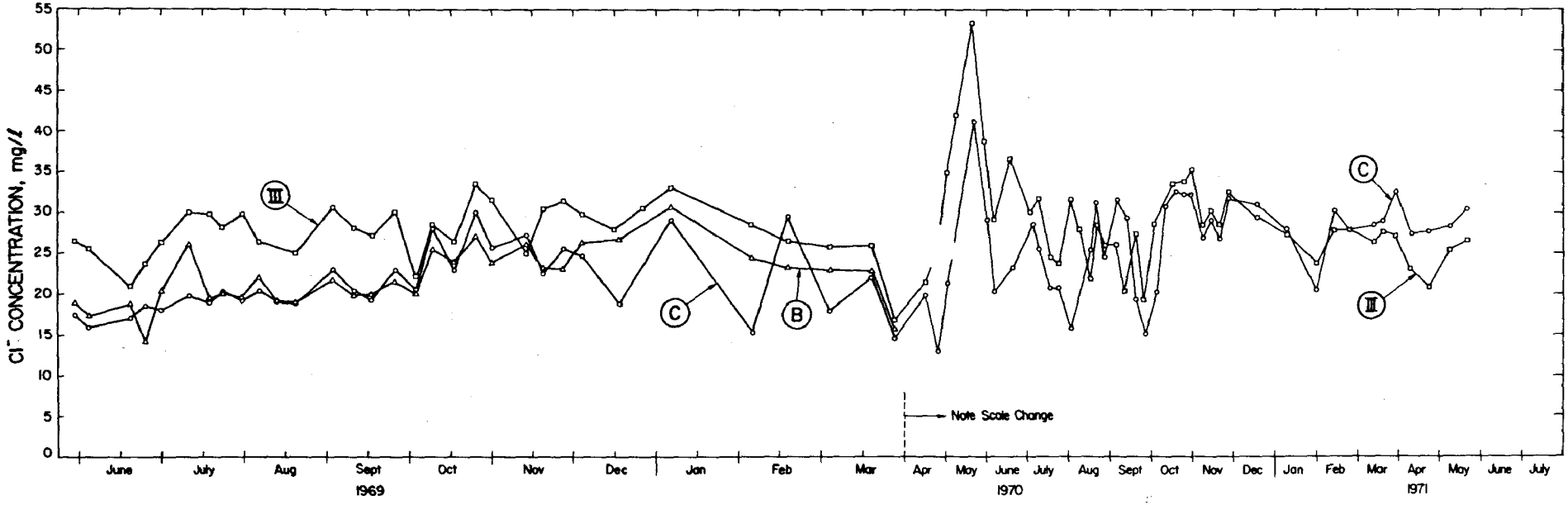

FIGURE 10. VARIATION IN CHLORIDE CONCENTRATION, INDIAN CREEK RESERVOIR

Chlorides

Figure 10 shows that the chloride concentration of the reclaimed water generally exceeded that of the impounded water prior to about September 1970 as the reservoir was filled and became somewhat stabilized. In September the two were essentially equal and remained so until the spring of 1971 when the impounded water concentration curve became slightly the higher of the two. In numerical terms the chloride concentration of influent reclaimed water averaged 27 mg/ℓ during the first period (April 1969 through March 1970) and 29 mg/ℓ during the corresponding 1970-71 period of study. Chlorides in the impounded water during these same time periods averaged 22 mg/ℓ and 26 mg/ℓ, respectively. Thus 5 mg/ℓ separated the reclaimed and impounded water chloride concentrations during 1969-70 and only 3 mg/ℓ during 1970-71.

In as much as chloride is a conservative material in biological systems, the observed difference in concentration of the reclaimed and impounded water is presumably due to a combination of surface runoff and evaporation after the initial leaching from underlying soil. It is difficult to estimate how much chloride may have leached from the disturbed soil during the initial reservoir filling operation. Normally, however, the chloride concentration in precipitation and surface runoff from undisturbed land is less than 2 mg/ℓ. Therefore it appears that the chloride concentration of the impounded water is principally a function of that of the reclaimed water plus the concentrating effect of evaporation.

pH

Variations in the pH of reclaimed and impounded water reported in Table 13, Appendix, are shown graphically in Figure 11. In general, the two waters showed very little difference in pH. However, because pH is the negative logarithm of the hydrogen ion concentration it requires a tenfold concentration difference to change the pH by one unit. Therefore the parameter is much less sensitive than other chemical parameters.

It is to be expected that during periods of extensive algal growth, free carbon dioxide will be utilized at such a rapid rate that the pH will show an increase. Such an increase is evident in Figure 11 during the February to April 1970 period, although somewhat less apparent during the equivalent period in 1971. Throughout the period of study the pH of the impounded water remained close to 8.0, indicating that Indian Creek Reservoir was in a healthy condition limnologically.

Conductivity

Values of conductivity observed during the period of study are summarized in Figure 12. The same slight tendency for an increase with time previously noted in relation to chlorides is evident in the conductivity of both reclaimed and impounded water. However, a consistent drop in conductivity is apparent throughout the period of study as reclaimed water was mixed with the impounded water which included both surface runoff and effluent from the STPUD plant. Table 13 (Appendix) shows that the conductivity of impounded water ranged from 229 to 530 μ mhos/cm at 25°C. This is within the 0.25 to 0.75 m mhos/cm range reported by Eldridge [15] to characterize about half of the irrigation waters used in the western U. S. It is also in the range where the salinity effects are reported by the USDA [16] to be mostly negligible on field, vegetable, and forage crops.

It is therefore concluded that in terms of conductivity, water impounded in Indian Creek Reservoir is of good quality for its current use in irrigated agriculture.

Calcium

Figure 13 summarizes the concentration of calcium observed in reclaimed and impounded water at Indian Creek Reservoir during the period herein reported. As in the case of other quality factors observed, transient fluctuations in the influent concentration are damped out in the mass of impounded water. The influent concentration is characteristically high, and the impounded water and discharged water curves are close

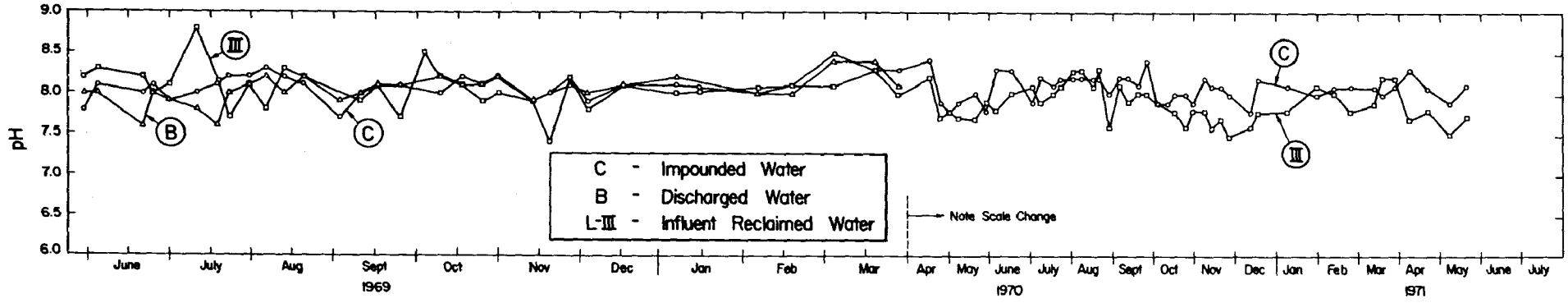

FIGURE 11. VARIATION IN pH, INDIAN CREEK RESERVOIR

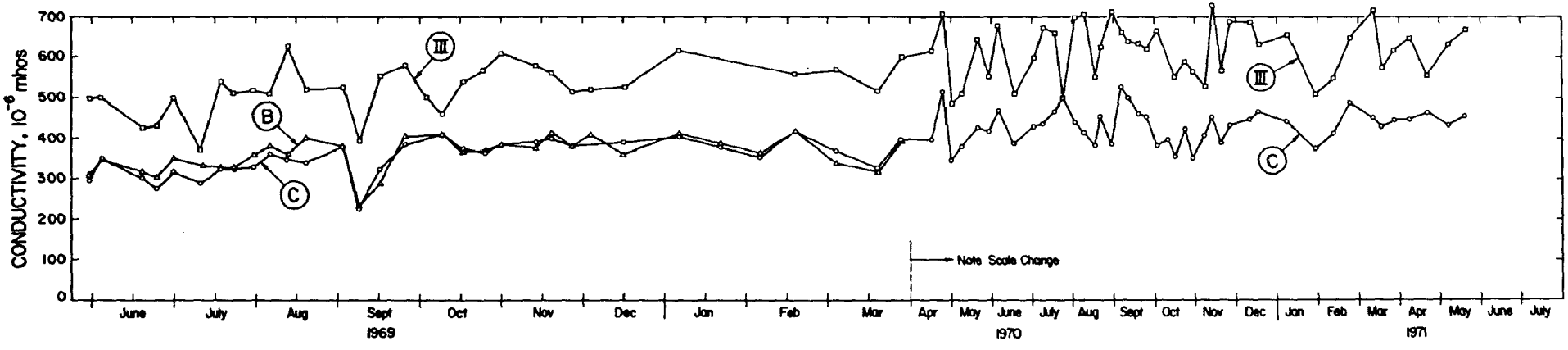

FIGURE 12. VARIATION IN CONDUCTIVITY, INDIAN CREEK RESERVOIR

together except when some unusual event occurred, i.e., in August and September 1969, for example, when water was released for irrigation use at a rate of some four times the influent rate. Analysis of the dicharged water (B) was not performed during the second period of study (April 1970 - May 1971) because, as noted in a preceding section, it was not significantly different than impounded water.

The question of whether dilution alone, or dilution plus precipitation of calcium carbonate or calcium phosphate, accounted for the difference in calcium concentration in influent and impounded water was explored [4]. The conclusion, based on hydrologic calculations, was that dilution rather than precipitation of calcium was the major factor.

Alkalinity

Variation in the alkalinity of ICR waters is summarized in Figure 14. Variability of the influent reclaimed water is again evident; and impounded and discharged water were generally the same during the period when both were measured except that the relationship was disturbed during the August 1969 release of water.

The figure shows an upward trend in alkalinity with time over the period of study. That this is a function of treatment plant operations in precipitating phosphorus with lime and restabilizing the water is shown in data on raw sewage at the STPUD plant. Here, for example, an increase in alkalinity from 192 mg/ℓ in the raw sewage to 221 mg/ℓ in the reclaimed water was reported [9] for June 25, 1968. On January 18, 1969 this increase through the treatment plant was from 84 mg/ℓ in raw sewage to 208 mg/ℓ in the plant effluent.

As in the case of both chlorides and calcium, there is an appreciable difference between the influent alkalinity curve and that for the impounded water. As before, this brings up the question of the role of dilution in reducing concentration. In comparing observed values of alkalinity as of December 31, 1969 with values computed from a water balance for the reservoir it was found [4] that dilution accounted for only 83 percent of the observed reduction from reclaimed to impounded water. Assuming the previous conclusion to be correct, that dilution alone accounts for the decrease in calcium, precipitation of calcium carbonate is ruled out as a possible cause of the apparent loss in alkalinity. Nor is precipitated $CaCO_3$ in the recarbonated reclaimed water the answer, because both the calcium and alkalinity data were obtained from filtered samples. Alkalinity in the exported reclaimed water is in the bicarbonate form as a result of recarbonation at the STPUD plant. However, no analyses were made for sodium or magnesium, hence it is impossible to be certain that all the alkalinity is accounted for by any study of the data on calcium. It is therefore necessary to look carefully into the matter of inorganic carbon.

Inorganic Carbon

Figure 15 shows the inorganic carbon content of reclaimed and impounded waters. Inorganic carbon values were computed on the basis that carbon present in the inorganic form is in the bicarbonate radical of alkalinity. The computed values, therefore, are not only a function of alkalinity but also vary with the pH and temperature. As in the case of alkalinity the difference in concentration of inorganic carbon (Figure 15) between influent and impounded water cannot be attributed to dilution alone. The difference between the observed and the computed inorganic carbon in the impounded water leads to the inescapable conclusion that bicarbonate alkalinity was used as a source of carbon by the biota of Indian Creek Reservoir during the period of study.

Phosphorus

Phosphorus removal at the STPUD plant is a highly efficient process, reducing the concentration in the reclaimed water to a level which seldom exceeds 300 μg/ℓ. Removal is achieved by lime precipitation followed by recarbonation to precipitate the excess calcium carbonate. Table 4 shows that during the first period of study (April 1969 - March 1970) the total phosphorus content of the reclaimed water

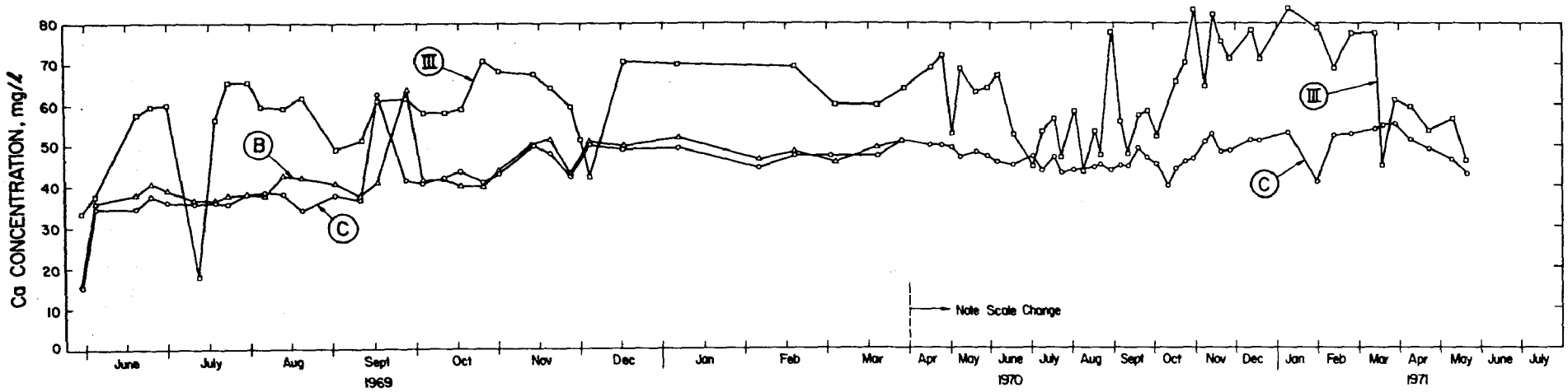

FIGURE 13. VARIATION IN CALCIUM CONCENTRATION, INDIAN CREEK RESERVOIR

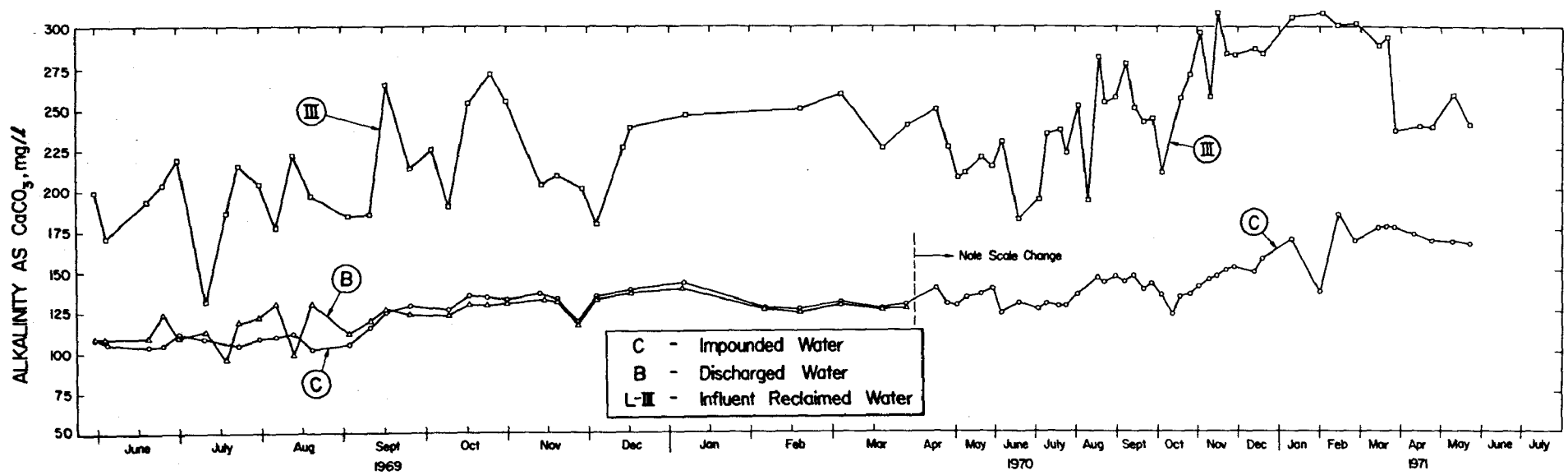

FIGURE 14. VARIATION IN ALKALINITY, INDIAN CREEK RESERVOIR

averaged 148 μg/ℓ and orthophosphate (PO_4-P) averaged 126 μg/ℓ. For the second period of study (April 1970 - May 1971) these same constituents averaged 119 and 86 μg/ℓ, respectively. Thus it appears, assuming that the raw sewage was of approximately of the same quality over the two study periods, that the efficiency of phosphorus removal improved at the STPUD plant as time progressed.

TABLE 4

SUMMARY OF CHANGES IN NUTRIENT CONCENTRATION, INDIAN CREEK RESERVOIR

Sample	Period	Mean Concentration of Nutrients μg/ℓ				
		NH_3-N	(NO_2 + NO_3)-N	Total-N	PO_4-P	Total-P
Influent (L-III)	April 1969 through	17,942	664	19,313	126	148
Indian Creek Reservoir (C)	March 1970	3,439	2,893	7,241	37	51
Influent (L-III)	April 1970 through	19,588	295	20,395	86	119
Indian Creek Reservoir (C)	March 1971	3,810	3,349	8,094	14	27

Total phosphorus in the impounded water during the first period was 51 μg/ℓ and orthophosphate was 37 μg/ℓ, whereas during the second period these two constituents averaged only 27 μg/ℓ and 14 μg/ℓ, respectively. Variations in the concentration of orthophosphate in ICR waters over the full period of study are shown graphically in Figure 16. Total phosphorus for the same waters over the same time period are shown in Figure 17.

The difference in phosphorus concentration in reclaimed and impounded water is only partially accounted for by dilution. Phosphorus is a nonconservative material in that it enters into life cycles and may spend a good portion of the cycle in the benthic sludge or in living cells, hence it cannot be accurately traced by the dilution approach applied to conservative elements. From Figure 16 there appears to have been more orthophosphate in the impounded water during the winter than during the summer seasons, especially in the second period of study. This is explainable because winter temperatures limit the ability of biota to increase and thus they cannot utilize the available phosphorus. From both Figures 16 and 17 it seems evident that especially during the second period of study phosphorus must have been the nutrient generally limiting to biota of Indian Creek Reservoir. This relationship, however, is further considered in a subsequent section dealing with the results of bioassays.

Organic Nitrogen

Organic nitrogen is the only major quality factor herein discussed in which the concentration in the impounded water fluctuated as wildly as did that in the influent reclaimed water. Biological processes are used in the reclamation process. They are followed by precipitation, filtration, and carbon adsorption. Nevertheless, the reclaimed water is far from a uniform product in terms of organic nitrogen

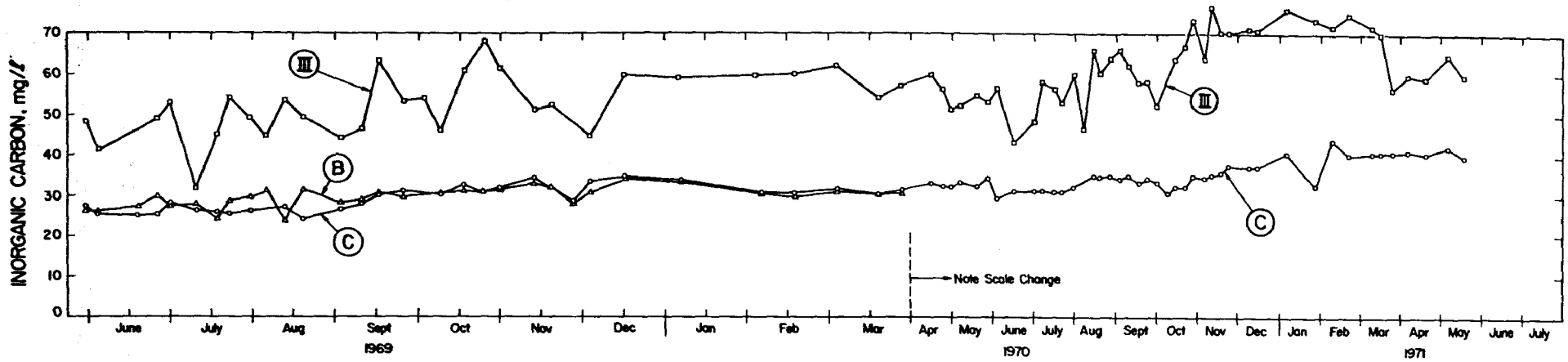

FIGURE 15. VARIATION IN INORGANIC CARBON, INDIAN CREEK RESERVOIR

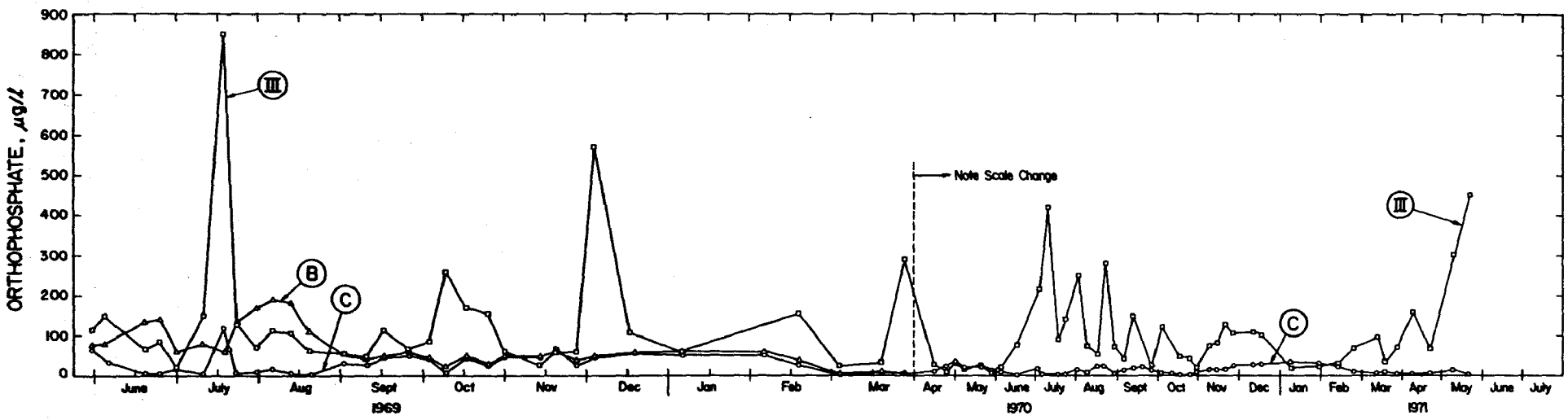

FIGURE 16. VARIATION IN CONCENTRATION OF ORTHOPHOSPHATE, INDIAN CREEK RESERVOIR

content. The data plotted in Figure 18 show that in summer there was a very rough tendency for the influent and impounded water curves to peak simultaneously. In the fall the reverse was the case. In December 1969, for example, the greatest concentration of organic nitrogen was in the reservoir water but in January 1969 it was evidently in the benthic stratum. There was a definite tendency for higher than average organic nitrogen concentration to prevail in impounded waters during the summer and fall months, and less than average in the winter. This is in accord with an observed tendency for Indian Creek Reservoir to support aquatic growth, and hence to produce a significant quantity of organic nitrogen which more than offset any dilution effect.

On the basis of Figure 18 it must be concluded that although there is nothing unexplainable in the behavior of the organic nitrogen curves, organic nitrogen is not a good parameter by which to describe the limnology of Indian Creek Reservoir.

Ammonia

Figure 19 summarizes the variation in the ammonia content of the reclaimed and impounded waters during the period of study. As in the case of most other water quality factors discussed in preceding paragraphs, the transient fluctuations in concentration characteristic of the influent water are damped out in the impounded water in the reservoir. From the figure, and from Table 4, it is obvious that only a minor fraction of the difference in ammonia concentration between influent and impounded water can be accounted for by dilution. For example, the influent reclaimed water had an average ammonia content of 17,942 μg/ℓ during the first period of study and 19,558 μg/ℓ during the second. At the same time the averages in impounded water were but 3,439 μg/ℓ and 3,810 μg/ℓ, respectively.

The mechanisms by which ammonia is so drastically reduced in Indian Creek Reservoir from influent to resident impounded water are perhaps the most important phenomena in the quality of ICR water. They represent the difference between a water definitely inimical to fish life and one in which fish have flourished for more than 2 years. They are discussed herein in greater detail in relation to the biological observations at Indian Creek Reservoir.

Nitrite Plus Nitrate Nitrogen

Table 13, Appendix, shows that the values for nitrite nitrogen averaged less than 10 percent of those for nitrate nitrogen. Consequently the two forms of nitrogen are combined for presentation in Table 4 and Figure 20. As was the case with organic nitrogen, biological activity more than overwhelmed the dilution effect with the result that the influent nitrate-nitrite nitrogen was only a small fraction of that present in the reservoir. These vastly greater concentrations appearing in the impounded water are largely due to the oxidation of ammonia by biological activity in the reservoir. They may also be a pathway by which ammonia is removed from the reservoir via nitrification-denitrification phenomena.

Total Nitrogen

Figure 21 and Table 4 show that the total nitrogen in the influent reclaimed water is comprised mostly of ammonia, whereas in the impounded water the total is only about 50 percent ammonia. In both cases the average has increased slightly with time; a trend, which if continued over a period of years in parallel with a decreasing concentration of phosphorus, could have a profound influence on the biota of Indian Creek Reservoir.

Dissolved Oxygen

Dissolved oxygen data for Indian Creek Reservoir waters throughout the period of study are presented in Table 13, Appendix. Variation in DO with depth below the water surface is shown for periodic sampling dates during the 1969-70 study period and at approximately weekly intervals during 1970-71 period. From the table it may be observed that the dissolved oxygen content of the influent reclaimed water

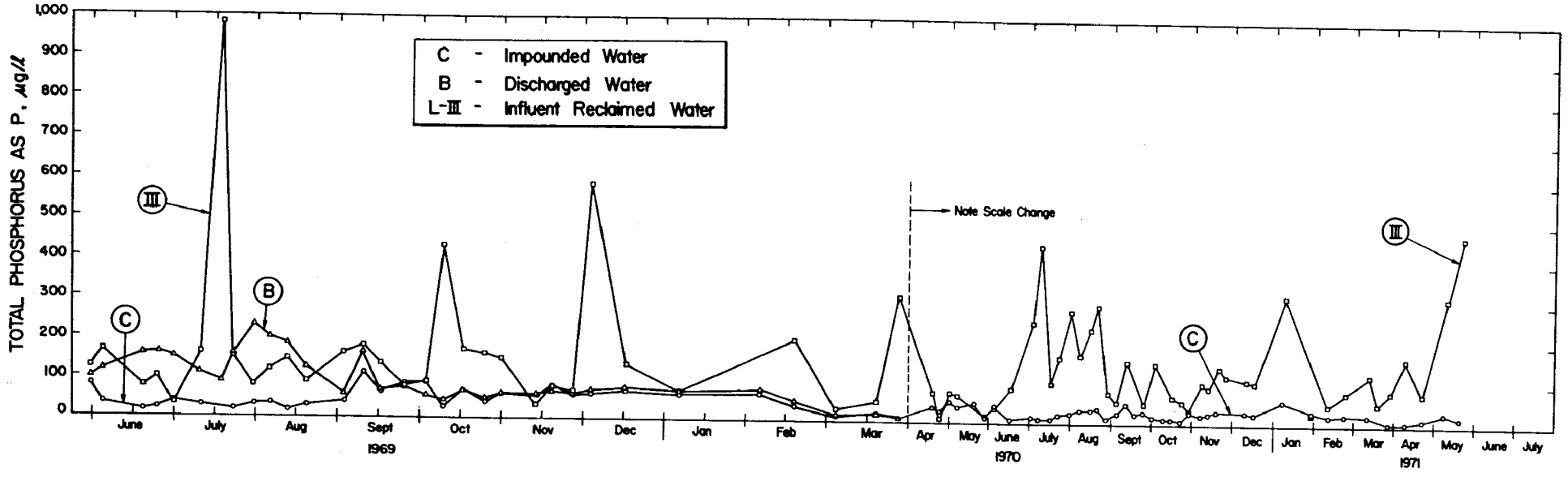

FIGURE 17. VARIATION IN CONCENTRATION OF TOTAL PHOSPHORUS, INDIAN CREEK RESERVOIR

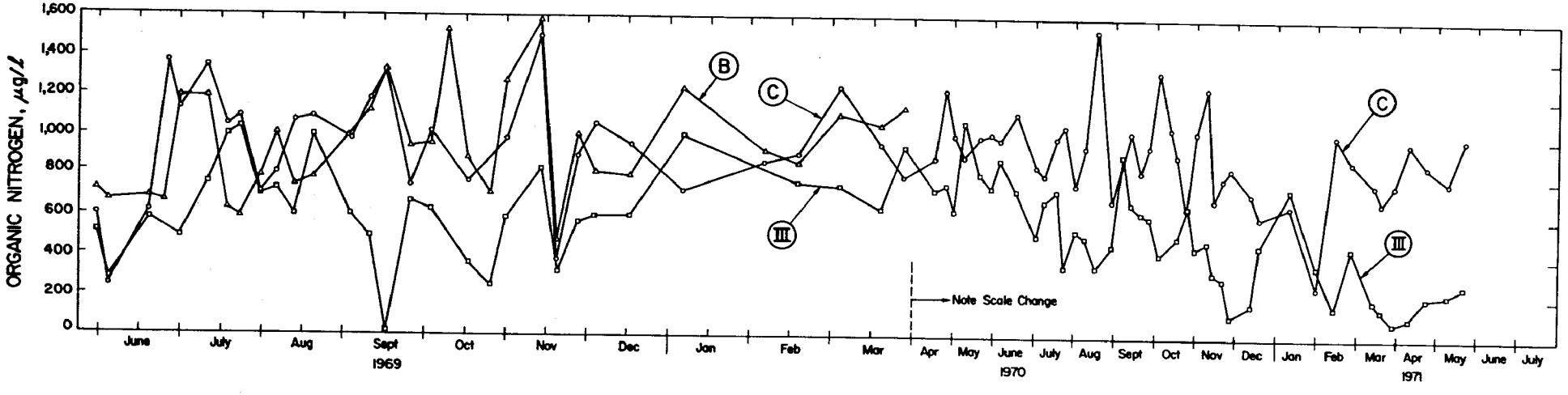

FIGURE 18. VARIATION IN CONCENTRATION OF ORGANIC NITROGEN, INDIAN CREEK RESERVOIR

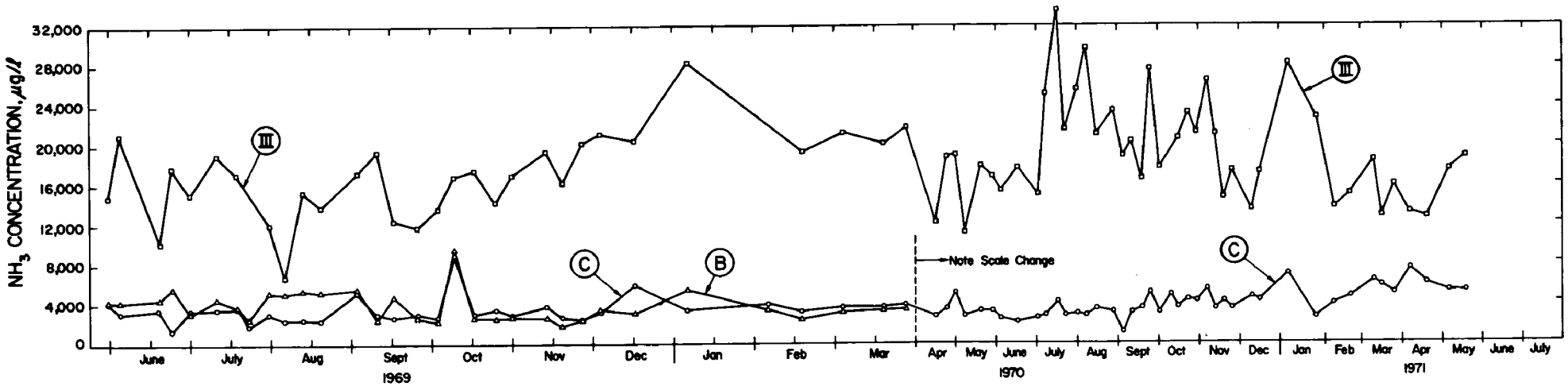

FIGURE 19. VARIATION IN CONCENTRATION OF AMMONIA, INDIAN CREEK RESERVOIR

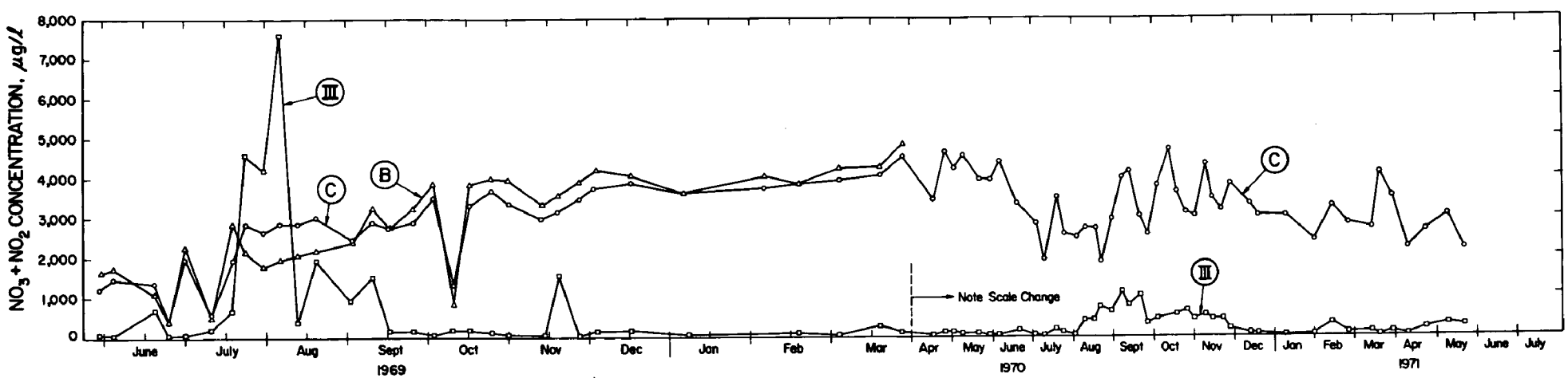

FIGURE 20. VARIATION IN CONCENTRATION OF NITRATE + NITRITE NITROGEN, INDIAN CREEK RESERVOIR

was constantly less than 2 mg/ℓ except on a few occasions which may well be in error due to problems of sampling from a pressure outfall line without aerating the sample.

Figure 22 shows that throughout the entire period of observation the impounded water in the top half-meter was near or above saturation, varying normally with water temperature. One notable exception appears in late October 1969, when an extremely high value of DO was observed.

Figure 3 has shown that the impounded water was exceptionally clear at that time and Figure 4 showed that the temperature stood at 9°C. Thus an unobserved algal bloom could not have been the cause. Attempts were made to discover whether any unusual event had occurred. Table 14, Appendix, shows that as early as September 15, 1969 the reservoir was well mixed vertically and on November 19 of that year both good mixing and high (9 + mg/ℓ) DO characterized the impounded water. Although a recheck of data and discussions with the personnel involved failed to reveal any identifiable error, it was concluded [4] at the time that some malfunction of the analytical procedure was the only logical explanation of the DO peak in October 1969.

Table 14 also shows that in July 1969 the dissolved oxygen in the vertical profile of the reservoir ranged from 7.6 mg/ℓ at 0.5 meters below the water surface to 0 mg/ℓ at 0.5 meters above the reservoir bottom. By September 1969, however, the dissolved oxygen profile at all three of the sampling stations (Figure 2, Section IV) revealed a well mixed water mass both vertically and horizontally, with a reduction in concentration of oxygen in the upper strata as a result of mixing with underlying oxygen-poor water.

By mid-November 1969 all quality factors reported in Table 13 (Appendix) were essentially uniform from surface to bottom of the reservoir water. At that time a sampling at the three stations showed that the DO ranged from 8.6 to 9.6 mg/ℓ in the entire water mass sampled. Table 14 shows that this well mixed condition continued in February 1970, at which time the DO had risen to 11 ± mg/ℓ.

In March of 1970 mechanical aeration was initiated but was interrupted after only about 10 days of operation until June 23. In the interval, in May 1970, an oxygen profile began to develop. By early June it showed a DO range of from 11.1 mg/ℓ at -0.5 meters to 1.4 mg/ℓ at -10 meters. However, a well mixed condition developed by June 16, before the artificial aeration system was restored. Thereafter, as the weather warmed up and aeration was practiced, oxygen profiles were less pronounced until mid-July when the steep oxygen profile of the preceding July was essentially repeated, albeit with a low of 1.5 mg/ℓ instead of 0 mg/ℓ as before. A second period of low oxygen in the bottom stratum occurred in August. Then from September 1970 to the end of the report period in May 1971 the DO in impounded water was at or above saturation throughout the vertical profile.

From the data observed, the exact effect of artificial aeration of Indian Creek Reservoir is obscure. Both before and after installation of the system, periods of complete mixing and strong stratification occurred. In general it appears that the oxygen depletion at the bottom of the reservoir was less severe and DO concentrations under well mixed conditions were somewhat higher after operation of the aerator began.

Nutrient Inventory

An inventory of several selected parameters, with special concern for nutrients, is presented in Table 5 for the two periods of study herein reported. Hydrologic data summarized in the table are the same as those presented in Table 2 with two exceptions. Loss by evaporation was omitted because the amount of chemicals transported by evaporation is insignificant in comparison with the amounts present in the reclaimed or impounded water; and water lost from the impoundment by percolation and by leakage through the outlet valve were combined into a single volume. The arithmetic signs (+ and -) shown in column 1 of Table 5 pertain to the inventory equation expressed in the form: $\Delta n = I + RO + P_L - D - P_o - V_o - \Delta S$, in which Δn

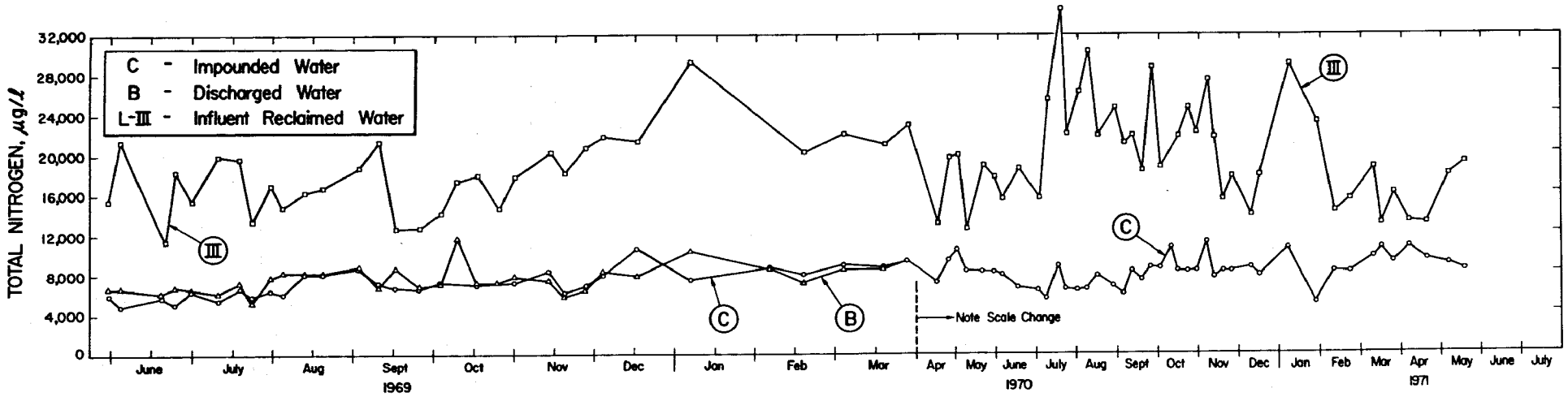

FIGURE 21. VARIATION IN CONCENTRATION OF TOTAL NITROGEN, INDIAN CREEK RESERVOIR

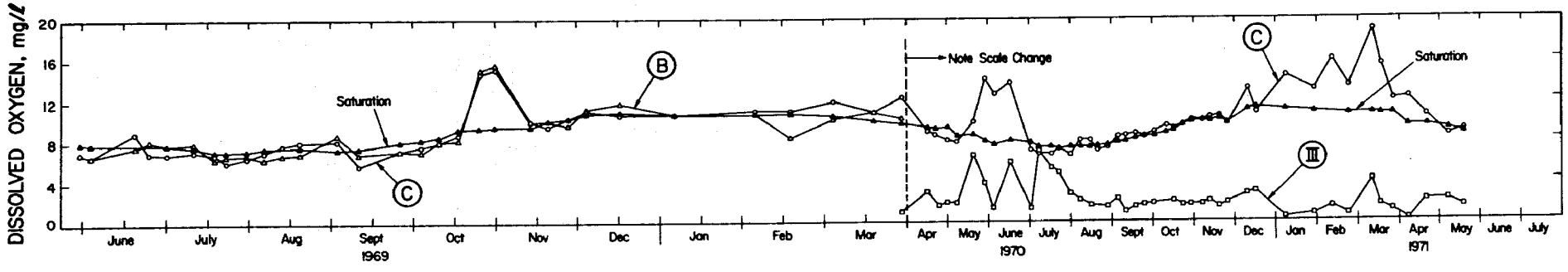

FIGURE 22. VARIATION IN DISSOLVED OXYGEN, INDIAN CREEK RESERVOIR

TABLE 5

INVENTORY OF SELECTED PARAMETERS OF INDIAN CREEK RESERVOIR

Time Period	Total Water Volumes Per Year		Average Chemical Values																Total N / Total P
			Nitrogen as N								Phosphorus as P				Cl		Ca		
			Organic		NH_3		$NO_2 + NO_3$		Total		PO_4		Total P						
	Location	ac-ft	ug/ℓ	kg	ug/ℓ	kg	ug/ℓ	kg	ug/ℓ	kg	ug/ℓ	kg	ug/ℓ	kg	mg/ℓ	kg	mg/ℓ	kg	Ratio
April 1969 through March 1970	(I) Influent from STPUD (+)	2674	647	2133	17,942	59,155	664	2189	19,253	63,477	126	415	148	488	27.4	90,338	57.6	189,907	130
	(P_L) Precipitation Directly on Reservoir Surface (+)	340	191	80	117	49	56	23	357	150	9	4	15	6	1.43	599	0.5	210	24
	(RO) Surface Runoff (+)	1145	99	140	38	54	17	24	154	217	11	16	23	32	0.46	649	0.5	706	7
	(D) Irrigation Discharge (-)	522	1005	647	3025	1947	3043	1958	7073	4552	26	17	46	30	20.6	13,258	43.8	28,190	154
	($P_O + V_O$) Percolation + Discharge Valve Loss (-)	2450	909	2746	3439	10,389	2893	8739	7241	21,873	37	112	51	154	21.6	65,249	41.6	125,665	142
	(ΔS) Δ Storage (-)	800	909	897	3439	3392	2893	2854	7241	7143	37	36	51	50	21.6	21,306	41.6	41,034	142
	Total Δn			-1937		43,530		-11,315		30,276		270		292		-8227		-4066	104
April 1970 through March 1971	(I) Influent from STPUD (+)	2687	525	1739	19,711	65,305	232	769	20,395	67,571	86	285	119	394	29.2	96,743	63.1	209,057	171
	(P_L) Precipitation Directly on Reservoir (Estimated) (+)	225	191	53	117	32	56	16	357	99	9	2	15	4	1.43	397	0.5	139	24
	(RO) Surface Runoff (Estimated) (+)	815	99	99	38	38	17	17	154	155	11	11	23	23	0.46	462	0.5	503	7
	(D) Irrigation Discharge (-)	2448	922	2783	3539	10,682	3059	9233	7590	22,910	11	33	25	75	24.7	74,554	46.3	139,752	304
	($P_O + V_O$) Percolation + Discharge Valve Loss (-)	1399	906	1563	3810	6572	3349	5777	8094	13,962	14	24	27	47	25.9	44,678	47.2	81,420	300
	(ΔS) Δ Storage (-)	(-)570	906	637	3810	2678	3349	2354	8094	5688	14	10	27	19	25.9	18,203	47.2	33,172	300
	Total Δn			-1818		50,799		-11,854		36,641		251		318		-3427		21,699	115

is the difference in the factor inventoried. A positive value of Δn indicates that more material went into the reservoir than is accounted for by the combination of observations, estimates, and assumptions available for evaluating its fate when making the inventory (Table 5). Other symbols used in the equation are as defined in relation to Table 2.

Water quality values for the first time period (April 1969 through March 1970) were obtained from a previous progress report [4] based on data in Table 13 of the Appendix (Section XI). Quality values for precipitation directly on the reservoir surface were assumed to be representative of the Lake Tahoe Basin [5]. The quality of surface runoff was likewise considered to be typical of undisturbed areas such as reported [5] for Ward Creek in the Lake Tahoe Basin. The quality of water released for irrigation was taken as that prevailing in the impounded water in August and September 1969, so as to coincide with the actual period of irrigation releases. Water lost by percolation and leakage through the discharge valve was assumed to be of the same quality as the impounded water.

For the second period of study (April 1970 through March 1971) values for the several water quality parameters used in the inventory were obtained from Tables 13 and 15 (Appendix). Quality factors for precipitation on the reservoir surface and for surface runoff into the reservoir were the same as used for the 1969-70 period. Irrigation discharge was again averaged for the months of significant discharge; in this case, June, July, August, and September, 1969 and March 1971. Percolation and outlet valve leakage were once more assumed to be of the same quality as that prevailing in the impounded water.

Δn for organic nitrogen during the first and second periods was -1937 kg and -1818 kg, respectively. These two values are quite comparable, probably because of similar influent reclaimed water volumes during the two periods. The negative sign, of course, indicates that more nitrogen came out of the reservoir in the organic form than entered it in that form, as a result of aquatic growth in the impounded water.

Ammonia, the most prevalent form of nitrogen in both the reclaimed and impounded waters, averages greater than 94 percent of the total nitrogen in reclaimed water, and 47 percent in the impounded water over the two-year period of study. The Δn values of 43,530 kg and 50,799 kg for the first and second study periods, respectively, indicate that the excess of influent over observed ammonia in the reservoir was relatively similar for the two periods. Because such a large amount of ammonia was disposed of in some manner from the impounded water, its fate becomes one of the most important questions in understanding the limnology of Indian Creek Reservoir.

As in the case of organic nitrogen, the Δn for the oxidizable forms of nitrogen (NO_2 + NO_3) for the two study periods were quite similar, with values of -11,315 kg and -11,854 kg, respectively. The greater output over input in both cases is apparently the direct result of oxidation of ammonia. This phenomenon, however, could account for scarcely 25 percent of the untraced ammonia noted in the preceding paragraph.

Inasmuch as the values for organic and nitrite plus nitrate nitrogen were both negative and nearly identical, the resulting Total Nitrogen inventory value would logically be in about the same ratio but of a lower magnitude. The first period showed an overall loss of 30,276 kg of total nitrogen, while the value for the second period was 36,641 kg. The overall unaccountable nitrogen loss from the impounded water is by this analysis therefore greater than 47 percent for the first period and nearly 50 percent for the second.

Δn for both forms of phosphorus – orthophosphate and total phosphorus – were in approximately the same range for the two study periods. Orthophosphate excesses were 270 kg and 251 kg for the first and second periods, respectively. At the same time total phosphorus values were 292 kg and 318 kg.

Some concept of the reliability of the nitrogen and phosphorus inventories herein presented may be gained by an evaluation of the chloride inventory summarized in

Table 5. Chloride is considered a major conservative element in water quality analysis and thus lends itself to use as a parameter for tracing water movement and for ascertaining the validity of hydrologic and chemical inventories. For the first period the chloride inventory value was -8227 kg and for the second period, -3427 kg. Although these values of Δn differ appreciably from each other they represent but a small percentage of the 90,000+ kg of chloride entering the reservoir with influent reclaimed water in each of the two periods. Specifically, the first period is out of balance by only 9 percent; the second by less than 4 percent. Such a close range of balance for the two study periods supports the general conclusion that the hydrologic estimates and measurements, as well as the sampling program for chemical analysis, are of reasonable validity.

A cursory observation of the calcium inventory of Table 5 shows a first period Δn value of -4066 kg, which is within 2 percent of balancing. The second period value of +21,699 kg is within 10 percent of balancing, albeit as an excess rather than as a deficit as during the first period. Although calcium is considered a somewhat conservative element, it does precipitate out as calcium carbonate under favorable conditions. A thin layer of calcium carbonate appearing on the rock surfaces at Indian Creek Reservoir indicates that precipitation is indeed occurring. Thus precipitation accounts for at least a portion of the missing calcium shown by the inventory for the second period.

The ratio of total nitrogen to total phosphorus (N/P ratio) in the influent reclaimed water was of the order of 130 for the first period and 171 for the second period of study. The impounded water showed N/P ratios of 142 and 300 for the two periods, respectively, again reflecting the increased efficiency in phosphate removal at the STPUD plant as time progressed. The N/P ratios for the 1969-70 and 1970-71 periods, based on Δn values in Table 5, were 104 and 115, respectively.

As previously noted in relation to Table 4, the total nitrogen of the reclaimed water increased slightly with time, whereas the various forms of phosphorus decreased significantly. This same trend, although more pronounced, was apparent in the impounded water. From a limnological viewpoint it would be desirable to reverse this trend and so to produce a more balanced nutrient, although concentrations would have to be controlled so as not to reach levels sufficient to generate objectionable algal blooms.

Nutrient Balance

From the preceding discussion, it is evident that during both the 1969-70 and 1970-71 periods of study a large amount of nitrogen and a much smaller amount of phosphorus was unaccounted for by the inventory presented in Table 5. Moreover, N/P ratios in influent reclaimed water and in impounded water ranged from 10 to 20 times the 10:1 to 15:1 ratio in which algae normally utilize nitrogen and phosphorus. Thus, unless there existed some source of phosphorus other than the reclaimed water and surface runoff, the nitrogen excess computed in Table 5 could not all have gone into the biota of the reservoir, although some of it most certainly went that route. A second possibility is that the assumption that percolating water had the same characteristics as impounded water may be invalid, hence less (or perhaps more) nitrogen may have left via that route than is estimated in Table 5. A third possibility is that phenomena not reflected in the inventory computations led to a loss of nitrogen from the system as gaseous nitrogen, nitrogen oxide, or ammonia, or by accumulation in benthic sludge. Because all of these phenomena are known to be involved in natural equilibria, it is necessary to explore the potential of each in any accounting for the nitrogen loss or estimating of the nutrient balance.

Inasmuch as the N/P ratios were heavily out of balance, with nitrogen in the excess, the limiting effects of phosphorus might be the first factor to consider in isolating the fate of the unaccounted for nitrogen. The fact that phosphorus is adsorbed on soil colloids under normal conditions identifies one inaccuracy inherent in the assumption that percolating water was the same as impounded water in quality. It also suggests that during the first year of operation, when the reservoir was being filled, the original soil may have been an important source of phosphorus.

Later, because only a small quantity of water (522 ac-ft) was released for irrigation during 1969-70, this same phosphorus could have been recycled via the biota of the reservoir during the second year.

To estimate the significance of soil as a source of phosphorus an analysis was made of a composite sample of soil taken from 20 locations in the cleared land area above the shore line in September 1969. Although this soil was typical of the reservoir bottom and was subsequently inundated as the reservoir level rose, it had been subjected to one winter's runoff and the steeper sections showed some microvein erosion. Thus it is possible that the sampled soil may have originally been richer in nutrients at the time flooding of the reservoir began in 1968, and that the nutrients lost from it were already in the reservoir sediments at the time of sampling. To obtain some estimate of the relative magnitudes, however, it is assumed that the phosphorus content of the original soil was 0.01 mg/g as reported in Table 6.

On the basis of previous studies of soils [13] it is further estimated that phosphorus in the top 0.5 cm of soil was available to benthic organisms. Taking 150 acres as the area flooded during the year, and assuming approximately 40 percent porosity of a soil having a specific gravity of 2.6, it is calculated that some 50 kg of phosphorus might have been added to the reservoir nutrient budget by extraction from the soil. At a maximum N/P ratio of 15:1 this could have tied up only 750 kg of the more than 30,000 kg shown as excess nitrogen in Table 5 for the 1969-70 period.

Whether or not the biota of the reservoir did make use of phosphorus from the soil, or whether it remained in the benthic sludge, is a somewhat academic question in terms of the problem of excess nitrogen. However, it may be computed that 750 kg of nitrogen and 50 kg of phosphorus could produce 7500 kg of algal cells, or about 2.3 mg/ℓ of volatile suspended solids in the 2700 ac-ft of water impounded when the water surface equaled 150 acres. This is in excess of the observed average values of VSS in the impounded water, i.e., 2.25 mg/ℓ in 1969-70 and 1.3 mg/ℓ in 1970-71. When it is considered that the phosphorus in the influent reclaimed water during the two periods of study averaged 0.126 mg/ℓ and 0.086 mg/ℓ, respectively, (Table 4), and that this phosphorus was likewise available to produce algal cells, it is evident that the observed VSS concentration did not account for all the available phosphorus in any event. This observation, however, does not take into account the cycle of growth and degradation, precipitation of dead cells, etc., that characterizes biological phenomena in the aquatic food chain.

The important fact is that the disparity between nitrogen and phosphorus inputs to Indian Creek Reservoir, as well as between the N and P unaccounted for in Table 5, indicates that an important fraction of the nitrogen did not leave the system in combination with phosphorus.

In order to explain the reduction in ammonia in the reservoir evident in Figure 19 and the nitrogen unaccounted for in Table 6, samples of the benthic sludge were taken at Stations 1 and 3 (Figure 2) and analyzed for nutrient content. The results, reported in Table 6, show that in October 1970 nitrogen in the accumulated sludge averaged 2.65 mg/g for the two stations. This represents about a 2-year accumulation of sludge, which for purpose of the calculations reported in Table 7 is assumed to be representative of the two-year period of study even though the time spans are not identical.

Table 7 represents an estimate of the nutrient balance for the reservoir over the two years of study. In preparing this estimate several assumptions and assignments were necessary:

1. All volatile suspended solids in the reservoir were assigned to algal cells having an N/P ratio of 15:1.

2. Macro aquatic plants were assumed to be distributed throughout the reservoir water mass in the same profusion as that reported in a following section (Biological Observations).

TABLE 6

BENTHIC AND SOIL SAMPLE ANALYSIS AT INDIAN CREEK RESERVOIR

Date	Source	Location	Nitrogen as N					Phosphorus as P		Total Carbon
			Organic mg/g	NH_3 mg/g	NO_2 mg/g	NO_3 mg/g	Total mg/g	Available mg/g	Total mg/g	%
Sept 1969	Soil (Composite)	20 locations above water line of reservoir	0.58	0.029	-	0.36	-	0.01	-	1.13
Oct 14 1970	Benthic	Station 1	2.96	0.0	0.0	0.014	2.97	0.04	0.209	-
	Benthic	Station 3	2.32	0.0	0.0	0.018	2.34	0.05	0.908	-

3. Fish taken from the reservoir by migratory waterfowl were assumed to be equal in number to those caught by fishermen. The remainder of the fish planted in the reservoir were assumed to be present in the impounded water and to be of the same average weight as those caught by fishermen.

4. Phosphate in the available form in the original soil was assigned to the benthic sludge along with the phosphate in water lost by percolation, plus sufficient organic matter to bring the phosphorus budget of the reservoir into balance.

TABLE 7

ESTIMATED NUTRIENT BALANCE
April 1969 through March 1971

Source	±	Available Phosphorus kg	Total Nitrogen kg
Volatile Suspended Solids	-	65	975
Vascular Plants	-	7	100
Fish Life	-	150	900
Benthic Deposits	-	433	22,900
Δn w/o Percolation Loss	+	655	102,299
Percolation of NO_2 + NO_3	-	-	14,337
Imbalance		0	+63,087

Although the actual relationship of origin and destination of any individual unit of phosphorus is not reflected in Table 7, the relationship is of no consequence if the location of various fractions of the total available phosphorus in the system is correct.

The item in Table 7 least subject to checking is "Benthic Deposits." No survey of the areal extent of the benthic sludge blanket was attempted. However, its existence was readily verified by soundings in deep water but it was not characteristic of the shallows except in the most southerly bays of the reservoir. Soundings at sampling stations and at random points in the reservoir indicated a depth of sludge of about 2.5 cm was characteristic. Assuming 2.5 cm as an average depth of a sludge having a specific gravity of 1.2 and the nutrient characteristics shown in Table 6, it was calculated that 433 kg of phosphorus (Table 7) would represent an area of 71 acres. Although such an estimate is at best rough, it is not implausible and hence supports the general conclusion that the estimates in Table 7 are reasonable ones.

Nitrogen values shown in Table 7 were obtained by the same approach used in establishing phosphorus values. Additional assumptions were that the nitrogen concentration shown for benthic sludge in Table 6 prevailed in 71 acres of sludge 2.5 cm deep; and that the soluble oxidized nitrogen initially present in percolating water left the reservoir with that water. On this basis it develops that some 63,000 + kg of nitrogen, or 48 percent of the identified influent nitrogen was lost from Indian Creek Reservoir during the two years of study. Such a loss may have involved a combination of two phenomena; gas, resulting from denitrification; and soluble nitrogen resulting from nitrification moving out with percolating water. Because nitrification might be expected to occur at the interface between sludge and the overlying impounded water, whereas denitrification should occur at lower depths in the sludge where oxygen is deficient, gasification would seem to be the most likely occurrence. In such case the 14,357 kg loss of nitrogen assigned to "Percolation" in Table 7 may be a gross overestimate and the nitrogen lost as gas might have been appreciably more than 48 percent of the influent nitrogen.

To discover whether denitrification was indeed a major factor in nitrogen loss from Indian Creek Reservoir, microbiological assays were made of the benthic sludge. The presence of both denitrifying and nitrifying bacterial in large numbers confirmed that such an imbalance as predicted by Table 7 is reasonable. Further consideration of the role of denitrification in the limnology of Indian Creek Reservoir is presented in the following section on biological observations.

BIOLOGICAL OBSERVATIONS

Scope of Observations

Biological data collected on Indian Creek Reservoir range from general and specific observations of an environmental nature made in the field, to detailed scientific analyses made in the laboratory. Included in the first category are such aspects as fish and wildlife of the reservoir and immediate area, qualitative observations of algae and rooted plants in the reservoir, and seasonal changes in the biota. The more scientific examinations include bioassays of the growth stimulating potential of influent, impounded, and discharged waters of the reservoirs, by methods outlined in Section IV; benthic invertebrate surveys in October 1969 and 1970; and plankton analyses in April 1970 and June 1971. Basically, the bioassays serve, within the limits of existing methodology and project budget, to assess the eutrophication potential of water reclaimed from domestic sewage [4,5] by the most advanced of currently developing technology. The less intensive program of field and biological examinations serve as checks on the validity of any conclusions which might logically be derived from chemical analyses and bioassays of the water.

General Environmental Observations

As noted in Section III, Indian Creek Reservoir is located in relatively open country with pinon pine and scrub brush on the east and north. Near the south end, but some hundreds of feet from the shore line there are larger pines. These occur in a sparse stand at the southwest, with a fairly dense growth on the west at the saddle dam and Stevens Lake. Stevens Lake is shallow and contains a heavy growth of aquatic plants, primarily Myriophyllum sp. which apparently have been transplanted into Indian Creek Reservoir by the wildfowl which frequent the area.

Trout were successfully introduced into the reservoir in August 1969. Soon thereafter grebes were observed on the water. A wildfowl count on one occasion in late September revealed the presence of more than 10 grebes and a similar number of coot; 12 ducks; a seagull; and a flock of sandpiper. Other wildlife present in the area included frogs and snakes; and some 50 Brewer blackbirds were resident in the area. On October 24, 1969, 50 ducks were present and in mid-November the duck population was estimated at 150. By late November all ducks had disappeared and no wildlife was in evidence during the next two months. Deer were numerous in the area by mid-February and by mid-March ducks had returned, 40 being counted on the March 18, 1970 sampling date. Fish netted in March were 11 inches in length, well fed, and weighed from 0.66 to 0.75 pounds each. On April 23, 1970 5 deer and two coyotes were observed in the area. Ducks were present on both Stevens Lake and Indian Creek Reservoir. Aquatic plants in the lake and muddied water and snail shell fragments gave evidence that ducks were feeding in the shallows.

Gross observations were made of the insect, plant, and plankton life in the reservoir on weekly sampling dates. Throughout the summer and fall of 1969 twigs and stones in the shallow waters were covered with attached filamentous algae (Mougeotia). This disappeared during the winter and was nowhere in evidence on April 23, 1970. However, at that time the early spring cold water alga, Ulothrix, was in evidence and growing in profusion in Indian Creek just below the outlet to the reservoir. In July 1969 midges (Diptera) were observed in flight and resting on the surface of shallow water. Daphnia were found at all sampling stations in the reservoir and were observed to decrease with depth, the density (number per liter) varying directly with dissolved oxygen concentration. In late July a profuse growth of filamentous green algae (Draparnaldia) was present on the buoy and anchor rope at Station 1

(Figure 2, Section IV). On September 10, 1969 this same alga appeared on the buoy anchor rope at Station 3, extending down to depth of 6 meters. At Station 1 the filaments were less noticeable. On September 15, Daphnia were present in all water samples taken at all three sampling stations. Rooted aquatic plants, predominantly Potamogeton, were found in profusion off the point of land between the main and saddle dams. Eel grass and other aquatic plants were present in the shallow south bays of the reservoir. Filamentous green algae Prasiola appeared, floating on the water surface in small clumps. Ten days later it was still present. In early December Indian Creek near the reservoir outlet was exceedingly green. In March 1970 the reservoir was likewise green in appearance. On April 23, 1970 green masses of algae in Indian Creek below the reservoir were observed to be, as previously noted a profuse growth of Ulothrix.

Numerous adult chironomids were present on the water surface, and floating clumps of algae were observed near the shore in April 1970. Early in May floating clumps of algae were observed over the entire surface of the reservoir. In June about 25 waterfowl were observed on the water and a few cattle were present on the drainage area. In July and August 1970, as water was released for irrigation, the water level in the reservoir dropped significantly, revealing a considerable amount of aquatic plants at the southern end of the reservoir and a deposit of $CaCO_3$ on the rock face of the dam at the north end of the reservoir.

With the opening of fishing season in May 1970 fishermen appeared in large numbers at Indian Creek Reservoir, but by September the fishing pressure was notably decreased. At that time flying insects (chironomids) were numerous in the vicinity of the reservoir and Daphnia were plentiful in the impounded water. Approximately 200 coots were observed on the reservoir in October 1970. These apparently remained until about the middle of November. In November deer tracks were plentiful along the shore and deer hunters were in the area. Ice was first observed on the reservoir surface on December 15 and by January 6, 1971 a 7-inch ice cover was on the reservoir. By the end of January the ice cover had decreased to about one inch and covered only about one-half of the reservoir surface.

On both the February sampling dates (1971) an extremely green cast was observed over the entire reservoir, indicating a marked increase in phytoplankton. The smallest Secchi disk readings (2.6 to 6.0 feet) were obtained in February, March, and April 1971 when this green color was most in evidence. Such a "phytoplankton bloom" likewise coincided with diminished clarity of the water identified by the Secchi disk during February to April of the preceding year (1970).

Coots were seen briefly in March 1971 and ducks and other waterfowl became numerous in April and May. In April chironomids were again observed flying near the shores of the reservoir.

Apparently within the brief span of existence of Indian Creek Reservoir several annual cycles have been established which involve and effect the limnology of the reservoir. The annual spring phytoplankton bloom evidently starts in February after the spring turnover when the surface water temperature warms up to above 4°C. This is followed in April and May by a bloom of Daphnia which harvest the algae and cause a marked increase in the clarity of the water. Migratory flocks of coots and ducks appear in fall and spring and these birds, as well as resident grebes, blackbirds, and swallows, may have a significant effect on increasing plant and animal species new to the reservoir as well as adding readily available nutrients which might increase plant growth in shallow shore line areas. Another limited source of such nutrients is the increased numbers of domestic cattle and wild deer which frequent the drainage area because of the availability of water.

Survey of Benthic Organisms

In October 1969 and again in October 1970, surveys of benthic invertebrates were made at Indian Creek Reservoir by Mr. W. Arthur Noble of the EPA in cooperation with the project staff. Results of these surveys are presented in detail in Table 16, Appendix.

Samples of bottom sediments were obtained at Stations 1 to 7 (see Figure 2) in the reservoir by means of an Ekman dredge with 6-inch square jaws. Shore line samples at Station 8 were obtained from rocks taken from 2 to 24 inches below the water surface at the main dam and scrubbed in a pail of water. This same technique was used at Station 9 (reservoir outlet). Material was screened through a U. S. 30 sieve (0.589 mm openings). The screenings were placed in jars and preserved in 10 percent borate buffered formalin for subsequent examination.

At the time of the first sampling, October 8-9, 1969, the water depth in the reservoir was 48.75 feet and the deepest points had been under water continuously for some 18 months. By October 14, 1970 (second sampling date) the reservoir had been in operation an additional 12 months and the depth had decreased from a maximum of 55.8 feet in the spring of 1970 to 43.5 feet in October. Three factors must be considered in evaluating reasons for changes in the composition of the benthic community: maturation of the reservoir; aeration of the impounded water; and interactions between the organisms themselves, e.g., predation, competition, etc.

In the 1969 samples only midges (chironomidae) were observed and about 90 percent of the midge larvae were of three types; Chironomus, Procladius, and Glyptotendipes - all of which have pigmented gills, making possible increased oxygen uptake in poorly oxygenated waters. Apparently there was an oxygen deficiency in the benthos that restricted the midge population to low oxygen resistant types. At the time of the 1970 sampling, aerators had been installed and had been in operation since June 23 of that year. This, as noted in a previous section, resulted in marked changes in the oxygen resources of the reservoir.

By October 1970 water mites had become common in all samples and the three midge genera observed in 1969 samples had declined to 66 percent of the total. The three dominant groups in 1970 - Hydrarina (water mites), Chironomus sp., and Procladius sp. - composed 91 percent of the total benthic community. Mites, however, being predaceous may have been somewhat responsible for the decline in the chironomid population.

As shown in Table 8, greater diversity was observed at Stations 1 to 5 in 1970 than in 1969 although the total biomass had decreased from a mean of 428 to 280 organisms per square foot.

TABLE 8

SUMMARY OF BENTHIC ORGANISMS COLLECTED FROM INDIAN CREEK RESERVOIR BY USE OF ECKMAN DREDGE[a]

Station Number	Number of Dredge Samples Collected	Average Number per Square Foot		Diversity[b]	
		1969	1970	1969	1970
1	(3)	412	588	0.35	0.93
2	(3)	588	160	0.70	1.2
3	(3)	528	392	0.72	1.4
4	(3)	648	260	0.36	1.4
5	(3)	268	160	1.05	1.9
6	(1)	364	120	1.22	0.8
7	(1)	176	---c	1.02	---c
Mean		428	280	0.94	1.5

[a]Copepods and Cladocera not included in totals.

[b]Diversity = $- \sum_{i=1}^{z} \frac{n_i}{N} \log_e \frac{n_i}{N}$ in which, n_i = number of individuals in a particular species and N = the total number of individuals in all species [17].

[c]No sample collected.

The presence of snails at Stations 4, 5, and 6, and mayflies at Stations 4 and 5, indicated an overall improvement in the water environment from 1969 to 1970. Aeration of the reservoir water was routine practice during the summer of 1970, hence the greater diversity in 1970 was probably associated with oxygenation of the low dissolved oxygen influent reclaimed water discharged into the reservoir near Station 1. This postulate is supported by the observation that in 1969, before aeration began diversity increased markedly in samples farther away from Station 1.

Although the diversity of the benthic organisms is lower than one would expect in a mature reservoir, it is apparently increasing as the reservoir continues to stabilize. However, the benthic standing crop is decreasing with time and thus the amount of food available from the benthos to the fish population may be decreasing.

Samples collected off the submerged rocks near the dam (Station 8) and in the tailwater (Station 9) just downstream from the reservoir outlet were not quantitatively related to the area of collection. It is obvious from the data (Table 16, Appendix) that the change in population diversity and density from 1960 to 1970 paralleled what occurred in the reservoir sediments. At Station 8 there were 15 groups of organisms represented in 1970 as compared with but 4 in 1969. Similarly at Station 9, 24 groups were present in 1970 where only 10 were found the previous year. Thus as a result of reservoir maturation and further introduction of viable species, the diversity at these two stations apparently increased as it did in the reservoir sediments.

At Station 8 in 1969 the dominant form of organism in the low species diversity of midge larvae was the low oxygen tolerant Glyptotendipes, which constituted 85 percent of the individuals present. The results from Indian Creek (Station 9) likewise showed a species diversity very low for a stream environment. "Dominance by midges, absence of stoneflies and caddisflies, and the presence of only the pollution tolerant mayfly nymph Siphonurus," Noble reported [4] "indicates enriched and eutrophic conditions." The presence of a heavy growth of algae at Station 9 likewise gave the impression of a nutrient rich stream.

In 1970 the midges were greatly reduced in relative importance and organisms associated with higher oxygen levels were more prominent at Station 8. This again may be evidence of an effect of aeration of the reservoir, permitting the development of a more diverse population of organisms. In any event the chironomids in 1970 were no longer as clearly an indicator of the condition of Indian Creek Reservoir as was the case in 1969.

Winter eggs of the Cladocera, Daphnia, (ephippia) averaged 3,142 per square foot of benthos in 1969 and but 1,965 per square foot in 1970. Both of these values indicate that a large population of Daphnia had previously existed during the summer months. This in turn means that a correspondingly high concentration of algae, bacteria, and detritus on which Cladocera fed must have been present. The decrease in number of eggs per square foot, however, does not necessarily indicate a loss of food supply was the cause of reduced numbers of Daphnia. Predation by fish may have kept the population down. Another year or two of observation of Indian Creek Reservoir may well be the only way to determine whether its ability to support aquatic life is decreasing or increasing with time.

Microscopic Examinations

Samples of water and benthic muds were taken on several of the sampling dates listed in Table 13, Appendix. These were preserved and later examined under the microscope by Dr. James M. Lackey, Consulting Biologist, along with fresh samples taken in the field on April 23, 1970. Subsequently, on June 21, 1971 both fresh and preserved samples were taken from the impounded water at 3 different depths at Stations 1, 2, and 3 (Figure 2). These were examined by Mr. Albert Katko of the EPA. The organisms observed by these microscopic surveys are summarized in Table 9.

From the survey of preserved samples reported in Table 9 it is evident that a varied plankton population, indicating good productivity, had developed in Indian Creek Reservoir by July 1969. Both green and blue-green algal forms were present, as were diatoms and anchored plants. Protozoa were present at the benthic interface. The presence of ammonia in the reservoir water would lead one to expect a diverse plankton population. Similarly, the reduction in ammonia and carbon, discussed in preceding sections, is in itself evidence of an active biota in the reservoir. These findings support the conclusion that a maturing of the reservoir was a necessary prelude to fish survival, not only to develop a food source but also to reduce toxicity.

The results of microscopic examination of fresh samples and benthic muds reported in Table 9 is more revealing of the productivity of the reservoir than are those of the preserved samples. The variety and amount of planktonic biota shows that the reservoir was a highly productive body of water. In fact the samples described in the table as "Floating Floc - Lake Debris" shows a spectrum of organisms typical of impounded water, which indeed characterized the reservoir in April 1970, inasmuch as no releases of water occurred after September 1969 and influent was diverted from the reservoir when it reached full capacity in March 1970.

TABLE 9

SUMMARY OF ORGANISMS OBSERVED IN MICROSCOPIC SURVEYS OF INDIAN CREEK RESERVOIR

Preserved Samples	
Sampling Date:	July 29, 1969
Profuse filamentous material on buoy and anchor rope at Sampling Station No. 1.	
Chlorophyta Draparnaldia	
Sampling Date:	September 10, 1969
Material on buoy anchor rope at Sampling Station No. 1. Heavy growth to six meters depth.	Material on buoy anchor rope at Sampling Station No. 3.
Bacterial slime (heavy growth) Chlorophyta Cosmarium (Desmid) Capsalated alga (unidentified) Diatoms Navicula	Chlorophyta Draparnaldia Cosmarium (Desmid) Closterium (Desmid) Cyanophyta Merismopedia Lyngbye Chrysophyta (Diatoms) Navicula (numerous)
Sampling Date:	September 15, 1969
Algae attached to dead sedge at point between main dam and saddle dam.	Live vascular plant. Heavy growth in one to two ft of water off point of land between main and saddle dams.
Chlorophyta Draparnalia (dominant) Cyanophyta Schizophrix (dominant) Chrysophyta Epiphytic algae	Potomageton
Floating green algae collected from lake surface near east shore and main dam.	Algal growth on live Eel Grass from one to two ft of water off land point between main and saddle dams.
Chlorophyta Prasiola	Chrysophyta Network of Epiphytic algae Chlorophyta Chlorella (very numerous) Cosmarium (Desmid) Draparnaldia
Benthic sample taken by dredge in 13-meter depth of water at Sampling Station No. 1. (Subsurface mud mixed with sample; preservation not good.)	Benthic sample by dredge at Sampling Station No. 2. Water depth, 12 m. (Subsurface mud mixed with sample, preservation not good.)
Chrysophyta Navicula (Diatom) Euglenophyta Euglena sp.	Chrysophyta Navicula (Diatom) Pine pollen Note: Very little to see in sample.
Benthic sample by dredge at Sampling Station No. 3. Water depth 9.5 m.	Benthic interface in 5-cm water depth at main dam near Indian Creek channel.
Chrysophyta Navicula (Diatom) Note: No other organism observed in sample.	Chlorophyta Cosmarium (Desmid) Chrysophyta Navicula (Diatom) Cyanophyta Schizothrix Ciliate Protozoa Colpoda

TABLE 9 (Continued)

Sampling Date:	September 15, 1969 (Continued)
Benthic interface in 5-cm water depth at boat launching ramp (east side of reservoir approximately 300 ft south of main dam).	Benthic interface in 5-cm water depth at south end of small embayment on east shore of reservoir.
Chlorophyta Closterium (Desmid) Chrysophyta Navicula (Diatom) (very numerous) Ciliate Protozoa Pleuronema	Chrysophyta Navicula (Diatom) (numerous) Cyanophyta Merismopedia Schizothrix Lyngbya Chlorophyta Cosmarium (Desmid) Ciliate Protozoa Colpoda
Sampling Date:	March 18, 1970
Surface tow with plankton net between main dam and Sampling Station No. 2.	Outlet from Indian Creek Reservoir. Filamentous bloom at time of sampling. Sample unpreserved.
Daphnia Rotifers Harpacticoid Copepod Worm	Chlorophyta (Filaments too decayed for positive species identification.) Cosmarium (Desmid) Ciliate Protozoa Paramecium Cyclidium
Fresh Samples	
Sampling Date:	March 18, 1970
Water Sample, Station No. 1 (centrifuged)	Water Sample, Station No. 2 (centrifuged)
Chlorophyta Green algal cells (unidentified) Cosmarium (Desmid) Chrysophyta Navicula (Diatoms) Meridion (Diatoms) Protozoa Zooflagellates	Chlorophyta Chlamydomonas Cosmarium (Desmid) Chrysophyta Navicula (Diatom) Flagellate Protozoa Zooflagellates Miscellaneous Hillea
Water Sample, Station No. 3 (centrifuged)	Water Sample, South Embayment (centrifuged)
Chlorophyta Cosmarium (Desmid) Cryptomonadidae Cryptomonas Chrysophyta Navicula (Diatom) Euglenophyta Euglena Flagellate Protozoa Zooflagellates	Chlorophyta Chlamydomonas Cosmarium (Desmid) Chrysophyta Navicula (Diatom) Flagellate Protozoa Zooflagellates Ciliate Protozoa Lionotus fasciola
Station No. 1, Bottom (centrifuged)	Lake Plankton, Including Small Amount of Bottom Sediment
Chlorophyta Chlorella Flagellate Protozoa Anisonema ovale Monas Bodo Zooflagellates Ciliate Protozoa Cyclidium Miscellaneous Cladocera ephippia	Chlorophyta Cosmarium (Desmid) Mougeotia Cryptomonadidae Cryptomonas Chrysophyta (Diatoms) Navicula Gomphonema Synedra capitata Asterionella formosa Flagellate Protozoa Zooflagellates

TABLE 9 (Continued)

Sampling Date: March 18, 1970 (Continued)	
Floating Floc – Lake Debris	Reservoir – Lake Debris
Chlorophyta Cosmarium (Desmid) Closterium Evastrum Cryptomonadidae Cryptomonas Chrysophyta Navicula (Diatom) Cyanophyta Oscillatoria Schizothrix Euglenophyta Euglena Flagellate Protozoa Bodo Chroomonas Notoseknas apocamptus Peranema Ciliate Protozoa Oxytricha Cinetochilum Aspidisca castata Chilodonella Stichotricha Miscellaneous Rotifer Dipterous larvae	Chlorophyta Cosmarium (Desmid) (vast amount) Chlamydomonas Ciliate Protozoa Cyclidium Oxytricha Flagellate Protozoa Notoselenas apocamptus Zooflagellates (vast number) Cryptomonas Chroomonas Chrysophyta Navicula (vast number) Miscellaneous Amoeba vespertilio Rotifer
Growth on Buoy, Sampling Station No. 2	Floating Floc Opposite East Boat Launching Ramp
Chlorophyta Cosmarium Closterium Chlamydomonas Chlorella Ulothrix Cyanophyta Oscillatoria Lyngbya Schizothrix Chrysophyta (Diatom) Navicula Eunotia Chryptomonadidae Chryptomonas	Chlorophyta Chlorella Cosmarium (Desmid) Closterium Chlamydomonas Chrysophyta Navicula (Diatom) Cyanophyta Merismopedia Oscillatoria Proteomyxa Nuclearia Mycetoza Amoeba Ciliate Protozoa Oxytricha Vorticalla Flagellate Protozoa Notoselenus apocamptus Chryptomonadidae Chryptomonas

TABLE 9 (Continued)

Sampling Date: March 18, 1970 (Continued)	
Growth on Concrete Bottom of Outlet from Reservoir	Dens Mat of Algae in Runoff Ditch Below Dam
Chlorophyta Cosmarium (Desmid) Chlorella Closterium Euglenophyta Petalmonas Euglena sp. Euglena gracilis Spenomonas teres Anisonema ovale Chrysophyta Navicula (Diatom) Cryptomonadidae Cryptomonas Mycetoza Amoeba vespertillio Ciliate Protozoa Vorticella Aspidisca costatus Cyclidium Flagellate Protozoa Notoselenus Chroomonas Miscellaneous Nematode Chirinomid larvae Carinita	Chlorophyta Ulothrix Closterium Cosmarium (Desmid) Scenedesmus Cyanophyta Merismopedia Cryptomonadidae Cryptomonas Euglenophyta Euglena viridis Ciliate Protozoa Oxytricha Cyclidium Miscellaneous Rotifer Chironomid larvae
	Growth on Dead Grass in Reservoir
	Chlorophyta Cosmarium (Desmid) Closterium Chlamydomonas Chrysophyta Eunotia Navicula (Diatom). Flagellate Protozoa Notoselenus Chroomonas Ciliate Protozoa Oxytricha Vorticella
Benthic Detritus Samples	
Sampling Date: October 14, 1970	
Rooted Aquatics	Algae
Myriophyllum sp.	Cyanophyta Oscillatoria Agmenellum Phormidium Chlorophyta Ulothrix Closterium Cosmarium Euglena Volvox Chrysophyta Navicula Achnanthes Surirella Hydrurus
Liverwort	
Riella	

TABLE 9 (Continued)

Preserved Samples

Sampling Date: June 21, 1971

Station No. 1 0.5 m	
Chlorophyta	
Chlamydomonas	264
Gleacystis	66
Chrysophyta	
Ochromonas	2838
Achnanthes	33
Total per mℓ	3201

Station No. 2 0.5 m	
Chlorophyta	
Chlamydomonas	361
Gleocystis	165
Schroderia	33
Chrysophyta	
Ochromonas	2937
Total per mℓ	3496

Station No. 1 7 m	
Chlorophyta	
Chlamydomonas	99
Gleocystis	99
Schroderia	33
Chrysophyta	
Ochromonas	561
Total per mℓ	792

Station No. 2 6 m	
Chlorophyta	
Chlamydomonas	99
Gleocystis	99
Chrysophyta	
Ochromonas	2244
Total per mℓ	2442

Station No. 1 14 m	
Chlorophyta	
Chlamydomonas	99
Total per mℓ	99

Station No. 2 12 m	
Chlorophyta	99
Gleocystis	
Chrysophyta	
Ochromonas	165
Total per mℓ	264

Station No. 3 0.5 m	
Chlorophyta	
Chlamydomonas	858
Gleocystis	33
Schroderia	99
Chrysophyta	
Ochromonas	5247
Achnanthes	33
Total per mℓ	6270

Station No. 3 5 m	
Chlorophyta	
Gleocystis	165
Schroderia	33
Chrysophyta	
Ochromonas	1617
Total per mℓ	1815

Station No. 3 10 m	
Chlorophyta	
Gleocystis	132
Chrysophyta	
Achnanthes	33
Cymbella	33
Nitzschia	66
Total per mℓ	264

Filamentous Material at Outlet
Chlorophyta
Chlamydomonas
Closterium
Cosmarium*
Dictyosphaerium
Oedogonium*
Scenedesmus
Stigeoclonium*
Chrysophyta
Gomphonema
Nitzschia*
Cyanophyta
Aggmenellum
Stigonema*
Phormidium

*Predominant type of organism.

As noted in a preceding section entitled "Survey of Benthic Organisms" bottom samples were taken on October 14, 1970, from which benthic invertebrates were separated by use of a U. S. No. 30 sieve. Organic debris retained along with these invertebrates was examined under the microscope by Mr. Albert Katko. As reported in Table 9, Myriophyllum sp. was present and the Liverwort, Riella sp. was common at all sampling stations. The most abundant forms were mats of the blue-green alga, Oscillatoria; the filamentous alga, Ulothrix; and the diatom Navicula. Other forms were typically benthic algae which were found in most samples at most times of the year.

On June 21, 1971, water samples were collected at surface, mid-depth, and bottom water at Stations 1, 2, and 3. At the same time filamentous material was collected from rocks in the stream at the outlet of the reservoir. As may be seen from Table 9, very little diversity was observed in the reservoir samples and the diatoms observed were typical of benthic rather than planktonic types. Except for the flagellates Ochromonas and Chlamydomonas, which were the dominant algae observed, the algal population was primarily associated with benthic production. This was borne out by the clarity of the water – 17.5 feet Secchi disk depth – observed on the sampling date (June 21, 1971).

Ochromonas and Chlamydomonas can utilize organic sources of nutrition and such sources would probably be benthic in origin because only a very low input of organic material from the STPUD effluent occurs, e.g., BOD less than 2.0 mg/ℓ more than 50 percent of the time (see Table 17, Appendix). The observation that most of the Ochromonas and Chlamydomonas were concentrated in the top layer of the reservoir indicates that light is probably the major energy source for their production.

The planktonic population was representative of unstable conditions in the reservoir. This is probably a result of some of the cycles (i.e., phytoplankton to Daphnia to phytoplankton) which occur in the reservoir. The grazing effect of Daphnia apparently is restricting the development of a large phytoplankton community. This should be of considerable importance in the prevention of severe algal bloom problems. However, the development of mats of Oscillatoria, as observed in the October 1970 detritus sample, may be of considerable long-term consequence. Such mats may presage the development of severe blue-green blooms of a noxious type of algae.

Trout in Indian Creek Reservoir

The history of fish plantings in Indian Creek Reservoir reveals much information concerning the maturing of the reservoir with time. During the summer of 1968 trout were placed in test boxes in the reservoir water but failed to survive for longer than 24 hours, some dying within 30 minutes. To test the reservoir environment further, 2,080 rainbow trout fingerlings 3 to 4 inches long were planted in the reservoir on October 16, 1968, some 6 months after filling of the reservoir began. No mortality was observed during the fall months but by springtime no fish apparently remained. Fish mortality was presumed to be due to a lack of dissolved oxygen caused by prolonged heavy ice cover of the water surface during the winter of 1968-69, although this presumption was not fully proven.

On August 8, 1969, 3,600 hybrid (rainbow and cutthroat) trout 1.7 inches in length were planted in the reservoir. Three days later 4,400 trout of the Hat Creek (Mono County) Rainbow strain were planted. These were some 4.5 inches in length. An overnight gill netting operation on October 1969 produced a catch of 130 of these fish. By that time the small fingerlings had grown to 6 inches in length and the second group averaged 8.9 inches long. Subsequently, in March 1970, a one-day gill net setting yielded 18 fish most of which were 11 inches long, the smallest being 10 inches.

On February 20, 26, and 27, 1970 a total of 31,000 rainbow trout of the Mt. Whitney strain, 4.5 to 6 inches long, were planted in the reservoir. Subsequent fish plants in 1970 were: June 12, 20,000 fingerlings; July 2, 5,500 legally catchable trout; August 17, 22,000 fingerlings. All these plantings were trout.

Obviously something occurred during the reservoir's development which made it compatible to trout. Although the exact cause of mortality of fish in the 1968 tests is not known, some toxic factor was evidently present. Inasmuch as the recommended limit for ammonia at normal outdoor values of pH is 2.5 mg/ℓ for trout, ammonia toxicity seems the most logical cause of fish mortality at that time, the influent to the reservoir having an ammonia concentration of from 12 to 20 mg/ℓ. The most important factor in fish survival must then be the phenomenon which reduced the concentration of ammonia in the impounded water from these high values to values ranging from 2.5 to 7.0 mg/ℓ in subsequent months. As previously noted, dilution alone was not the cause of nitrogen reduction. Evidence presented in a preceding section indicates that denitrification in the benthic sludge is the factor. However, if ammonia toxicity was indeed the toxic factor, two conclusions are supported by the experience with trout in Indian Creek Reservoir:

1. That the establishment of a balanced ecosystem in which ammonia toxicity was not a problem was necessary before the water became a suitable environment for trout.

2. Some trout, especially those of the species and strains introduced to Indian Creek Reservoir, can thrive at concentrations of ammonia more than double the recommended limit.

Of course, the factors involved in fish mortality and fish survival in Indian Creek Reservoir are likely to be vastly more complex and subtle than the simple factor of ammonia. Whatever the spectrum of such factors may be they seem to have been stabilized, resulting in a good fishery. From the first plants of catchable trout an estimated 32 lbs/acre of trout (more than 5,000 pounds) were harvested during the 1970 fishing season. The largest fish caught was 19 inches long and weighed 3.25 pounds. In February, April, and May 1971 plantings of small trout were 25,000, 30,000, and 20,000, respectively. The total weight of fish planted in 1971 was 3,090 pounds, compared with the total of 2,970 pounds from which the 5,000 pounds were later harvested. Because the fishing season for 1971 extends until September, far beyond the closing date of the study herein reported, it is too early to estimate what the 1971 catch may total. Nevertheless the most recent observations of fish survival during the 1971 season indicates that the reservoir continues to be a habitat conducive to rapid fish growth and good survival of planted trout species. For example, a gill net setting of only 3 to 4 hours during the first week of July 1971 yielded a catch of 120 fish.

Some indication of the changes which may be taking place in the reservoir may be gained from an examination of the contents of the stomachs of trout. Such an analysis reveals that either the food supply or the food preference of fish changed during the period of study. In the spring of 1970 chironomids constituted most of the stomach contents of trout, whereas Daphnia predominated in the spring of 1971, and most recently (first week of July 1971) snails were the most common food, particularly in the larger fish. The observed decrease in the chironomid larval population reported in the preceding section is quite probably the factor most responsible for the decline of the importance of this organism in the diet of trout. However, this decline in food may have had an effect on the trout population as well.

On the opening weekend of trout season, fishing results were considerably poorer in 1971 than in 1970. This may have been due to inclement weather, or to a reduction in the fish population. Also differences on the availability of feed and cover in the reservoir may have caused changes in the catch of fish. Although the catch rate from boats was nearly the same in 1970 and 1971, the shore fishermen had very poor results in the latter year. Table 10 presents data on this point supplied by the California Department of Fish and Game. Changes in shoreline

conditions may have resulted from such factors as increased growth of aquatic plants, thus increasing feed and cover for fish while physically interfering with the fishermen.

As in the case of evidence drawn from benthic surveys of invertebrate organisms, the results of fish catches during the period of study suggest that the reservoir may be declining in capacity to support aquatic life. Such an indication, however, must remain highly tentative until data from more years of observation either confirm or deny its validity.

TABLE 10

SUMMARY OF CREEL CENSUS RESULTS FOR OPENING WEEKEND OF FISHING SEASON AT INDIAN CREEK RESERVOIR, 1970 AND 1971

Factor Observed	1970	1971
Number of anglers	939	606
Man-hours of fishing	3382	2196
Total of fish caught	1202	238
Catch per hour	0.36	0.11
from shore	0.37	0.08
from boats	0.26	0.20
Catch per angler	1.28	0.39
from shore	1.42	0.28
from boats	0.76	0.83

Aquatic Vascular Plants

At least six different aquatic plants are present in Indian Creek Reservoir in some abundance. Five of these are tentatively identified as: Ceratophyllum (coontail), Myriophyllum (milfoil), Elodea (waterweed), Salvinia (water fern), and Potamogeton (pondweed). The sixth is an unidentified grass. In a survey made by the project staff in August 1970, Myriophyllum was found to be the most abundant plant. The estimated standing crop of all species in the entire reservoir at that time was approximately 5560 pounds dry weight of plant material. Of this total, Myriophyllum comprised about 70 percent. Plants of the different species were present as discrete clumps, generally circular in shape and separated from other clumps by clear areas of sediment. Potamogeton was found only in the deeper waters.

The estimates reported in Table 11 for August 1970 were obtained by first determining by observation the fraction of the total reservoir where plants were abundant. This fraction was then studied in detail at low water to determine the frequency of occurrence of each type of plant and the area of each individual clump, thus obtaining an estimate of the percent areal occurrence. (Column 2). The weight of randomly selected clumps were then measured by sampling and determining in the laboratory the dry weight of sample per square foot of area sampled.

TABLE 11

ESTIMATE OF VASCULAR AQUATIC PLANT STANDING CROP
IN INDIAN CREEK RESERVOIR, 1970

Plant	Area Covered (% of area studied)	Dry Weight	
		(lb per sq ft of area covered)	Total lb in Reservoir
Myriophyllum	4.8	0.16	3800
Ceratophyllum	0.6	0.27	740
Salvinia	0.3	0.28	410
Grass	1.2	0.057	340
Potamogeton	0.1 (assumed)	0.40	200
Elodea	0.1	0.14	70
Total	7%		5560

Figure 23 shows the results of a field experiment conducted on August 19, 1971. To obtain the data summarized in Figure 23 A, samples were collected at noontime along a transect at the southern end of the reservoir in an area where the plant growth was generally profuse. Sampling points were selected in open water where no plants were growing. In all cases the DO at the surface was greater near the shore than at the middle of the transect, about 900 feet offshore, where the water was deepest. As shown in the figure the highest observed DO was 8.2 mg/ℓ at a distance of 12 feet from the shore. Thereafter it decreased linearly until at 96 feet offshore it was but 5.7 mg/ℓ, or essentialy the same as the 5.3 mg/ℓ at the middle of the transect. Thus it is evident that a substantial area of the surface water of the reservoir was being oxygenated by the vascular plants underlying it.

More dramatic evidence of this effect is seen in Figure 23 B. Here the dissolved oxygen concentration was measured with time in the center of a large patch of Potamogeton sp. in a water depth of 4 feet. Between sunrise and noon the DO concentration rose from a concentration close to that found at the center of the transect to a value greater than 11 mg/ℓ by noon. Almost immediately thereafter a wind came up, mixing the water and causing a precipitous decline in the dissolved oxygen at the point of sampling.

From the results of the field study of vascular plants at Indian Creek Reservoir it is evident that such plants affected the DO resource of the reservoir to a marked degree. Thus they are quite important in the chemical and biological aspects of the water quality, although as shown in Table 7 their importance in the nutrient balance is minimal.

Microbiological Studies of ICR

In the summers of 1970 and 1971 experiments were performed to determine the effects of microbial activity on nitrogen metabolism in Indian Creek Reservoir. The purpose of these experiments was to answer more precisely the question of what happens to the influent ammonia nitrogen (NH_3-N) once it enters the reservoir ecosystem. However, due to constraints of time and personnel, these experiments represent only single measurements of conditions existing at a particular time

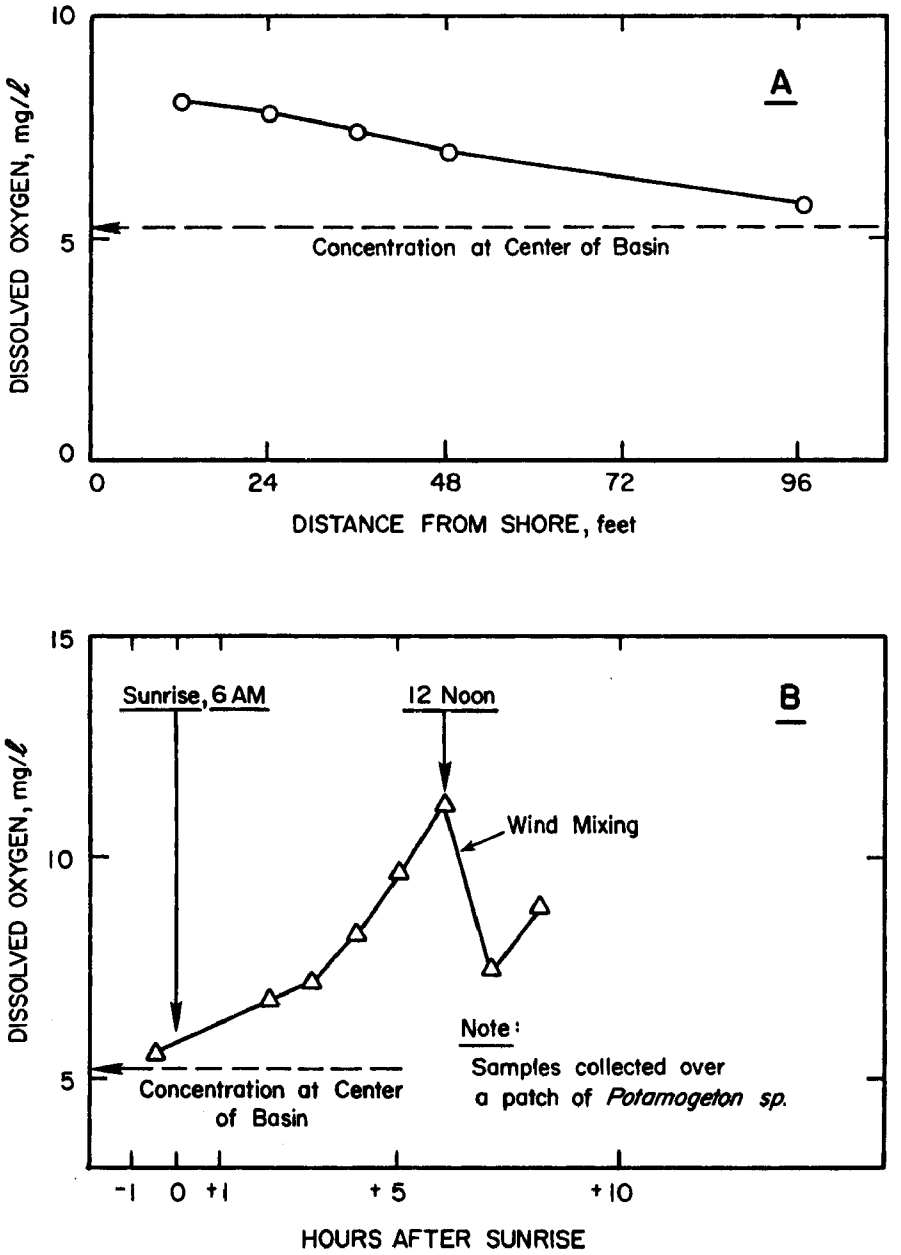

FIGURE 23. DISSOLVED OXYGEN INCREASE BY VASCULAR PLANTS

of year when the metabolic rates are expected to be the greatest. Thus the results of the experiments provide a basis for estimates only of the active conditions in the reservoir.

From a comparison of the concentrations of oxidized forms of nitrogen observed in the influent reclaimed water and the impounded water (see Table 13, Appendix; and Figure 20) it was apparent that some of the influent ammonia was being metabolized to nitrates by nitrifying bacteria in the reservoir waters. A considerably greater quantity of ammonia, however, was (see Table 7) leaving the system in a manner not readily identified. To explore the question of nitrogen metabolism as a factor in this apparent loss of nitrogen from the reservoir system, measurements of the rate of nitrification were made on August 19, 1970.

Samples were collected at 1:00 p.m. from Station 1 (Figure 2) at 5 different depths below the water surface and analyzed for dissolved oxygen as well as for nitrites and nitrates (NO_3-N, and NO_2-N). Within three to four hours after collection, the samples were placed in the dark at a temperature of 16.5°C and vigorously aerated. Further measurements of NO_3-N, NO_2-N, and NH_3-N were made at daily intervals and the nitrification rates were calculated by dividing the difference between the initial and 5-day NO_3-N concentration by the period of incubation (5 days).

The results of the experiment, summarized in Figure 24, show that nitrification apparently does not become measurable by the procedure used except in the impounded water below the thermocline, i.e., in the hypolimnion. In this region it increased sharply with depth to a certain point; then decreased rapidly, probably because the dissolved oxygen decreased to a level below which it became limiting to nitrifying bacterial activity. The thermocline apparently provided a density barrier to the distribution of the nitrification activity throughout the water column. At other times of the year when density differences are insufficient to maintain a stratification, and dissolved oxygen is in abundant supply, it might be expected that nitrification would be more generally distributed throughout the water mass and would also proceed at a greater rate for the reservoir as a whole.

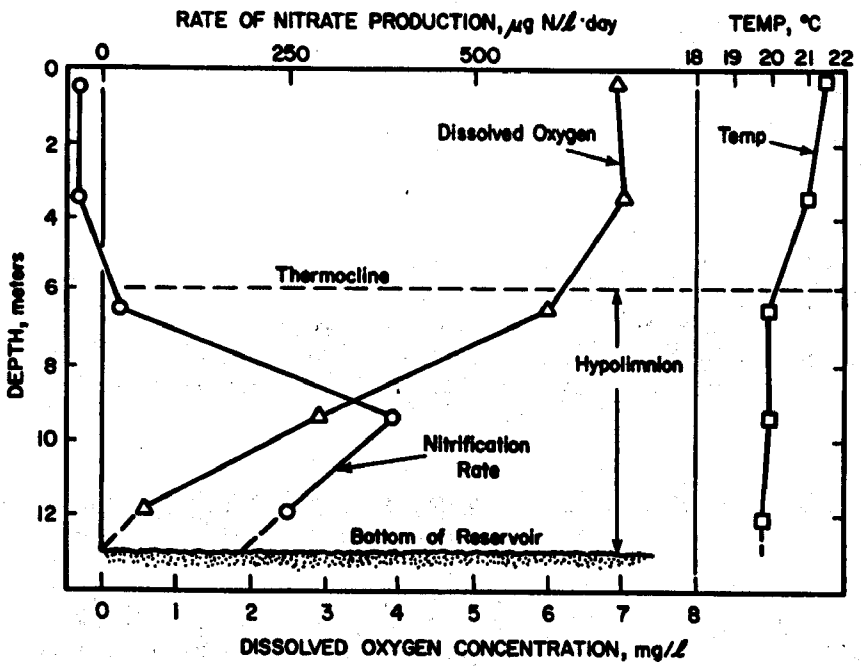

FIGURE 24. VARIATION IN NITRIFICATION RATE, DISSOLVED OXYGEN AND TEMPERATURE WITH DEPTH, INDIAN CREEK RESERVOIR, AUGUST 1970

The overall nitrate production for the water column at Station 1, assuming a column one meter square and 13 meters high, was about 1.5 g N/m^2/day. The specific rate (μg NO_3-N produced/μg NH_3-N available) per day for water below the thermocline was about 0.1 $days^{-1}$.

An uneven distribution of nitrification activity throughout the hypolimnion, because of lack of uniformity of water depth and the variation observed in nitrification rate with depth, precludes and accurate assessment of the overall rate for the entire reservoir. A crude estimate can, however, be obtained from the experimental data of August 1970. At that time the thermocline was at about 6 meters (19.7 ft), hence a relatively small proportion of the reservoir volume was involved in the nitrification activity observed. Estimating that the mean rate of nitrification was 200 μg N/ℓ/day below the thermocline, and that nitrification took place within a volume of 320,840 m^3 (260 acre-ft), (the volume below the thermocline) the overall rate of nitrification for the whole reservoir was 64 kg N/day. This compares with an average daily input of 170 kg NH_3-N/day for the 2-year period of study. On this basis it follows that about 35-40 percent of the input ammonia was nitrified, resulting in a concentration of 7-8 mg NO_3-N/ℓ. Although this is two or three times the ammonia concentration observed in the reservoir the estimate is not too unreasonable, particularly when one considers the annual fluctuation in volume, dissolved oxygen, and temperature as well as all the biological reactions which would serve to remove nitrogen.

The biological reaction responsible for removing nitrogen which appears to be most important in Indian Creek Reservoir is bacterial denitrification. An estimate of denitrification rates was made as a part of the August 1970 study. A water sample was collected from Station 1 and immediately processed by placing aliquots in individual BOD bottles, adding approximately 0.2 g of sodium sulfite to remove oxygen, and inoculating all but the controls with 5 cc of a slurry of benthic sludge taken from the top 1-2 cm of sludge at the interface in about 2 feet of water. The BOD bottles were then sealed, placed in the dark, and allowed to incubate at 16.5°C. Initial and daily measurements of NO_3-N, NO_2-N, and NH_3-N were made to determine the net loss of ammonia in controls and in test samples.

Calculated rates of denitrification were 133 μg N/ℓ/day for the controls and 161 μg N/ℓ/day for the sediment inoculated samples. Expressed in terms of the volume of benthic sludge in the system the denitrification rate was 16 μg N/cc sediment/day. For 135 acres of sediment 1.32 cm deep (equivalent to 71 acres at 2.5 cm depth used in previously presented estimates) one obtains a value for total benthic sediment of 7200 m^3. Thus 120 kg N/day would be lost from the reservoir by denitrification through the effect of bacterial activity in the benthic sludge.

If the daily input of NH_3-N averages 170 kg/day and the denitrification loss is 120 kg/day, it follows that this 120 kg must first be nitrified and incorporated in the sludge so that denitrification could release it to the atmosphere as gaseous material. The remainder of the initial NH_3-N input to the reservoir (50 kg/day) would remain in the impounded water and lead to a concentration of 6 mg/ℓ in that water. Such a value is not too different from the observed 4 to 7 mg/ℓ reported in Table 13, Appendix.

If the denitrification rate of 120 kg N/day is applied to the 2 years over which the nutrient budget was taken, the nitrogen loss by denitrification would approximate 85,000 kg N. The estimated nutrient budget for nitrogen (Table 7) showed a deficit ascribed to denitrification of some 63,000 kg for the period of study, plus any fraction of an additional 14,337 kg of nitrogen carried as oxidized nitrogen in percolating water which may have been denitrified in the benthic zone. Thus the values for nitrogen lost by denitrification are not unreasonably far apart considering the assumptions involved in both.

Nitrification-denitrification rate estimates are summarized in Table 12, along with the input of NH_3-N computed on both a daily basis and the two-year total. For purposes of comparison, estimates are also made of the rates which would be necessary to produce the average concentrations of NO_3-N + NO_2-N and NH_3-N actually observed in the reservoir over the two years of study (see Table 5).

TABLE 12

ESTIMATES OF RATES OF AMMONIA OXIDATION AND OF DENITRIFICATION OF NITRATES IN INDIAN CREEK RESERVOIR AS OF AUGUST 1970
(Values in terms of N)

Input of NH_3-N by Reclaimed Water		Nitrification Rate		Denitrification Rate	
Daily	2-year Total	Daily	2-year Total	Daily	2-year Total
170 kg	124,000 kg	64 kg 120 kg*	47,000 kg 91,000 kg*	120 kg 83 kg*	85,000 kg 61,000 kg*

*Estimated from actual mean chemical concentrations over the two-year period of study (data from Table 5).

Calculated Nitrification Rate $= \frac{D}{A}\left(A - \frac{B}{C}\right)$

Calculated Denitrification Rate $= \frac{D}{A}\left(A - \frac{B + E}{C}\right)$, in which

A = input NH_3-N concentration = 18,826 μg/ℓ
B = NH_3-N concentration in reservoir = 3,624 μg/ℓ
C = dilution factor = 0.7
D = kg input of NH_3-N on daily or 2-year basis
E = NO_3-N + NO_2-N concentration in reservoir water = 3,121 μg/ℓ

Further confirmation of the importance of nitrification-denitrification in Indian Creek Reservoir was obtained by analysis of benthic sludge samples for bacteria during July 1971.

This analysis, made under the direction of Dr. R. C. Cooper of the University of California, revealed the presence of denitrifying bacteria in numbers characteristic of a healthy denitrifying benthic sludge.

Bioassays

Bioassays of influent reclaimed water and impounded water at Indian Creek Reservoir were made by the flask assay method described in Section IV. This method was adopted because considerable experience in the technique and interpretation of the test results had been acquired by the project staff during previous and concurrent studies [5,8,9,14] in the Lake Tahoe Basin and in Indian Creek Reservoir [4]. Moreover, the development of standard techniques by the EPA [20] and its contracting groups had not yet produced a more acceptable alternate procedure.

As noted in Section IV, the test involves the use of a single species of test alga (in this case Selenastrum capricornutum). This allows the analysis of a large number of samples in a limited space, yet provides a reasonable estimate of the comparative biostimulatory response of different samples.

From flask assays of Indian Creek Reservoir waters, undiluted and at various concentrations in filtered Lake Tahoe water, three measures of growth response were computed: They are specific growth rate, $\hat{\mu}_b$; cell concentration, $\hat{X}_5$; and cell mass produced during five days of growth, SS_5. These are likewise reported in Table 18, Appendix. The value of $\hat{\mu}_b$ was calculated by computer analysis as the maximum slope of the growth curve identified by cell counts after 1, 3, and 5 days of incubation.

$\hat{X}_5$ is the maximum number of cells attained at the end of a 5-day growth period, evaluated as the average after replicate counts. SS_5 represents the suspended solids measurement obtained after 5 days of growth.

As previously noted, and as evident in Table 13, Appendix, the influent reclaimed water entering Indian Creek Reservoir was apparently so overwhelmingly phosphorus limited that no biochemical changes during the period of impoundment came within one order of magnitude of bringing N and P into biological balance in either the impounded water or the discharged water during the period of study. Quite likely, as discussed in a preceding section, biological activity in the benthos utilizing and recycling phosphorus from sediments and the soil, together with denitrification and dilution, accomplished the observed loss and conversion of nitrogen compounds necessary to make the reservoir water tenable to trout.

The results of bioassays of undiluted samples of reclaimed water (III), and impounded water (C), are shown in Figure 25. These show a considerable variation in values of $\hat{\mu}_b$. For impounded water, a comparison of the chemical data summarized in Figures 3 through 22, reveals very little coincidence of peaks in the water quality curves and those in the $\hat{\mu}_b$ curves of Figure 25. A general trend, however, is for $\hat{\mu}_b$ to increase during the winter season when the reservoir temperature and incident solar energy are low, and algal growth is at a minimum; and to decrease during the warmer months when conditions for algal growth are favorable. A reciprocal of this general trend can be seen in the variation in water temperature, suspended solids, and volatile suspended solids; Figures 4, 7, and 8, respectively. The foregoing trend is especially apparent in the almost complete lack of growth response in impounded water during the February-March 1971 period. At that time a sharp increase in both the suspended solids and volatile suspended solids values occurred. The explanation of this phenomenon again is that as the organic growth which appears as suspended solids increases, the nutrients are correspondingly reduced until one or more become limiting. A physical factor such as temperature or solar energy, or a toxic substance, could also limit growth. Thus a sample collected during this time period would already be deficient in some essential nutrient and hence would not produce further algal growth in the flask assays even though other nutrients might be present or in excess.

Although phosphate was assumed to be limiting to growth in impounded water, there is little identifiable relationship between $\hat{\mu}_b$ in Figure 25 and phosphate concentration in Figure 16. This might suggest that some other element, possibly a minor nutrient or biostimulant, was the limiting factor. However, when aliquots of phosphate solution were added to the flask assays (data not herein reproduced) algal growth was clearly promoted. Therefore, considering the large N/P ratio, concentration of individual chemicals, and the observed increase in algal growth with phosphate additions, it seems probable that the standing crop of algae in the reservoir incorporates the available phosphorus in cell material at such a rate as to render the water incapable of supporting much further growth in the flask assays. In this case $\hat{\mu}_b$ may be said to reveal the efficiency of utilization of phosphorus in the reservoir rather than the true growth stimulating potential of the impounded water.

The growth response ($\hat{\mu}_b$) of reclaimed water (Figure 25) shows little relationship to that of the impounded water and is generally lower in value. Fluctuations did, of course, occur throughout the period of study but because the water had just emerged from the reclamation plant its variation in quality was a function of plant performance rather than of the seasonal cycles of organic growth and decay to which the impounded water was subject. Thus it must be recognized that whereas the values of $\hat{\mu}_b$ for the impounded water were influenced by the quality of influent water and surface runoff, as well as by pre-stripping of nutrients during seasonal cycles of biological growth, the growth rates ($\hat{\mu}_b$) in reclaimed water were a function of its basic chemical quality, which may have included toxic materials or been deficient in trace elements.

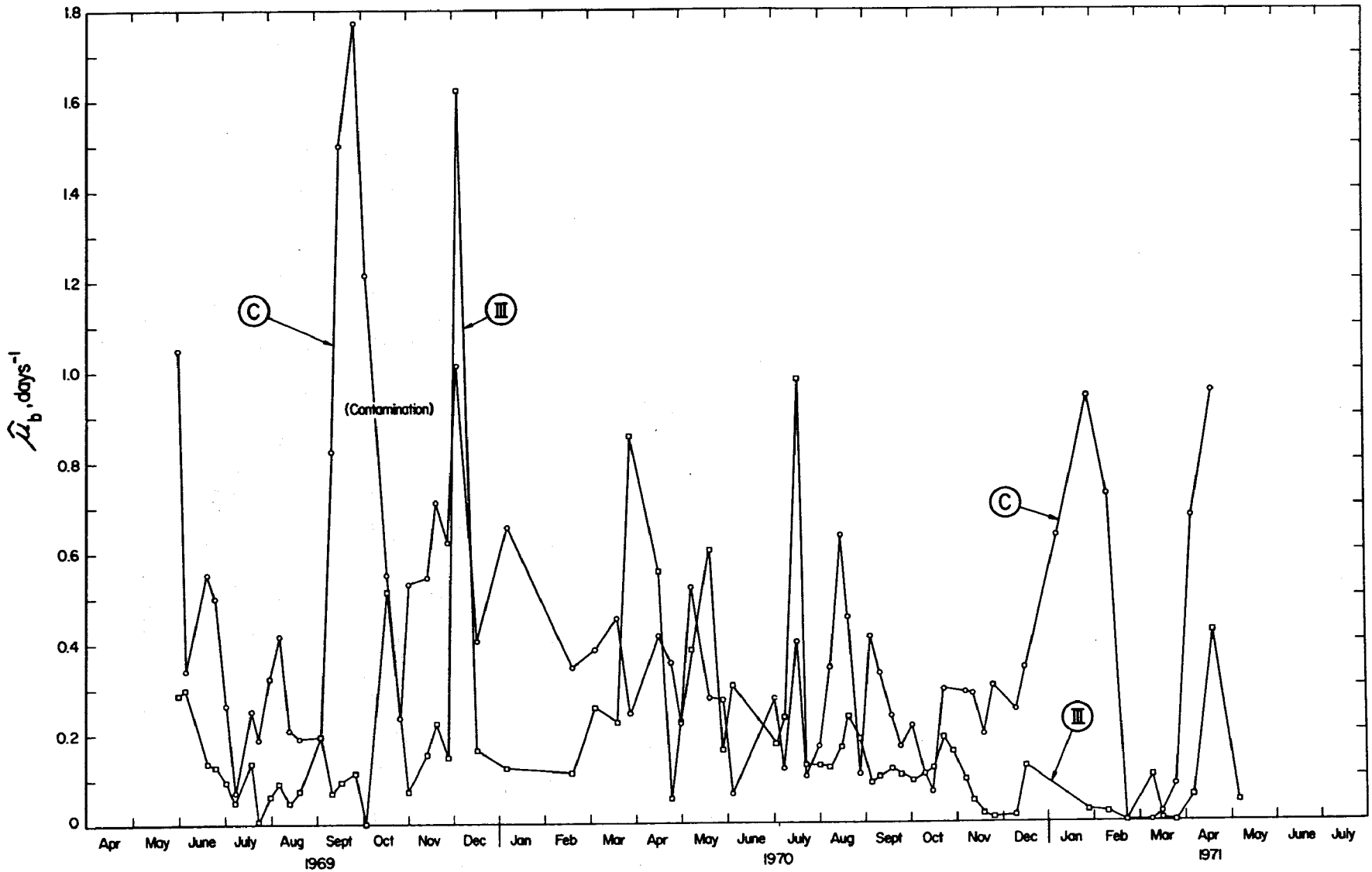

FIGURE 25. MAXIMUM SPECIFIC GROWTH RATE, $\hat{\mu}_b$ FOR UNDILUTED SAMPLES FROM THE INDIAN CREEK RESERVOIR SYSTEM

In view of the different factors influencing the growth rates in bioassays of reclaimed water and impounded water, no especial relationship between the two curves in Figure 25 is to be expected. However, the fact that impounded water which is supporting some growth is still more capable of producing growth in the flask assays than is the influent reclaimed water is a significant finding.

SECTION VI

DISCUSSION AND EVALUATION OF RESULTS

Evaluation of specific findings of environmental, chemical, and biological observations of Indian Creek Reservoir is included in Section V as a part of the interpretation and discussion of the individual subjects therein presented. Conclusions are drawn in that section as deemed appropriate by the authors. These are summarized and extended in Section I, and recommendations are summarized in Section II. Therefore it seems appropriate to consider in this section what the Indian Creek Reservoir study has thus far shown concerning the reclamation of water from domestic wastes for recreational use and its import in the context of eutrophication of surface waters, as well as the changes observed with time in the impounded water itself.

In evaluating the results of the study herein reported it must be borne in mind that although Indian Creek Reservoir in 1970 and 1971 was providing recreational opportunity in the form of sport fishing and development for contact sports is contemplated, it was adapted rather than designed for such purpose. This is to say that the processes to be applied to secondary waste water effluent at the South Tahoe Public Utility District Plant were not originally selected with the objective of producing a water quality ideally suited to the multiple beneficial uses which are compatible in a wilderness. Instead they were the outgrowth of concern on the part of water quality control officials for the consequences of fertilizing surface waters with nutrients added by domestic use of water — nutrients which are only stabilized and not removed by the best, or even perfect, sewage treatment plants of the conventional type. Overriding even this national problem, and the national objective of its solution, was the unique situation existing in the Lake Tahoe Basin. Here it was deemed unacceptable, and on good evidence, to discharge into Lake Tahoe even water which meets U. S. drinking water quality standards, because in the matter of nutrients such standards exceed by some two orders of magnitude the concentrations presently found in the lake.

The factors underlying process design were therefore based on a number of rational concepts, not all of which were necessarily explicit in the decisions which followed:

1. The time is at hand when in many circumstances conventional waste water treatment processes must be extended to include nutrient removal or reduction.

2. Phosphorus is capable of triggering objectional algal growths when low oxygen concentrations encourage algal species capable of utilizing nitrogen from the atmosphere.

3. We know how to remove phosphorus, therefore in the course of "pollution control" it should be removed as an act of faith if not of scientific necessity.

4. Nitrogen removal, although not immediately technologically developed, must in the future likewise be applied to waste water effluents.

5. At the present state of technology and knowledge of the sensitivity of Lake Tahoe, even the most highly treated waste water cannot be allowed to enter the lake, either directly or indirectly. Therefore, export from the basin is a practical necessity.

6. Given present aesthetic attitudes of people, exported effluents must be good enough to be acceptable to the exporter himself under normal conditions, i.e., were it not for the unique quality of Lake Tahoe.

7. Emerging standards of surface water quality must be met by any process of water reclamation.

8. A pioneering task of process development has to be undertaken if other concepts of water quality are to be achieved.

Given objectives, constraints, and problems such as the foregoing, and the political climate in which they must be resolved, the objectives of process design were necessarily different than might have been the case had the creation of a recreationa reservoir been the water quality objective. This fact is extremely important in understanding what has been observed at Indian Creek Reservoir; and in considering what observations are required for the future.

The data herein presented show quite clearly that the reclaimed water delivered to Indian Creek Reservoir during its first three years of operation were so low in phosphorus as a result of purposeful phosphate removal by the South Tahoe Public Utility District as apparently to be phosphate limited as an algal growth medium. That is, it contained nitrogen in excess of phosphorus in some 10 times the N/P ratio at which algae utilize these two nutrients, while at the same time being near the concentration (0.10 mg/ℓ) of phosphorus at which growth is often thought to be limited. Moreover, in its undiluted state it was toxic to both trout and the test alga (Selenastrum) used in bioassays of its growth potential. For this reason it was tentatively concluded early in the study that ammonia was the toxic factor. Later it became apparent that in the impoundment this same water lost ammonia from its initial 15 to 20 mg/ℓ concentration to a level generally less than 4 mg/ℓ.

That the observed profound change in ammonia content was not due to simple dilution was shown by a hydrological balance which revealed the reservoir input to be approximately 70 percent reclaimed water from STPUD and 30 percent surface runoff and rainfall directly on the reservoir water surface. That it was not due to nitrification alone was likewise evidenced by the failure of nitrates to reach any sustained levels above about 4 mg/ℓ.

Loss of nitrogen from the reservoir by nitrification-denitrification was early suspected as the cause of the observed nitrogen imbalance. From the evidence developed in the study there is no doubt but that nitrification in the hypolimnion and denitrification in the benthic zone is the major mechanism. Analysis of the benthic sludge in 1971 revealed the presence of denitrifying bacteria in numbers characteristic of a healthy denitrifying sludge. Similarly, direct experiments showed nitrification activity in the hypolimnion during the summer months sufficient to account for the nitrogen lost by denitrification. Aeration of the reservoir by mechanical means during 1970-71, however, gives reason to believe that the benthos is the site of denitrification activity.

The amount of nitrogen lost from the reservoir was, as reported in Section V, estimated by two approaches: a nitrogen balance based on hydrological and chemical analyses, and microbiological studies of the reservoir. The amount of nitrogen loss necessary to produce the levels of nitrogen observed in the weekly sampling program cannot be determined with exactitude. The reasons are that the amount of influent from the reservoir environment is unknown, and estimates can only approximate the amount of nitrogen tied up in biota and organic sludge in the reservoir at any time. However, two estimates made from different approaches independently place the total nitrogen loss during the two years of study herein reported in the range of 61,000 to 84,000 kg.

From the nitrogen studies it is concluded that nitrogen loss from the reservoir is taking place; that nitrification-denitrification is the major mechanism, and that the estimates of the amount lost are reasonable. Whether or not the reservoir has reached a state of limnological stability is still unknown. The two-year curves for ammonia and nitrates seem to indicate a tendency to increase with time. It is too early to say whether this is a long-term trend. However, its implications are sufficiently serious to suggest that this factor should be monitored for an additional period of years.

The efficiency of removal of phosphorus by the STPUD reclamation plant increased with time until during the 1970-71 year of study it was near the margin of detectability in the reservoir water. No corresponding reduction in ammonia concentration occurred, hence the N/P ratio increased drastically. Other sources of phosphorus available to the biota in Indian Creek Reservoir must have compared favorably with that of reclaimed water, otherwise it is difficult to explain the algal growth which, in the early months of 1971, was sufficient to give the reservoir a green cast. Possible sources of phosphorus include the original soil on which the reservoir was constructed, animal and plant wastes washed in from the small (1700-acre) drainage area, and such allochthnous material as wind blown dust and pollens. Although these sources might conceivably be considered minor, they could add to a buildup in the benthic sludge which eventually becomes out of scale with the concentration coming in the STPUD effluent.

The extent to which phosphate limitation is responsible for the apparent good quality of Indian Creek Reservoir should be further studied in relation to sources of phosphorus in order that the true value of phosphate removal as a waste water treatment process may be determined. In the specific case of the Indian Creek Reservoir, where the annual discharge equals the annual input and represents a large percentage of the reservoir capacity, the buildup of phosphate by biological recycling may be either more or less important than in larger lakes, depending upon where the phosphorus is in the system at the time of water releases. Further observations of the buildup of benthic sludge with time will be necessary to clarify this point.

Biologically, Indian Creek Reservoir showed important changes over a two-year period. From an initial situation in which it apparently would not support fish life, it developed in 1970 into an excellent trout fishery. However, in 1971 the fish production, as measured by early season catches, appeared to have declined. Gill netting studies indicated that this might not be the case. In view of somewhat contradictory, albeit fragmentary evidence, such as the nitrogen increase and the question of fish population, it is clear that a number of factors should be monitored for a longer period to determine whether the reservoir has reached stability.

Evidence that with time the reservoir increased rather than decreased in biological health is to be found in an increase in the diversity of benthic invertebrates from 1969-70 to 1970-71. This diversity was the more convincing because of a decline in the predominance of low oxygen tolerant species of chiromonads. The extent to which this was the result of mechanical aeration of the water is uncertain but it is well established [13] that such aeration of water will not preclude an anaerobic zone in the underlying sludge or soil. This is further specifically evidenced in Indian Creek Reservoir by denitrification activity traceable to the benthic sludge.

Plankton in the impounded water, as well as the emergence of a normal cycle of algae and grazers (Daphnia) in the impounded water in 1971 likewise suggests an improving limnological situation. Previously, in April 1970, a plankton survey of the reservoir revealed a species distribution typical of impounded water.

Bioassays of impounded and reclaimed water were especially revealing of the maturation of Indian Creek Reservoir. The cyclical nature of growth response, as measured by the specific growth rate ($\hat{\mu}_b$) of Selenastrum, showed clearly that the growth potential of the impounded water increased during the cold season and decreased during the warm season when the biota of the reservoir were utilizing the nutrients. In contrast, no such cyclical response was clear in the reclaimed water. This finding is logical and is particularly important because it differentiates between the growth potential and the residual growth potential of a water. This is to say that a bioassay of a waste water (filtered) may reveal its true algal growth potential (within the limits of capability of the test), whereas in an outdoor body of water it can only measure the residual potential in the water. In wintertime more of the total potential of an impounded water might be in undecomposed organic matter in the benthic sludge than in the water, whereas in the summer time the reverse may be the case. But in any case a bioassay must be interpreted with

caution when applied to a natural body of water. Conceivably, an extremely highly eutrophied body of water could show little response because the test utilizes only that fraction of the nutrients currently being recycled between decomposing and growing biota. In contrast, a filtered waste water, or the reclaimed water influent to Indian Creek Reservoir, harbors no nutrient sinks such as those in a lake or reservoir. In this circumstance the lesser growth shown by reclaimed water than by the impounded water indicates clearly that Indian Creek Reservoir as a limnological entity is influenced by many factors not implicit in the mere quality of its principal source of influent.

In an overall evaluation of Indian Creek Reservoir it might be said that the impoundment affords an unprecedented opportunity to observe, for practical as well as scientific reasons, what may be expected from a ponding of water reclaimed from domestic return flows. As noted in the opening paragraphs, no attempt was made originally to design the waste water reclamation plant at South Tahoe to produce a water of optimum quality for recreational purposes, if indeed such an optimum could be defined. Eventually, however, the data from Indian Creek Reservoir should indicate whether such an optimum process would be appreciably different than that presently installed at STPUD. In the meantime it may be said that the STPUD plant is a very efficient system for removing phosphorus, and Indian Creek Reservoir is a good system for removing nitrogen. Whether or not the phosphorus removal is presently unnecessarily effective, is the controlling factor, or is of little consequence is an important practical and economic question. It cannot be answered at Indian Creek Reservoir until the productivity of the reservoir has been observed for another two or three seasons. If the water cycle is stabilized already, it may be that nitrogen removal is not necessary in the treatment plant. If it is not, it may mean that nitrogen removal is inadequate and, possibly, that phosphorus removal is more than optimum.

SECTION VII

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SECTION IX

PUBLICATIONS AND PATENTS

No patents were produced in the course of the project. One publication was released in May 1970 by the Lake Tahoe Area Council pursuant to the terms of the initial grant. This report is:

> "Eutrophication of Surface – Indian Creek Reservoir. First Progress Report (FWQA Grant No. 16010 DNY)." Lake Tahoe Area Council, South Lake Tahoe, Calif., 141 pp. (May 1970).

SECTION X

GLOSSARY

The following list represents the sense or context in which various terms and symbols are used in this report, without specific regard to generalized or standard definitions.

Benthic Sludge - Accumulated organic and organic sediment on the bottom of the reservoir.

Benthic Invertebrates - Invertebrate organisms living in or upon the benthic sludge.

Bioassay - Laboratory measurements of the effect of nutrients or other factors on the rate of growth of a test alga under specified conditions.

Biostimulation - Increase in the expected or normal response of an organism as a result of the presence of some growth stimulating factor.

Conservative Element - Chemical element not significantly removed or increased by chemical, physical, or biological processes.

Denitrification - Reduction of nitrate or nitrite to nitrogen gas by aerobic bacteria living under anaerobic conditions.

Discharged, or Released, Water - Water purposefully released from Indian Creek Reservoir for irrigation use.

Eutrophic - Nutrient rich condition of water.

Grazers - Aquatic animals which eat plant material, e.g., herbivorous zooplankton such as *Daphnia*.

Hypolimnion - Region below the thermocline in a body of water.

Impounded Water - Mixture of influent reclaimed water and surface runoff plus precipitation stored in Indian Creek Reservoir.

Infiltration - Movement of water downward into the soil through the soil-water interface, or bottom, of the reservoir.

Influent Reclaimed Water - Domestic sewage effluent exported to Indian Creek Reservoir after advanced treatment at the South Tahoe Public Utility District's reclamation plant.

Limnology - The study of physical, chemical, biological, and environmental interrelationships in fresh water, particularly lakes and ponds.

Mechanical Aeration - Bubbling or air through the impounded water with the purpose of saturating it with oxygen in equilibrium with the atmosphere.

Mixing - The intermingling of water masses in Indian Creek Reservoir so that passive materials such as chemical constituents are uniformly distributed horizontally and vertically when the reservoir is well mixed.

Nitrification - Oxidation of ammonia to nitrate or nitrite by specific bacteria, called nitrifiers.

Nutrient Budget - The algebraic sum of the effect of all factors which add or subtract a specific plant nutrient, such as nitrogen or phosphorus, in the reservoir, i.e., an accounting for all inputs and outputs of a particular nutrient.

Nutrient Recycling - Movement of nutrients through the natural cycle of growth and decay of organic matter.

Oligotrophic - Nutrient poor condition of water.

Plankton - The host of free living microscopic plants (phytoplankton) and animals (zooplankton) in water.

Productivity - The rate of change of biomass with time in a system, expressed in amount per unit area or unit volume, e.g., lbs fish per acre per year.

Secchi Disk - An 8-inch diameter white disk used to measure the clarity of water in terms of depth below the water surface at which it disappears from sight of the observer.

Seiche - An oscillating wave motion in the reservoir caused by winds.

Toxicity - The presence of factors which decrease or inhibit the expected or normal response of an organism.

$\hat{u}_b$ - Maximum rate of increase in algal cell numbers or mass during a 5-day flask bioassay.

$\hat{X}_5$ - Algal cell count at the end of a 5-day bioassay.

SS_5 - Dry weight of suspended solids in flask at end of 5-day bioassay.

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TABLE 13

INDIAN CREEK RESERVOIR ANALYSES

Date	Sample Type	Res. Depth	Solar	Secchi Disk	Temperature		Unfiltered Samples									0.45 μ Millipore Filtered Samples											
									Nitrogen as N							Nitrogen as N					Phosphorus as P						
					Water	Air	Susp. Solids	Vol. Susp. Solids	Org.	NH_3	Total Phos.	COD	BOD_5	DO	Inorg. C	Org.	NH_3	NO_2	NO_3	Total	PO_4	Total	Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-4})
		ft	ft-c	ft	°C	°C	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ		mg/ℓ	mhos
1968																											
10/3	A[a]											44	12			810	2120	2660	2260	7850	46	60	20.0	43.8	30	8.9	67.0	374
	B[b]											21	9			1625	6800	1460	3690	13575	43	66	27.5	44.7	< 1	8.1	188.7	440
11/4	A											2	5			1625	10500	740	2260	15125	130	170	32.5	52.4	20	8.3	197.0	400
	B											< 1	9			1440	10250	1140	2010	14840	140	210	33.2	50.6	< 1	8.3	185.2	450
1969																											
4/1	A											-	2			620	6150	220	480	7470	60	69	32.5	23.6	22	8.0	106.0	216
	B											-	3			420	5500	360	640	6920	67	71	30.9	18.8	23	8.1	99.6	219
4/28	A											18	1			700	4250	88	172	5210	3	14	39.0	21.9	25	8.8	104.0	229
	B											20	7			650	5000	145	315	6110	10	17	35.0	20.0	37	8.4	107.0	238
	C[c]											15	< 1			510	86	10	25	651	18	37	14.1	1.8	< 1	7.7	63.8	104
	D[d]											9	< 1			240	22	7	12	281	25	34	6.2	1.6	48	7.4	30.6	51
	E[e]											4	< 1			270	30	6	10	316	19	31	7.3	1.4	77	7.3	36.9	53
	F[f]											42	10			720	5100	83	257	6160	< 1	6	34.8	21.1	24	8.9	105.0	230
5/29	A						2.22	0.96	425	2700	105	-	6			665	3400	648	1192	5905	59	77	15.4	19.4	2	7.8	101.3	300
	B						12.25	3.15	715	4300	134	-	6	6.8	26.0	725	4300	312	1308	6645	77	98	16.0	19.0	20	8.0	108.4	310
	C	49.8		5.5	17.0		1.49	0.64	960	8250	99	-	2	6.9	27.1	600	4200	282	918	6000	63	78	15.5	17.5	16	7.8	108.5	295
	F						3.22	1.03	800	4750	100	-	< 1	-	-	690	4300	282	1098	6370	62	78	15.6	18.1	12	8.0	108.2	297
	S-III[g]						0.64	0.64	800	14250	134	-	2	4.3	48.0	510	14900	49	30	15489	112	122	33.6	27.0	7	8.2	199.3	498
6/4	B						6.89	2.11	815	4550	127	29	4	6.7	25.9	670	4250	480	1240	6640	80	118	36.1	17.4	26	8.0	108.0	347
	C	49.8		3.8	18.0		6.52	2.84	765	3600	35	32	2	6.6	25.3	245	3100	469	1001	4815	33	35	34.7	16.0	9	8.1	105.6	350
	S-III						3.26	2.52	545	19000	205	31	3	2.9	41.0	275	21000	55	14	21344	150	165	37.6	25.5	16	8.3	171.2	500
6/19	B						0.86	0.47	720	7125	179	29	7	7.5	27.1	685	4500	540	520	6245	135	158	38.0	18.8	18	7.6	108.5	316
	C	50.1		3.0	18.0		12.12	8.00	1380	4150	43	34	5	8.8	24.8	930	3450	455	905	5740	5	13	34.4	18.1	55	8.0	103.5	300
	S-III						0.63	0.66	850	14500	85	19	< 1	2.1	46.3	580	10200	154	536	11470	66	77	57.6	20.8	30	8.2	193.0	425
6/24	B						1.92	0.77	725	6200	176	-	8	8.1	29.7	665	5650	300	80	6695	141	160	40.4	14.2	14	8.0	123.9	302
	C	50.4		6.7	18.0		3.07	1.74	860	3625	50	-	4	6.9	25.2	1365	3300	260	140	5065	5	21	37.5	18.6	9	8.1	105.1	275
	S-III						0.53	0.53	490	19250	105	-	< 1	1.8	48.7	540	17800	28	13	18381	84	97	59.6	23.7	9	8.0	203.6	430
7/1	B						5.84	2.83	635	3300	91	18	6	7.7	27.1	1190	3175	520	1720	6605	59	92	38.8	20.4	24	7.9	108.4	350
	C	50.5		6.6	18.0		2.82	1.80	1000	3600	47	28	2	6.7	27.9	1130	3350	500	1480	6460	16	40	36.0	18.1	17	7.9	111.6	318
	S-III						0.87	0.66	365	17100	53	21	2	2.6	52.8	490	14900	18	43	15451	20	34	60.6	26.4	< 1	8.1	219.8	500
7/10	B						7.86	4.83	860	4825	335	34	7	7.8	28.5	1190	4475	275	205	6145	83	109	36.6	26.2	16	7.8	113.8	332
	C			4.8	19.0		2.66	2.66	1180	3225	88	53	2	7.0	26.0	1345	3500	215	325	5385	5	28	35.8	19.7	18	8.0	108.2	290
	S-III						1.56	1.30	620	20200	184	24	< 1	3.1	31.4	760	19100	100	96	20056	148	160	17.8	30.0	17	8.8	131.0	370
7/17	#1[h]	50.7		7.2	22.2	30.5	4.57	3.46					2		26.5	810	4700	20	1820	7350	86	125	34.0	18.9	47	8.3	110.0	288
	#2[h]			8.0	22.2	30.5	9.36	3.04					3		26.9	670	4625	21	2120	7436	72	105	35.8	21.1	37	8.3	112.0	295
	#3[h]			7.3	22.2	30.5	3.45	2.22					3		26.5	560	4525	19	2140	7244	53	92	35.2	21.4	32	8.3	110.0	290
	0.5 m_1				22.0		3.86	2.25					2		26.7	685	3850	22	2138	6695	16	47	33.0	19.9	34	8.3	111.0	320
	3.5 m_1				20.6		4.67	2.94					2		26.7	845	3950	23	2137	6955	43	72	35.8	22.1	55	8.2	111.0	326
	6.5 m_1				18.7		3.49	2.33					2		30.2	865	5500	20	1880	8065	121	150	36.6	21.1	34	7.9	121.0	325
	Bottom plus 0.5 m_1				18.3		15.71	4.23					4		29.8	885	5225	22	1500	7632	118	146	36.4	20.7	33	7.8	119.0	333
	B						4.89	1.84	1060	4375	179	24	6	6.2	24.0	625	3750	1280	1580	7235	61	89	36.6	19.5	17	7.6	96.0	327
	C		6600	7.2	22.0	30.5	1.23	0.90	1240	3000	-	32	2	6.7	25.4	1050	3600	250	1710	6610	122	-	36.0	19.0	13	8.1	106.0	323
	L-III[j]						0.96	0.89	1630	16000	-	23	< 1	5.8	44.8	1000	17100	580	80	18760	850	980	56.6	29.7	4	8.2	186.8	540
7/22	B						3.58	1.00	640	5000	180	33	5	6.6	28.3	590	2500	420	1720	5230	136	155	37.4	20.1	4	8.0	117.7	328
	C	50.7	960	6.0	23.1	29.4	2.58	1.09	875	3125	24	53	2	6.0	25.1	1090	1850	450	2430	5820	5	17	35.6	20.2	7	8.2	104.4	324
	L-III						0.85	0.31	950	13600	155	23	< 1	5.4	54.0	1040	7750	450	4150	13390	128	150	65.8	28.2	< 1	7.7	215.8	510

TABLE 13 (Continued)

Date	Sample Type	Res. Depth ft	Solar ft-c	Secchi Disk ft	Temperature Water °C	Temperature Air °C	Unfiltered Samples: Susp. Solids mg/ℓ	Vol. Susp. Solids mg/ℓ	Nitrogen as N: Org. µg/ℓ	Nitrogen as N: NH_3 µg/ℓ	Total Phos. µg/ℓ	COD mg/ℓ	BOD_5 mg/ℓ	DO mg/ℓ	Inorg. C mg/ℓ	0.45 µ Millipore Filtered Samples: Nitrogen as N: Org. µg/ℓ	Nitrogen as N: NH_3 µg/ℓ	Nitrogen as N: NO_2 µg/ℓ	Nitrogen as N: NO_3 µg/ℓ	Nitrogen as N: Total µg/ℓ	Phosphorus as P: PO_4 µg/ℓ	Phosphorus as P: Total µg/ℓ	Ca mg/ℓ	Cl^- mg/ℓ	Fe µg/ℓ	pH	Alk. as $CaCO_3$ mg/ℓ	Cond. (10^{-6}) mhos
7/29	B	50.8	4900	10.2	22.2	22.8	4.03	0.79	800	4550	255	30	6	6.5	29.3	790	5250	240	1460	7740	170	250	38.0	19.6	17	8.1	122.0	359
	C						1.57	0.19	810	3000	34	26	1	6.4	26.0	710	3050	280	2340	6380	9	30	38.0	19.3	7	8.2	108.5	328
	L-III						-	-	700	9600	110	13	< 1	4.3	48.9	680	12100	110	4090	16980	68	79	65.6	29.7	7	8.1	203.7	519
8/5	B	50.8	5400	7.8	20.8	25.5	3.36	0.79	900	5000	218	24	6	6.3	31.2	1090	5100	240	1720	8150	189	200	37.8	22.2	7	8.2	130.0	382
	C						2.56	0.86	1180	2625	40	21	2	7.0	26.2	810	2400	310	2570	6090	15	34	38.2	20.4	7	8.3	109.0	358
	L-III						0.55	0.00	740	6750	122	51	4	10.6	44.3	530	6700	40	7560	14830	113	117	59.6	26.3	10	7.8	177.0	510
8/12	B	51.0	4600	4.9	20.3	25.0	1.09	0.41	933	5595	191	20	6	6.6	23.5	748	5355	210	1850	8163	160	183	42.6	19.2	5	8.0	98.0	359
	C						5.75	4.52	1033	2355	26	30	4	7.7	26.9	1071	2475	300	2560	6406	7	17	38.0	19.1	2	8.2	112.2	346
	L-III						0.43	3.23	610	16280	186	-	-	-	53.3	605	15290	2	378	16275	104	145	59.0	-	25	8.3	222.0	625
8/19	B	50.2	5200	5.8	20.0	21.7	0.95	0.73	-	-	-	-	5	6.7	31.3	785	5200	450	1730	8165	110	125	42.0	19.0	10	8.2	130.5	400
	C						6.14	5.16	986	4590	47	-	3	7.9	24.5	1090	2450	281	2739	6560	1	29	34.0	18.9	< 1	8.1	102.0	340
	L-III						1.21	1.05	743	13800	115	-	< 1	5.2	49.1	990	13600	175	1765	16730	60	89	61.6	25.0	15	8.2	196.5	520
9/2	B	49.3	4600	8.8	21.0	31.0	2.45	1.33	1067	1800	70	12	6	8.5	28.0	1000	5525	350	2050	8925	52	60	40.4	21.8	7	7.9	111.8	380
	C						1.84	1.17	1393	5750	49	14	1	8.1	26.2	977	5275	210	2250	8712	32	40	37.8	23.0	10	7.7	104.7	380
	L-III						0.45	-	723	17350	185	2	< 1	3.8	44.0	594	17250	70	850	18764	53	162	49.0	30.6	22	8.0	183.5	524
9/10	B	49.5	4600	6.4	20.5	29.5	4.24	2.11					6	6.6	28.6	1120	2390	400	2860	6770	44	165	37.6	19.8	8	8.0	119.0	232
	C						2.17	1.08					1	5.6	27.6	1182	2990	260	2540	7072	27	112	36.4	20.4	7	8.0	115.0	228
	L-III						1.09	0.86					< 1	2.9	46.3	489	19330	95	1425	21339	47	83	51.0	28.2	22	7.9	185.0	395
9/16	#1	49.6	4600	4.5	18.5	24.5						17	-		31.8	905	3015	312	2688	6920	47	68	39.1	19.4	37	7.8	127.0	291
	#2		5600	4.0		23.0						13	-		31.6	819	3155	268	2132	6374	45	69	39.6	19.4	-	7.9	126.0	292
	#3		6000	4.2		22.8						13	-		31.3	876	3060	250	2350	6536	47	66	39.2	19.7	22	7.8	125.0	292
	0.5 m				18.4							15	-		31.6	883	2895	250	2310	6358	40	57	39.5	44.2	-	7.8	126.0	500
	3.5 m				18.2							14	-		31.3	1020	3470	290	2270	7050	51	71	40.6	25.0	36	7.8	125.0	400
	6.5 m				18.0							13	-		31.3	776	2990	350	2130	6246	48	67	40.6	21.2	22	7.8	125.0	318
	B						9.75	2.35	5165	3150	93	25	-		30.5	1148	4855	365	2375	8743	49	70	41.0	20.1	33	8.1	127.0	289
	C	49.6	4600	4.5	18.5	24.5	1.59	0.69	4230	2820	76	15	-		30.0	1335	2655	294	2426	6710	47	69	62.6	19.3	33	8.1	125.0	328
	L-III						0.41	0.41	532	13828	135	6	-		63.6	< 5	12440	4	138	12584	113	134	61.0	27.2	33	8.1	265.0	555
9/25	B	48.2	5500	4.6	17.0	25.0	5.82	1.81	943	2320	95	102	7	6.9	29.6	943	2630	380	2860	6813	59	78	63.8	21.6	25	8.1	123.2	405
	C						4.75	1.33	809	2535	32	22	3	7.0	30.9	752	2895	300	2600	6547	49	85	41.2	23.0	< 1	8.1	128.6	385
	L-III						0.64	0.64	512	15400	45	28	< 1	5.9	53.2	670	11870	15	150	12705	67	82	61.6	30.0	7	7.7	212.8	580
10/2	B	49.2	5200	3.7	16.0	20.5	4.16	1.35	847	1745	80	17	7	6.9	-	962	2250	290	3570	7072	45	56	41.3	20.1	27	-	-	-
	C						3.79	1.67	914	2585	73	22	5	7.4	-	1024	2680	340	3160	7204	44	91	40.6	20.6	16	-	-	-
	L-III						1.45	1.41	532	15210	113	17	< 1	2.6	53.9	627	13640	6	81	14354	84	92	58.0	22.1	30	8.5	224.5	500
10/8	B	48.6	2200		14.0		5.11	1.61				20	8	7.8	29.4	1532	9520	350	470	11872	25	44	41.7	25.5	11	8.2	122.5	410
	C						11.32	3.24				21	5	7.9	30.2	-	9115	270	1020	-	6	28	42.1	28.0	17	8.0	125.8	410
	L-III						1.51	1.16				15	3	5.3	45.7	532	16790	19	155	17496	258	430	37.7	28.5	15	8.2	190.4	460
10/16	B	48.6	4000	4.2	9.5	12.0	-	-	766	2465	77	39	2	8.0	31.0	886	2535	310	3510	7241	49	69	39.6	23.9	9	8.1	129.0	364
	C						5.12	1.55	809	2965	79	36	< 1	8.6	32.4	776	2945	420	2880	7011	47	70	43.4	23.0	4	8.2	135.2	375
	L-III						0.70	0.71	249	17030	223	29	< 1	1.6	60.8	364	17460	12	163	17999	168	170	59.0	26.3	12	8.1	253.2	540
10/24	B	48.7	1340	6.2	9.0	13.5	-	-	1000	2510	63	48	14	15.0	30.8	713	2510	290	3710	7223	29	48	40.0	27.0	8	8.1	128.5	368
	C						-	-	526	2510	67	57	2	14.6	30.8	-	3340	260	3420	-	28	41	41.0	29.9	9	8.1	128.3	364
	L-III						-	-	240	15550	177	46	< 1	3.3	68.0	249	14350	4	106	14709	153	160	70.8	33.4	6	7.9	272.1	570
10/30	B	48.8	4400	7.2	9.0	11.3	-	-	-	-	-	-	< 1	15.8	31.2	1277	2580	260	3720	7817	51	62	44.0	23.7	33	8.2	129.8	384
	C						2.07	1.04	924	2580	80	50	7	15.0	31.8	977	2650	310	3070	7207	52	63	43.0	25.6	29	8.2	132.5	385
	L-III						1.97	1.33	603	18270	137	45	14	3.4	61.2	589	17120	9	71	17789	59	148	68.2	31.5	16	8.0	255.0	610
11/13	B	48.8	4200	9.2	8.5	16.0	1.22	0.72	1029	2200	67	17	7	10.1	33.1	1584	2510	170	3150	7414	50	59	50.4	26.1	9	7.9	132.5	376
	C						1.59	0.76	1161	2325	66	23	2	10.0	34.2	1498	3850	120	2860	8328	48	58	50.0	27.3	11	7.9	136.8	390
	L-III						1.82	1.61	943	19470	95	25	< 1	3.1	50.8	838	19380	3	56	20277	28	33	68.6	24.9	13	7.9	203.2	580

TABLE 13 (Continued)

Date	Sample Type	Res. Depth ft	Solar ft-c	Secchi Disk ft	Temperature Water °C	Temperature Air °C	Unfiltered Samples: Susp. Solids mg/ℓ	Vol. Susp. Solids mg/ℓ	Nitrogen as N: Org. µg/ℓ	Nitrogen as N: NH_3 µg/ℓ	Total Phos. µg/ℓ	COD mg/ℓ	BOD_5 mg/ℓ	DO mg/ℓ	Inorg. C mg/ℓ	0.45 µ Millipore Filtered Samples: Nitrogen as N: Org. µg/ℓ	Nitrogen as N: NH_3 µg/ℓ	Nitrogen as N: NO_2 µg/ℓ	Nitrogen as N: NO_3 µg/ℓ	Nitrogen as N: Total µg/ℓ	Phosphorus as P: PO_4 µg/ℓ	Phosphorus as P: Total µg/ℓ	Ca mg/ℓ	Cl^- mg/ℓ	Fe µg/ℓ	pH	Alk. as $CaCO_3$ mg/ℓ	Cond. (10^{-6}) mhos
11/19	0.5 m				6.5										34.0	1087	2920	156	444	4607	48	58	50.9	26.7	11	8.0	136.0	-
	3.5 m				6.3										34.6	1326	2825	161	539	4851	49	64	49.1	27.0	9	7.9	138.0	-
	6.5 m				6.2										32.5	1249	3110	155	445	4959	48	61	50.8	25.9	11	7.9	130.0	-
	9.5 m				6.1										32.5	292	2680	155	445	3582	50	67	48.9	26.6	19	7.9	130.0	-
	B						0.80	0.55	163	2335	94	36	5	9.9	31.7	474	1770	170	3390	5804	60	66	51.4	23.2	6	8.0	132.1	415
	C	49.0	5000	9.2	6.5	11.8	1.65	0.73	532	3350	85	24	< 1	9.4	31.8	378	2680	145	2975	6178	71	82	48.0	22.5	< 1	8.0	132.5	400
	L-III						0.53	0.87	469	18858	85	22	< 1	1.9	52.2	321	16270	124	1426	18141	60	78	63.8	30.3	17	7.4	209.0	560
11/26	B						-	-	809	2200	64	15	5	9.5	28.0	1005	2440	105	3895	7445	38	61	43.3	23.2	2	8.1	116.7	380
	C	49.1	4000	10.0	5.0	9.0	-	-	771	2845	60	8	2	10.3	28.3	895	2415	100	3380	6790	40	60	42.6	25.5	5	8.2	118.0	380
	L-III						-	-	627	20570	136	< 1	< 1	1.4	48.1	570	20190	5	13	20778	57	69	59.4	31.4	4	8.2	200.5	515
12/3	B						1.01	0.78	981	2510	67	< 1	5	11.1	30.9	819	3300	160	4040	8319	50	71	50.9	26.4	9	8.0	132.6	410
	C	49.2	4000	11.3	4.0	11.0	1.49	0.57	943	2680	67	15	3	10.8	33.6	1058	3180	190	3550	7978	45	62	50.2	24.7	2	7.9	134.6	385
	L-III						1.45	0.96	847	22730	706	< 1	< 1	1.8	44.7	594	21120	13	117	21844	568	583	42.1	29.8	4	7.8	178.8	520
12/16	B						1.39	0.68	-	294	82	9	4	11.7	34.0	804	3060	200	3860	7924	55	77	49.8	21.6	7	8.1	136.0	360
	C	49.9	4600	8.8	3.0	11.0	1.80	0.78	1096	306	84	-	1	10.6	34.1	957	5960	170	3670	10757	54	70	49.0	18.8	< 1	8.1	136.4	390
	L-III						1.00	0.79	575	20350	161	-	< 1	2.0	59.4	603	20530	65	95	21293	107	134	70.6	27.9	6	8.1	238.0	527
1970 1/5	B						1.55	0.58	991	4975	79	-	3	10.6	33.2	1240	5550	120	3480	10390	60	70	52.6	30.7	< 1	8.2	138.0	414
	C	50.8	2800	9.2	4.0	-0.5	1.81	0.53	733	2885	68	20	2	10.9	33.7	723	3420	110	3486	7739	51	60	49.6	28.1	2	8.1	140.3	405
	L-III						1.71	1.15	1048	25170	132	26	< 1	0.7	59.0	1000	28250	4	31	29265	60	71	70.0	33.0	7	8.0	246.0	618
2/5	Sta. 2																											
	0.5 m				4.2			-				-	-	10.9	30.5	632	4065	160	3770	8627	56	61	45.0	22.9	9	8.0	127.0	400
	3.5 m				3.5			-				-	-	11.2	30.3	756	4065	150	3570	8541	54	69	45.8	17.8	10	8.0	126.3	385
	6.5 m				3.5			-				-	-	11.2	30.4	742	4530	130	3870	9272	53	65	45.4	15.2	6	8.0	126.7	400
	9.5 m				3.5			-				-	-	11.1	30.5	723	4115	150	4146	9134	92	101	46.6	17.2	5	8.0	127.0	382
	B						5.9	1.63	1125	3710	92	32	3	10.5	30.2	928	3540	230	3810	8508	58	77	46.4	24.4	6	8.0	126.0	366
	C	54.1	2000	2.7	4.2	10.0	7.11	1.89	1297	3015	92	45	2	10.9	30.5	867	4045	160	3580	8652	52	65	44.4	15.3	4	8.0	127.0	353
	L-III																											
2/18	B						8.07	3.77	761	2585	64	< 1	< 1	8.2	29.6	866	2465	167	3681	7179	36	50	48.6	23.2	10	8.0	123.7	420
	C	54.6	6400	2.8	4.0	5.0	7.58	3.05	857	2825	61	1	1	10.8	30.5	914	3250	133	3715	7992	27	37	47.4	29.5	< 1	8.1	126.7	420
	L-III						1.56	1.49	642	20280	174	7	< 1	0.9	60.0	770	19420	18	87	20295	157	203	69.4	26.5	3	8.1	250.0	560
3/3	B						5.23	3.15	1297	3110	38	< 1	3	10.0	30.8	1115	3160	125	4115	8515	8	15	46.0	23.0	2	8.4	128.5	340
	C	54.6	6400	3.2	5.0	8.0	8.98	6.37	1402	3805	36	18	4	11.8	31.5	1249	3730	70	3850	8899	5	13	47.4	18.0	< 1	8.5	131.5	368
	L-III						1.47	1.35	819	21670	72	12	< 1	1.9	62.1	752	21290	6	40	22088	24	29	59.8	25.7	6	8.1	259.0	570
3/18	B						9.06	6.02	1130	2705	34	6	6	10.9	30.2	1058	3300	144	4136	8638	8	16	49.6	22.9	< 1	8.4	126.0	321
	C	55.5	6800	2.8	6.8	4.2	10.88	8.07	1622	3180	35	15	4	10.8	30.3	962	3705	115	3945	8727	10	19	47.4	22.1	< 1	8.3	127.0	330
	L-III						1.55	1.19	522	21530	84	5	< 1	3.7	54.2	641	20190	5	265	21101	32	48	59.8	26.0	12	8.3	226.0	520
	Sta. 1																											
	0.5 m				6.8		11.21	9.96	1416	3300	49	15	-	13.8	32.2	1154	3060	70	3704	7988	7	19	49.6	20.7	3	8.3	134.0	380
	6.5 m				6.8		12.50	8.97	1177	3470	39	19	-	15.1	32.4	1106	4140	77	3783	9106	6	26	49.2	18.1	< 1	8.4	135.0	365
	15 m				6.8		12.72	10.05	1191	3470	56	28	-	14.0	32.2	1000	3420	66	3694	8180	-	-	52.0	20.8	4	8.3	134.0	340
	Sta. 2																											
	0.5 m				6.8		-	-	1287	3350	43	18	-	14.5	32.0	1000	3060	65	3995	8120	4	15	49.0	21.5	< 1	8.3	133.0	410
	3.5 m				6.8		10.59	6.81	1383	3300	50	19	-	12.7	32.2	1192	4115	76	3764	9147	6	17	49.0	22.9	11	8.4	134.0	380
	6.5 m				6.8		9.42	5.29	914	2680	46	20	-	14.1	32.2	1034	3850	72	4148	9104	4	16	49.0	23.2	< 1	8.4	134.0	360
	10 m				6.7		12.57	12.57	612	3060	53	23	-	13.4	31.8	1096	3780	70	4010	8956	5	16	49.0	-	2	8.4	132.0	350
3/26	B						5.99	4.00	880	3060	31	4	5	9.9	30.6	1144	3350	190	4670	9354	4	10	51.0	15.7	< 1	8.1	127.5	394
	C	55.2	5200	2.8	8.2	12.0	7.69	5.50	1096	3540	34	34	4	12.2	31.2	804	3945	130	4410	9289	4	10	51.0	14.5	< 1	8.3	129.8	400
	L-III						1.92	1.65	1106	20330	362	37	< 1	1.0	57.2	953	21820	16	104	22893	288	311	64.0	16.7	18	8.0	239.1	602

TABLE 13 (Continued)

Date	Sample Type	Res. Depth	Solar	Secchi Disk	Temperature		Unfiltered Samples									0.45 μ Millipore Filtered Samples												
									Nitrogen as N							Nitrogen as N					Phosphorus as P							
					Water	Air	Susp. Solids	Vol. Susp. Solids	Org.	NH_3	Total Phos.	COD	BOD_5	DO	Inorg. C	Org.	NH_3	NO_2	NO_3	Total	PO_4	Total	Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
		ft	ft-c	ft	°C	°C	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ		mg/ℓ	mhos
1970																												
4/15	C	55.6		19.3	10.0	7.0	0.84	0.58						8.9	33.1	895	2920	70	3370	7255	10	39	49.2	19.6		8.4	138.0	396
	III						1.72	1.52						3.0	60.2	733	12344	3	29	13109	26	74	68.0	21.5		8.2	251.0	616
	0.5 m				9.2									9.2	32.4	771	3420	75	3625	7891	9	18	48.4	23.2		8.6	135.0	429
	3.5 m				8.9									11.8	32.2	857	3300	75	3665	7897	13	19	48.4	24.0		8.2	134.0	396
	6.5 m				8.9									8.0	33.1	957	3350	70	3950	8327	10	18	48.0	22.8		8.0	138.0	385
	11.0 m				8.9									8.8	32.9	900	3395	80	4040	8415	10	18	47.4	22.8		8.4	137.0	376
4/23	C	55.8		19.1	10.5	15.0	0.97	0.75						8.5	32.4	1235	3660	120	4500	9515	23	29	49.4	12.9		7.9	129.7	518
	III						1.06	0.94						1.6	56.6	761	18850	21	89	19721	9	11	71.0	25.8		7.7	226.2	707
	0.5 m				10.5		1.46	1.34						7.8	32.3	1120	3470	95	3885	8570	21	27	50.2	16.4		7.8	129.0	472
	3.5 m				9.5		1.88	0.84						8.1	31.6	1010	3780	115	3905	8810	21	26	49.4	15.8		7.8	126.5	452
	6.5 m				9.0		2.61	1.45						7.4	31.6	1048	3450	100	4080	8678	21	30	49.4	17.6		7.9	126.5	460
	11.0 m				8.7		5.06	2.27						7.8	31.3	1154	3540	95	3985	8774	21	27	49.4	19.6		7.8	125.2	466
4/30	C	55.8		19.0	9.5	11.0	0.90	0.53						8.0	32.3	1010	5240	115	4105	10470	35	52	48.6	21.4		7.8	129.3	348
	III						1.42	0.88						1.9	51.7	632	19140	30	93	19895	30	73	52.0	34.8		7.8	206.8	485
5/7	C	55.8		16.0	14.0	18.0	0.98	0.48						7.8	33.3	905	2965	135	4405	8410	22	39	46.0	18.8		7.9	133.0	380
	III						4.17	2.97						1.8	52.5	1077	11390	27	59	12553	16	70	67.8	41.7		7.7	210.0	508
	0.5 m				14.0									8.5	32.3	1130	3350	130	4450	9060	20	47	46.0	22.3		7.9	129.0	572
	3.5 m				13.5									8.4	33.3	1020	3255	140	4360	8775	22	48	45.4	21.5		7.9	133.0	561
5/19	C	55.6		13.5	13.4	15.7	2.93	1.11						9.8	32.3	1000	3397	110	3810	8317	21	50	47.8	40.7		8.0	134.5	426
	III						1.66	0.51						6.5	55.0	814	17940	12	84	18850	23	49	62.4	52.2		7.8	220.0	644
5/27	C	55.6		5.4	16.5	16.5	2.71	2.15						11.2	34.5	1015	3395	105	3815	8330	7	12	47.0	28.7		7.8	138.0	416
	III						2.99	1.46						3.8	53.5	751	16889	13	39	17692	10	16	63.0	38.5		7.9	214.0	558
	0.5 m				16.5		5.88	4.73						11.6	34.5	1168	3710	125	4235	9238	5	15	46.6	21.1		7.8	138.0	408
	3.5 m				16.1		6.20	4.84						11.2	31.8	1034	3635	130	4070	8869	4	14	47.4	23.2		7.8	139.0	423
	6.5 m				13.0		4.09	2.29						5.8	33.8	1010	4735	110	3650	9505	37	43	48.0	18.5		7.8	135.0	437
	10.0 m				12.0		3.14	1.99						3.7	34.3	910	5550	100	2860	9420	56	70	49.0	20.7		7.8	137.0	437
6/4	C	55.3		12.3	19.5	26.5	3.46	2.25						10.5	29.5	991	2630	185	4175	7981	7	44	45.2	20.2		8.3	122.8	466
	III						2.22	1.35						1.4	56.9	890	14550	15	47	15502	21	35	66.0	29.0		7.8	227.5	673
	0.5 m				18.0		3.70	2.71						11.1	29.0	972	2460	160	4280	7872	5	62	45.0	18.5		8.2	121.0	451
	3.5 m				17.0		2.87	2.31						8.6	29.2	1000	2705	150	3930	7785	1	10	44.0	21.5		8.2	121.5	448
	6.5 m				14.3		3.15	2.50						4.6	35.3	517	4520	135	3625	8797	7	14	49.4	27.6		7.9	141.0	479
	10.0 m				12.0		7.70	2.48						1.4	37.0	833	4305	120	3000	8258	40	56	50.4	18.1		7.9	148.0	498
6/16	C	54.9		8.3	17.0	19.5	3.37	2.98				12.5		11.6	31.2	1120	2275	138	3182	6715	2	8	44.2	23.1		8.3	130.0	383
	III						2.89	2.03				16.8		5.8	43.5	737	17700	41	109	18587	72	81	52.0	36.3		8.0	181.1	510
	0.5 m				15.5		3.71	3.10						10.2	31.2	1197	3040	135	2865	7237	2	10	45.2	27.1		8.2	130.0	396
	3.5 m				15.2		3.73	3.02						9.2	31.2	1230	2440	105	1855	5630	1	9	45.0	24.2		8.2	130.0	384
	6.5 m				15.0		5.91	5.00						7.8	31.9	1575	3135	145	3135	7990	2	9	46.0	17.5		8.2	133.0	394
	10.0 m				14.5		3.10	2.39						5.9	34.1	1192	4350	155	2405	8082	30	44	46.2	21.3		8.0	142.0	415
7/1	C	54.4		17.2	18.5	23.5	1.31	0.88				8.4		7.0	31.2	857	2705	595	2245	6402	17	17	43.4	28.3		8.2	130.0	429
	III						1.91	1.45				15.2		1.3	48.5	512	15020	38	12	15582	215	251	46.2	29.7		7.9	194.0	594
	0.5 m				18.5		1.78	1.47						6.8	30.3	809	3160	130	2710	6809	4	14	44.6	34.2		8.1	126.3	468
	3.5 m				17.8		1.67	1.26						6.8	31.0	957	2845	170	1030	5002	6	20	45.2	28.5		8.1	129.2	429
	6.5 m				17.5		2.03	1.63						5.9	32.1	905	3160	80	1200	5345	8	37	45.0	34.1		8.1	133.7	438
	10.0 m				17.0		2.15	1.60						4.6	32.2	953	3110	122	1718	5903	15	28	44.6	26.2		8.1	134.0	440
7/7	C	54.0		17.8	21.0	23.0	1.26	0.75				15.7		6.8	31.2	809	2920	162	1758	5649	3	10	43.4	25.3		8.2	130.0	436
	III						3.58	1.88				15.3		6.8	58.5	680	25160	17	18	25875	428	442	52.4	31.1		7.9	234.0	670
	0.5 m				21.0									6.5	30.8									28.1		8.1	128.3	458
	3.5 m				19.7									4.4	30.7									20.2		8.2	127.8	445
	6.5 m				18.0									4.4	30.3									19.1		8.2	126.2	416
	10.0 m				17.2									5.9	33.3									24.5		8.2	138.8	463

TABLE 13 (Continued)

Date	Sample Type	Res. Depth	Solar	Secchi Disk	Temperature		Unfiltered Samples									0.45 μ Millipore Filtered Samples											
									Nitrogen as N							Nitrogen as N					Phosphorus as P						
					Water	Air	Susp. Solids	Vol. Susp. Solids	Org.	NH_3	Total Phos.	COD	BOD_5	DO	Inorg. C	Org.	NH_3	NO_2	NO_3	Total	PO_4	Total	Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
		ft	ft-c	ft	°C	°C	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ		mg/ℓ	mhos
1970																											
7/16	C	53.8		14.0	21.0	17.4	2.47	0.97				11.6		6.6	31.0	1000	4305	165	3315	8785	1	10	46.8	20.9		8.1	129.0	462
	III						3.35	2.11				15.8		5.2	56.7	737	33500	31	149	34417	91	98	55.6	24.2		8.0	236.2	660
	0.5 m				21.0									6.6	32.4									20.9		8.1	135.0	442
	3.5 m				21.0									6.6	31.7									20.2		8.1	132.0	441
	6.5 m				19.5									2.5	33.0									20.9		8.0	140.2	449
	10.0 m				17.8									1.5	37.3									20.6		8.0	155.6	462
7/21	C	53.6		10.6	22.5	26.0	2.45	1.08				17.2		7.1	31.0	1058	2870	150	2410	6488	2	19	42.6	20.7		8.2	129.0	499
	III						1.57	0.88				21.1		4.8	53.3	355	21540	63	42	22,000	140	161	46.4	23.6		8.1	222.0	499
7/30	C	50.7		6.3	20.8	23.0	2.58	0.88				12.6		6.5	32.3	766	3160	175	2305	6406	14	25	43.4	15.9		8.2	134.5	440
	III						1.13	0.55				9.3		2.7	60.2	556	25560	9	21	26146	252	278	57.4	31.2		8.3	250.9	696
	0.5 m				20.8									6.9	32.8									25.9		8.3	136.5	
	3.5 m				20.5									7.2	32.2									21.4		8.3	134.0	
	6.5 m				20.4									6.9	32.3									30.6		8.2	134.5	
	10.5 m				20.0									5.9	32.4									24.8		8.2	135.0	
8/7	C	49.2		5.2	20.8	26.8	3.65	1.22				17.7		7.9		953	2870	230	2490	6543	8	32				8.2		412
	III						2.35	1.54				8.1		2.1	46.6	503	29280	131	264	30178	72	168	43.0	27.6		8.3	194.0	702
	0.5 M													7.1	33.4									24.5		8.2	139.0	405
	3.5 m													7.5	32.9									23.9		8.2	137.0	456
	6.5 m													8.1	33.2									26.0		8.2	138.5	453
	10.0 m													5.4	33.6									24.5		8.2	140.0	544
8/14	C	48.0		7.2	21.7	27.0	2.38	0.89				12.5		7.8	35.0	1532	3590	220	2480	7822	24	35	44.0	25.1		8.2	145.7	382
	III						1.15	0.77				7.3		1.5	66.3	359	21060	102	298	21819	52	234	52.4	21.7		8.1	276.2	556
	0.5 m				21.7									7.8										19.5				460
	3.5 m				21.0									9.8										24.5				472
	6.5 m				20.7									7.5										24.1				462
	9.5 m				19.8									3.3										25.4				474
8/19	C	47.2		7.8	21.3	27.5	2.57	0.98				10.2		6.9	34.6			285	1574		25	38	45.0	31.1		8.2	144.2	456
	III						1.10	0.83				9.5			60.7			94	641		289	295	46.2	28.5		8.3	253.0	621
	0.5 m				21.3									6.7	34.4									27.2		8.2	143.5	456
	3.5 m				21.3									6.5	34.5									25.8		8.2	143.9	458
	6.5 m				20.4									4.5	34.6									32.0		8.2	144.2	467
	9.5 m				19.8									2.1	33.0									29.9		8.0	137.6	456
8/26	C	46.9		7.4	20.0	23.0	2.80	1.00				17.3		7.2	35.0	685	3205	365	2575	6830	3	13	43.2	24.1		8.1	145.7	386
	III						0.88	0.52				8.8		1.4	64.1	465	23440	14	606	24525	71	80	77.0	25.6		7.6	256.5	719
	0.5 m				20.0									7.6	35.5									22.9		7.9	141.9	413
	3.5 m				19.5									8.6	36.3									26.7		7.9	145.2	413
	6.5 m				19.0									8.6	36.5									23.5		7.9	146.0	423
	9.0 m				19.0									6.0	38.6									22.7		7.9	154.4	417
9/4	C	44.7		6.7	17.7	25.0	3.02	0.86				12.4		8.3	34.2	847	1175	380	3580	5982	12	25	44.4	31.2		8.2	142.7	530
	III						1.84	1.25				11.1		2.2	66.4	914	18860	7	1113	20894	42	55	55.6	25.8		8.1	276.6	660
	0.5 m				17.7									7.9	35.0									22.7		8.3	145.7	612
	3.5 m				17.7									7.8	34.5									19.9		8.3	143.7	515
	6.5 m				17.7									7.6	34.3									26.0		8.3	142.9	505
	7.5 m				17.7									8.8	34.4									15.3		8.3	143.5	526
9/10	C	43.9		9.6	18.2	28.0	2.25	0.87				12.0		8.2	35.0	1030	3105	315	3845	8295	20	47	44.0	29.2		8.2	145.7	498
	III						1.18	0.86				10.6		0.8	62.4	672	20300	6	789	21767	147	156	47.2	20.2		7.9	249.5	636
	0.5 m				18.2									8.6	34.6									22.8		8.1	144.0	477
	3.5 m				18.0									8.8	34.2									19.5		8.1	142.7	488
	6.5 m				17.5									10.9	34.2									23.2		8.1	142.7	472
	7.5 m				17.0									6.9	34.2									23.4		8.1	142.7	451

TABLE 13 (Continued)

Date	Sample Type	Res. Depth ft	Solar ft-c	Secchi Disk ft	Temperature Water °C	Temperature Air °C	Unfiltered Samples: Susp. Solids mg/ℓ	Vol. Susp. Solids mg/ℓ	Nitrogen as N: Org. µg/ℓ	Nitrogen as N: NH_3 µg/ℓ	Total Phos. µg/ℓ	COD mg/ℓ	BOD_5 mg/ℓ	DO mg/ℓ	Inorg. C mg/ℓ	0.45 µ Millipore Filtered Samples: Nitrogen as N: Org. µg/ℓ	Nitrogen as N: NH_3 µg/ℓ	Nitrogen as N: NO_2 µg/ℓ	Nitrogen as N: NO_3 µg/ℓ	Nitrogen as N: Total µg/ℓ	Phosphorus as P: PO_4 µg/ℓ	Phosphorus as P: Total µg/ℓ	Ca mg/ℓ	Cl^- mg/ℓ	Fe µg/ℓ	pH	Alk. as $CaCO_3$ mg/ℓ	Cond. (10^{-6}) mhos
1970 9/17	C	44.0		13.6	16.3	23.0						17.5		8.5	33.1	833	3535	295	2625	7288	22	27	48.4	19.2		8.1	137.8	460
	III											6.5		1.3	58.4	626	16660	22	1008	18316			56.6	27.2		8.0	243.4	629
	0.5 m				16.0									8.0	33.6									19.2		8.1	140.2	[illegible]
	3.5 m				16.0									9.4	33.5									17.2		8.1	139.7	[illegible]
	6.5 m				15.0									10.9	33.0									27.6		8.1	137.4	[illegible]
	8.0 m				14.7									8.1	33.0									19.5		8.1	137.4	[illegible]
9/23	C	44.1		17.8	15.0	25.0	1.70	0.88				10.9		8.2	34.2	960	5075	260	2320	8615	13	29	46.0	15.0		8.4	142.4	[illegible]
	III						1.34	1.06				7.9		1.5	58.4	601	27580	13	327	28521	25	51	57.8	19.4		8.0	243.4	[illegible]
	0.5 m				15.0									8.2	33.8									15.2		8.4	140.9	[illegible]
	3.5 m				14.0									8.6	33.9									20.5		8.4	141.3	[illegible]
	6.5 m				14.0									9.2	33.4									24.2		8.4	139.0	[illegible]
	8.0 m				14.0									8.0	33.4									18.0		8.4	139.2	[illegible]
10/1	C	43.5		18.4	15.0	23.0	0.82	0.52				14.2		8.7	33.5	1329	3335	250	3550	8464	7	18	44.6	20.0		7.9	134.0	[illegible]
	III						1.87	1.46				10.9		1.6	52.5	420	17680	57	398	18555	119	149	51.8	28.5		7.9	210.0	[illegible]
	0.5 m				14.3									9.5	33.9									24.6		7.8	135.5	[illegible]
	3.5 m				14.0									9.1	32.3									35.7		8.0	134.4	[illegible]
	6.5 m				13.8									9.0	33.3									36.8		7.9	133.1	[illegible]
	8.0 m				13.5									9.6	33.0									24.3		7.9	132.1	[illegible]
10/9	C	44.0		19.2	13.0	21.5						14.0		9.3	30.7	1046	4850	275	4405	10576	5	12	39.4	30.8		7.9	122.8	[illegible]
	0.5 m				13.0									9.6	28.4											7.8	113.7	[illegible]
	3.5 m				13.0									9.6	30.2											7.9	120.6	[illegible]
	6.5 m				12.2									9.8	28.3											8.0	117.9	[illegible]
	8.0 m				12.0									9.7	26.4											7.9	105.5	[illegible]
10/14	C	44.0		20.2	13.0	19.0	0.69	0.49				10.6		8.9	32.2	915	3635	230	3390	8170	3	12	43.8	32.4		8.0	134.0	[illegible]
	III						1.18	0.95				7.7		1.9	64.0	505	20500	4	551	21560	49	67	64.8	33.2		7.8	255.9	[illegible]
	0.5 m				13.0									9.0	31.9									30.6		8.0	132.9	[illegible]
	3.5 m				12.8									8.9	32.2									30.9		8.0	134.0	[illegible]
	6.5 m				12.2									9.8	31.7									31.0		8.0	132.0	[illegible]
	8.5 m				12.1									9.8	31.7									31.1		8.0	132.0	[illegible]
10/22	C	44.2		13.3	9.5	9.5	2.10	0.65				9.6		9.1	32.3	626	4345	200	2920	8091	2	9	45.8	32.0		8.0	134.5	[illegible]
	III						0.64	0.54				6.4		1.5	67.4	657	23140	4	656	24457	42	55	63.8	33.8		7.6	269.5	[illegible]
	0.5 m				9.5									9.0	33.0									29.7		7.9	131.9	[illegible]
	3.5 m				9.5									9.0	32.3									32.9		8.0	134.7	[illegible]
	6.5 m				9.5									8.7	33.8									30.1		7.9	135.0	[illegible]
	8.0 m				9.5									8.7	31.9									31.4		8.0	133.1	[illegible]
10/28	C	44.4		21.5	8.0	14.0	0.47	0.41				10.3		9.8	35.0	1031	4165	175	2845	8216	7	29	46.0	32.1		7.9	140.0	[illegible]
	III						0.65	0.47				7.9		1.6	73.9	450	21120	2	443	22015	17	34	83.0	35.1		7.8	295.6	[illegible]
	0.5 m				7.5									9.8	32.4									32.4		8.0	135.2	[illegible]
	3.5 m				7.0									9.6	34.2									31.5		7.9	136.7	[illegible]
	6.5 m				7.0									10.0	34.2									31.5		7.9	136.9	[illegible]
	8.0 m				7.0									10.0	33.8									30.9		7.9	135.0	[illegible]
11/6	C	44.9		11.5	7.0	6.0	2.06	0.54				12.4		9.3	34.6	1253	5430	195	4125	11003	15	22	49.8	26.6		8.2	144.3	[illegible]
	III						0.43	0.42				8.8		1.6	64.2	480	26260	4	536	27280	72	100	64.0	28.2		7.8	256.9	[illegible]
	0.5 m				7.0									9.3	33.9									28.3		8.2	141.2	[illegible]
	3.5 m				7.0									9.8	34.1									26.5		8.1	142.1	[illegible]
	6.5 m				7.0									10.4	34.3									25.5		8.0	142.8	[illegible]
	8.0 m				7.0									9.6	33.8									28.1		8.0	140.8	[illegible]
11/11	C	45.0		14.0	7.4	11.0	1.09	0.44				9.1		10.1	35.2	691	3410	180	3300	7581	14	23	51.6	29.1		8.1	146.6	[illegible]
	III						1.22	0.90				3.4		1.9	77.4	328	20900	7	413	21648	79	89	81.8	30.0		7.6	309.6	[illegible]
	0.5 m				7.4									10.1	35.2									31.6		8.1	146.6	[illegible]
	3.5 m				7.3									10.8	34.8									29.9		8.1	145.2	[illegible]
	6.5 m				7.1									10.0	34.8									30.3		8.1	144.8	[illegible]
	8.0 m				7.0									10.0	34.4									30.3		8.1	143.5	[illegible]

TABLE 13 (Continued)

Date	Sample Type	Res. Depth	Solar	Secchi Disk	Temperature		Unfiltered Samples									0.45 μ Millipore Filtered Samples												
									Nitrogen as N							Nitrogen as N					Phosphorus as P							
					Water	Air	Susp. Solids	Vol. Susp. Solids	Org.	NH_3	Total Phos.	COD	BOD_5	DO	Inorg. C	Org.	NH_3	NO_2	NO_3	Total	PO_4	Total	Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
		ft	ft-c	ft	°C	°C	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ		mg/ℓ	mhos
1970																												
11/18	C	45.1		18.0	6.8	8.5	1.01	0.63				10.4		10.3	35.9	795	4180	185	2995	8155	17	30	48.0	26.6		8.1	149.6	388
	III						1.95	1.65				7.6		1.3	70.9	295	14640	36	394	15365	126	139	74.6	28.4		7.7	283.4	562
	0.5 m				6.8									10.3	35.7									24.5		8.1	148.7	400
	3.5 m				6.5									10.1	35.0									26.2		8.1	146.0	389
	6.5 m				6.2									9.7	35.4									27.6		8.1	147.3	382
	8.0 m				6.1									9.4	35.6									25.0		8.1	148.5	387
11/24	Grab C	45.3			7.8	19.0	6.20	1.83				18.6		9.5	37.7	850	3410	150	3690	8100	24	36	48.2	31.6		8.0	150.7	433
	III						1.45	1.18				8.9		1.7	70.7	113	17280	3	182	17578	105	117	71.2	32.3		7.5	282.9	684
12/9	C	46.7		11.6	2.8	6.0	3.87	0.69				18.8		12.9	37.2	722	4590	130	3190	8632	27	32	50.8			7.8	148.6	444
	III						1.67	0.36				9.0		2.6	71.6	172	13460	3	102	13737	106	109	77.8			7.6	286.5	684
	0.5 m				2.8									12.9	37.9									34.1		7.9	151.7	477
	3.5 m				2.7									11.1	37.9									29.0		8.0	151.7	464
	6.5 m				2.5									11.0	37.9									30.9		8.0	151.7	475
	8.5 m				2.5									10.9	37.2									29.9		8.0	148.6	469
12/15	C	46.9		15.0	2.7	12.0	1.27	0.41				12.5		10.5	37.3	604	4180	150	2870	7804	27	28	50.2	30.8		8.2	155.6	464
	III						0.48					25.4		2.9	71.4	464	17180	10	80	17734	97	105	70.2	29.3		7.8	285.7	634
	0.5 m				2.7									10.5	37.5									30.1		8.2	156.3	458
	3.5 m				2.7									10.5	37.5									30.3		8.2	156.3	478
	5.0 m				2.7									10.2	37.4									28.3		8.2	155.8	476
1971																												
1/6	C	48.0		17.0	2.9	-3.0	0.93	0.30				10.9		14.2	40.8	661	6826	34	2994	10515	34	58	53.0	27.9		8.1	169.8	443
	III						2.67	1.48				30.3		0.3	76.5	745	28000	< 1	45	28790	18	332	83.2	27.2		7.8	306.0	647
	0.5 m				2.9									14.2	40.6									27.2		8.1	169.1	404
	3.5 m				3.0									9.1	40.1									27.4		8.0	167.1	404
	6.5 m				3.5									8.5	41.3									25.2		8.0	172.2	409
	7.5 m				3.5									9.5	42.1									25.8		8.0	175.3	413
1/27	C	49.6		18.0	4.0	9.5	1.07	0.88				11.0		12.8	32.7	258	2440	65	2335	5098	29	31	40.8	20.4		8.0	136.3	380
	III						3.06	1.73				9.3		0.6	74.0	362	22620	8	52	23034	21	28	78.6	23.4		8.1	308.5	517
	0.5 m				4.0									12.8	41.1									29.1		8.0	171.2	398
	3.5 m				4.0									12.6	40.6									27.1		8.0	169.1	386
	7.0 m				4.0									14.7	40.1									28.2		8.0	167.1	392
2/10	C	50.0		6.0	5.5	17.0	5.05	4.05				15.1		15.8	44.0	1021	3833	62	3198	8114	22	23	52.5	30.0		8.1	183.5	416
	III						0.54	0.53				14.0		1.4	72.3	160	13600	5	315	14080	29	49	68.5	27.6		8.0	301.4	553
	0.5 m				5.5									15.8	48.7									27.7		8.1	202.9	418
	3.5 m				4.8									15.2	47.7									28.2		8.1	198.9	417
	6.5 m				4.8									15.4	50.9									28.0		8.0	212.2	411
	9.5 m				4.6									16.8	45.8									27.5		8.1	190.7	411
2/22	C	50.6		5.0	5.0	6.0	6.14	4.80				15.2		13.1	40.3	896	4415	45	2775	8131	9	26	52.5	27.9		8.1	168.1	493
	III						1.60	1.06				16.2		0.5	75.4	458	14900	4	76	15438	58	82	77.3	28.0		7.8	301.4	650
	0.5 m				5.0									13.1	40.8									30.3		8.3	170.2	518
	3.5 m				5.0									12.0	39.1									28.9		8.3	162.9	475
	6.5 m				5.0									12.4	40.8											8.4	170.2	443
	9.5 m				4.9									12.4														
3/9	C	51.0		4.0	4.5	11.0	6.95	5.52				20.5		18.7	40.8	777	6115	41	2658	9591	6	25	53.8	28.4		8.1	170.2	448
	III						4.43	2.11				10.2		4.0	72.1	198	18200	4	124	18526	92	123	77.5	26.0		7.9	288.5	717
	0.5 m				4.5									18.7	41.6									30.4		8.2	173.2	483
	3.5 m				4.5									12.9	45.8									29.5		8.2	190.7	483
	6.5 m				4.5									12.7	41.6									27.9		8.3	173.2	538
	9.5 m				4.5									11.5	41.1									27.2		8.2	171.2	443

TABLE 13 (Continued)

Date	Sample Type	Res. Depth	Solar	Secchi Disk	Temperature		Unfiltered Samples									0.45 μ Millipore Filtered Samples												
									Nitrogen as N							Nitrogen as N					Phosphorus as P							
					Water	Air	Susp. Solids	Vol. Susp. Solids	Org.	NH_3	Total Phos.	COD	BOD_5	DO	Inorg. C	Org.	NH_3	NO_2	NO_3	Total	PO_4	Total	Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
		ft	ft-c	ft	°C	°C	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ		mg/ℓ	mhos
1971 3/15	C	51.6		3.6	4.9	10.0	8.47	2.78				10.5		15.2	40.8	683	5790	95	3987	10555	9	36	54.4	29.0		8.0	170.2	435
	III						0.59	0.35				11.4		1.5	70.4	144	12741	3	25	12913	33	52	44.9	27.3		8.2	293.2	577
	0.5 m				4.9									15.2	41.6									28.6		8.3	173.2	459
	3.5 m				4.7									13.2	41.1									27.8		8.3	171.2	504
	6.5 m				4.6									12.0	41.6									28.0		8.4	173.2	521
	9.5 m				4.5									11.6	41.8									28.7		8.3	174.3	515
3/24	C	51.7		3.0	4.9	11.0	9.07	1.84				20.0		11.8	40.8	775	4833	80	3400	9088	5	9	55.1	32.5		8.1	170.2	450
	III						1.42	0.42				11.6		1.0	56.6	84	15765	11	99	15959	71	83	61.0	26.9		8.2	235.8	624
	0.5 m				4.9									11.8	41.1									33.4		8.1	171.2	538
	3.5 m				4.8									12.3	41.1									30.7		8.0	171.2	498
	6.5 m				4.7									17.3	41.3									31.7		8.3	172.2	493
	9.5 m				4.6									11.5	39.9									30.5		8.1	166.1	479
4/5	C	52.1		2.7	10.0	19.5						21.8		12.0	41.1	983	7398	40	2161	10582	5	9	51.4	27.1		8.3	171.2	454
	III											9.5		0.0	60.0	105	12980	4	37	13126	158	165	59.0	22.7		7.7	239.9	552
	0.5 m				10.0									12.1	42.1									26.2		8.3	175.3	410
	3.5 m				9.0									11.4	41.6									25.8		8.3	173.2	412
	6.5 m				8.5									10.5	41.8									26.5		8.3	174.3	425
	9.5 m				8.2									10.2	41.8									27.3		8.3	174.3	419
4/19	C	52.5		5.5	10.2	15.5	3.46	2.35				13.1		10.3	40.6	867	5854	60	2572	9353	6	14	49.2	27.9		8.1	169.1	470
	III						0.97	0.88				8.3		1.9	59.5	206	12460	6	176	12848	65	78	53.2	20.6		7.8	237.8	560
	0.5 m				10.2									10.3	40.8									27.0		8.1	170.2	452
	3.5 m				9.8									13.5	40.8									26.9		8.1	170.2	462
	6.5 m				9.6									8.9	40.6									27.6		8.1	169.1	461
	10.5 m				9.4									10.6	40.6									29.4		8.1	169.1	440
5/5	C	53.0		19.7	12.0		0.66	0.45				20.8		8.2	42.3	791	5030	23	2977	8821	14	30	46.5	28.1		7.9	169.1	440
	III						0.52	0.47				13.7		2.0	65.0	221	17240	11	274	17746	301	318	56.3	25.2		7.5	259.8	638
	0.5 m				12.0									8.2	42.3									29.0		7.9	169.1	484
	3.5 m				11.3									11.0	42.0									28.7		7.8	168.1	483
	6.5 m				11.0									7.0	42.6									28.9		7.8	170.2	484
	10.5 m				10.3									8.8	42.3									28.3		7.9	169.1	483
5/17	C	53.2			14.0		1.61	1.14				14.8		8.8	39.9	1006	5028	370	1790	8194	3	21	43.4	30.4		8.1	166.1	462
	III						1.18	0.76				10.5		1.3	60.0	267	18548	6	229	19050	458	475	46.8	26.3		7.7	239.9	572
	0.5 m				14.0									8.8	41.3									27.2		8.1	172.2	575
	3.5 m				13.9									8.6	41.1									27.5		8.1	171.2	529
	6.5 m				13.2									8.2	40.6									26.9		8.1	169.1	506
	8.5 m				13.2									7.8	41.6									25.8		8.0	173.2	506

NOTE: Unless otherwise noted blanks or dashes indicate no analysis made.

[a]Shore sample collected by the riprap at the north dam at Indian Creek Reservoir (ICR).

[b]Effluent sample collected at the discharge weir at ICR.

[c]Snowmelt from a normally dry creek bed on the east side of ICR.

[d]Creek at the southeast side of ICR.

[e]Indian Creek located at the south end of ICR.

[f]Bay at ICR.

[g]Tertiary effluent from South Tahoe Public Utility Districts (STPUD) Waste Water Treatment Plant.

[h]Number location of permanent bouy where composite samples over 24-hr were collected.

[i]Depth that composite samples over 24-hr of (bouy) station No. 1, 2, and 3 were collected.

[j]STPUD tertiary effluent collected at the Luther Pass pumping station.

TABLE 14

MEASUREMENTS OF VERTICAL DISTRIBUTION OF WATER QUALITY FACTORS THROUGHOUT 24 HOURS

Sampling Date	Station	Time of Sampling	Sample Depth meters	Temp. °C	pH	Alk. as $CaCO_3$ mg/ℓ	Dissolved Oxygen mg/ℓ	Inorganic Carbon mg/ℓ
1970								
8/18	1	1315	0.5	21.8	8.1	144.9	6.9	34.8
			3.5	21.3	8.1	145.0	6.9	34.8
			6.5	20.8	8.1	148.0	6.0	35.5
			9.5	20.0	7.9	150.6	4.1	37.7
			12.0	19.2	7.9	153.8	0.9	38.5
	1	1700	0.5	22.0	8.2	140.4	7.2	33.7
			3.5	21.4	8.2	147.8	6.9	35.5
			6.5	20.4	8.1	150.4	5.4	36.1
			9.5	20.0	7.9	151.2	2.0	37.8
			12.0	19.5	7.9	155.6	0.4	38.9
	1	2115	0.5	22.0	7.9	144.5	7.0	36.1
			3.5	21.5	7.9	147.1	6.9	36.8
			6.5	21.2	7.9	146.3	6.7	36.6
			9.5	19.9	7.7	148.8	2.7	37.2
			12.0	19.2	7.6	152.3	0.3	38.1
8/19	1	0100	0.5	21.3	8.1	146.9	7.0	35.3
			3.5	21.2	8.2	144.7	7.0	34.7
			6.5	20.2	8.0	148.5	4.7	37.1
			9.5	19.8	7.9	146.6	1.8	36.7
			12.0	19.3	7.9	155.7	0.4	38.9
	1	0520	0.5	21.0	8.1	145.8	6.4	35.0
			3.5	21.0	8.1	146.1	6.2	35.1
			6.5	20.2	8.0	148.8	4.8	37.2
			9.5	19.8	7.8	149.5	2.4	37.4
			12.0	19.2	7.8	155.6	0.2	38.9
	1	0915	0.5	21.0	7.9	142.9	6.7	35.7
			3.5	20.8	8.0	147.1	6.5	35.3
			6.5	20.5	7.9	145.8	5.8	36.5
			9.5	20.2	7.8	147.1	5.3	36.8
			12.0	19.7	7.9	149.9	2.8	37.5
	1	1300	0.5	21.5	8.1	148.8	6.8	35.7
			3.5	21.0	8.1	146.9	7.0	35.3
			6.5	20.0	8.0	148.5	5.9	35.6
			9.5	20.0	7.7	149.6	2.8	37.4
			12.0	19.7	7.6	150.1	0.6	37.5

TABLE 15

MONTHLY AVERAGE VALUES OF QUALITY FACTORS IN INDIAN CREEK RESERVOIR WATER (C) OBSERVED BY LTAC DEMONSTRATION GRANT LABORATORY (≈ WEEKLY SAMPLES)

Month	No. of Samples	Unfiltered Samples						0.45 μ Millipore Filtered Samples														
		SS μg/ℓ	VSS μg/ℓ	Org. N μg/ℓ	NH_3 μg/ℓ	Total P μg/ℓ	COD mg/ℓ	Org. N μg/ℓ	NH_3 μg/ℓ	NO_2 μg/ℓ	NO_3 μg/ℓ	Inor. N μg/ℓ	Total N μg/ℓ	PO_4 μg/ℓ	Total P μg/ℓ	Ca mg/ℓ	Cl mg/ℓ	Fe μg/ℓ	pH	Alk. mg/ as $CaCO_3$	Cond. 10^{-6} μ mhos	Inor. C mg/ℓ
1969																						
Apr																						
May	1	1,490	640	960	8,250	99	8	600	4,200	282	918	5,400	6,000	63	78	15.5	17.5	16	7.8	108.5	295	27.1
Jun	3	7,237	4,193	1,002	3,791	43	33	847	3,283	395	682	4,380	5,207	14	23	35.5	17.6	24	8.0-8.1	104.7	308	25.1
Jul	5	1,600	1,328	1,021	3,190	48	40	1,065	3,070	339	1,657	5,066	6,131	30	30	36.2	19.3	12	7.9-8.2	107.7	317	26.1
Aug	3	4,817	3,513	1,066	3,190	38	25	990	2,442	297	2,623	5,362	6,352	8	27	36.7	19.5	3	8.1-8.3	107.7	348	25.9
Sep	4	2,587	1,067	2,144	3,701	52	17	1,021	3,608	268	2,425	6,301	7,322	43	65	50.9	21.8	15	7.7-8.1	119.4	364	29.0
Oct	5	5,575	1,875	822	2,710	77	36	922	2,825	357	3,036	6,218	7,140	48	75	42.3	23.1	16	8.2	133.8	380	32.1
Nov	3	1,620	750	821	2,840	70	18	924	2,981	122	3,071	6,174	7,098	53	67	46.8	25.1	6	7.9-8.2	129.1	350	31.4
Dec	2	1,645	675	1,020	1,493	76	15	1,008	4,570	180	3,610	8,360	9,368	54	66	49.6	24.7	2	7.9	134.6	385	33.6
1970																						
Jan	1	1,810	530	733	2,885	68	20	723	3,420	110	3,486	7,016	7,739	51	60	49.6	28.1	2	8.1	140.3	405	33.7
Feb	2	7,345	2,750	1,077	2,920	76	45	890	3,638	146	3,648	7,432	8,322	40	51	45.9	22.4	-	8.0-8.1	126.8	386	30.5
Mar	3	9,183	7,377	1,373	3,508	35	22	1,005	3,793	105	4,068	7,966	8,971	6	20	48.6	18.2	1	8.3-8.5	129.4	366	31.0
Apr	3	0.90	0.62					1,047	3,940	102	3,992	8,034	9,080	23	40	49.1	18.0		7.8-8.4	132.3	421	32.6
May	3	2.21	1.25					973	3,252	117	4,010	7,379	8,352	17	34	46.9	29.4		7.8-8.0	135.2	407	33.4
Jun	2	3.42	2.62				12.5	1,056	2,453	162	3,679	6,294	7,348	5	26	44.7	21.7		8.3	126.4	425	30.4
Jul	5	2.01	0.91				13.1	898	3,192	249	2,407	5,848	6,746	7	16	43.9	22.2		8.1-8.2	130.5	453	31.3
Aug	4	2.85	1.02				14.4	1,057	3,222	275	2,280	5,777	6,834	15	30	44.1	26.8		8.1-8.2	145.2	409	34.9
Sep	4	2.32	0.87				13.2	918	3,223	313	3,093	6,629	7,545	17	32	45.7	23.7		8.1-8.4	142.2	485	34.1
Oct	5	1.02	0.52				11.7	989	4,066	226	3,422	7,714	8,703	5	16	43.9	29.5		7.9-8.0	133.1	384	32.7
Nov	4	2.59	0.86				12.6	897	4,108	178	3,528	7,814	8,710	18	28	49.4	28.5		8.0-8.2	147.8	420	35.9
Dec	2	2.57	0.55				15.7	663	4,385	140	3,030	7,555	8,218	27	30	50.5	30.8		7.8-8.2	152.1	454	37.3
1971																						
Jan	2	1.00	0.59				11.0	460	4,633	50	2,665	7,348	7,807	32	45	46.9	24.2		8.0-8.1	153.1	412	36.8
Feb	2	5.60	4.43				15.2	959	4,124	54	2,987	7,165	8,123	16	25	52.5	29.0		8.1	175.8	455	42.2
Mar	3	8.16	3.38				17.0	745	5,579	72	3,348	8,999	9,745	7	23	54.4	30.0		8.0-8.1	170.2	444	40.8
Apr	2	3.46	2.35				17.5	925	6,626	50	2,367	9,043	9,968	6	12	50.3	27.5		8.1-8.3	170.2	462	40.9

TABLE 16

BENTHIC ORGANISM SURVEY, INDIAN CREEK RESERVOIR

Station 1					
Sample Date - October 9, 1969					
Organism	Sample			Total	Mean
	a	b	c		
Cladocera					
Ephippia*	2168	1960	2360	6488	2163
Chironomidae					
Tanypodinae					
Procladius sp.	35	17	33	85	28
Chironominae					
Chironomus (*Chironomus*) sp.	55	47	119	221	74
Glyptotendipes sp.	-	-	2	2	.7
Total Organisms	90	64	154	308	103
Sample Volume (liters)	.6	.6	.6	1.8	.6
Sample Date - October 14, 1970					
Cladocera					
Adults*	6	8	17	31	10
Ephippia*	3080	2800	2400	8280	2760
Copepoda*	3	2	5	10	3
Hydracarina	25	36	44	105	35
Chironomidae					
Tanypodinae					
Procladius sp.	31	27	34	92	31
Chironominae					
Chironomus (*Chironomus*) sp.	74	81	77	232	77
Chironomus (*Cryptochironomus*) sp.	-	1	2	3	1
Glyptotendipes sp.	2	-	1	3	1
Tanytarsus sp.	2	-	3	5	2
Total Organisms	134	145	161	440	147
Sample Volume (liters)	0.9	0.9	1.2	3.0	1.0
Station 2					
Sample Date - October 9, 1969					
Cladocera					
Ephippia*	2560	2440	2280	7280	2427
Chironomidae					
Tanypodinae					
Procladius sp.	80	60	56	196	65
Chironominae					
Chironomus (*Chironomus*) sp.	73	78	88	239	80
Glyptotendipes sp.	2	3	2	7	2
Total Organisms	155	141	146	442	147
Sample Volume (liters)	1.2	1.2	1.2	3.6	1.2

*Not included in totals.

Station 2 (Continued)					
Sample Date - October 14, 1970					
Organism	Sample			Total	Mean
	a	b	c		
Cladocera					
Adults*	11	4	3	18	6
Ephippia*	1800	2100	1600	5500	1833
Copepoda*	2	-	3	5	2
Hydracarina	22	20	30	72	24
Chironomidae					
Tanypodinae					
Procladius sp.	7	14	9	30	10
Chironominae					
Chironomus (*Chironomus*) sp.	1	7	3	11	4
Chironomus (*Cryptochironomus*) sp.	3	-	1	4	1
Glyptotendipes sp.	2	1	-	3	1
Tanytarsus sp.	1	-	-	1	1
Total Organisms	36	42	43	121	40
Sample Volume (liters)	0.4	0.3	0.6	1.3	0.4

Station 3					
Sample Date - October 9, 1969					
Cladocera					
Ephippia*	2208	3160	1760	7128	2376
Chironomidae					
Tanypodinae					
Procladius sp.	40	80	60	180	60
Chironominae					
Chironomus (*Chironomus*) sp.	30	111	74	215	72
Glyptotendipes sp.	-	1	-	1	.3
Tanytarsus sp.	1	-	-	1	.3
Total Organisms	71	192	134	397	132
Sample Volume (liters)	.5	.9	.7	2.1	.7
Sample Date - October 14, 1970					
Cladocera					
Adults*	13	21	37	71	24
Ephippia*	1600	1900	1850	5350	1783
Copepoda*	-	-	16	16	5
Hydracarina	32	20	26	78	26
Chironomidae					
Tanypodinae					
Procladius sp.	42	34	53	129	43
Chironominae					
Chironomus (*Chironomus*) sp.	20	21	12	53	18
Chironomus (*Cryptochironomus*) sp.	1	-	-	1	1
Glyptotendipes sp.	-	1	3	4	1
Tanytarsus sp.	8	11	8	27	9
Orthocladiinae					
Trichocladius sp.	1	-	-	1	1
Total Organisms	104	87	102	293	98
Sample Volume (liters)	0.9	0.9	1.2	3.0	1.0

*Not included in totals.

TABLE 16 (Continued)

Station 4					
Sample Date - October 9, 1969					
Organism	Sample			Total	Mean
	a	b	c		
Cladocera					
Ephippia*	1840	2520	1632	5992	1997
Chironomidae					
Tanypodinae					
Procladius sp.	50	41	32	123	41
Chironominae					
Chironomus (*Chironomus*) sp.	121	141	91	353	117
Glyptotendipes sp.	1	2	4	7	2
Tanytarsus sp.	1	1	1	3	1
Total Organisms	173	185	128	486	162
Sample Volume (liters)	1.2	1.0	.6	2.8	.9
Sample Date - October 14, 1970					
Cladocera					
Adults*	23	5	72	100	33
Ephippia*	3500	2000	600	6100	2033
Copepoda*	3	-	7	10	3
Hydracarina	26	33	4	63	21
Ephemeroptera					
Siphlonurus sp.	1	-	1	2	1
Chironomidae					
Tanypodinae					
Procladius sp.	37	30	13	80	27
Chironominae					
Chironomus (*Chironomus*) sp.	12	16	10	38	13
Chironomus (*Cryptochironomus*) sp.	-	-	1	1	1
Glyptotendipes sp.	3	3	1	7	2
Gastropoda					
Lymnaea sp.	-	-	1	1	1
Physa sp.	2	-	-	2	1
Total Organisms	81	82	31	194	65
Sample Volume (liters)	0.3	0.9	0.4	1.6	0.5
Station 5					
Sample Date - October 9, 1969					
Cladocera					
Ephippia*	480	400	2520	3400	1133
Chironomidae					
Tanypodinae					
Procladius sp.	17	13	35	65	22
Chironominae					
Chironomus (*Chironomus*) sp.	34	8	69	111	37
Glyptotendipes sp.	1	8	2	11	4
Tanytarsus sp.	-	3	10	13	4
Unidentified pupae	-	-	1	1	.3
Total Organisms	52	32	117	201	67
Sample Volume (liters)	.6	.9	.6	2.1	.7

*Not included in totals.

Station 5 (Continued)					
Sample Date - October 14, 1970					
Organism	Sample			Total	Mean
	a	b	c		
Cladocera					
Adults*	6	16	2	24	8
Ephippia*	1420	2310	2140	5870	1957
Copepoda*	5	-	8	13	4
Hydracarina	2	16	12	30	10
Ephemeroptera					
Siphlonurus sp.	-	5	2	7	2
Chironomidae					
Tanypodinae					
Procladius sp.	3	12	20	35	12
Chironominae					
Chironomus (*Chironomus*) sp.	10	8	6	24	8
Glyptotendipes sp.	3	7	5	15	5
Tanytarsus sp.	-	1	1	2	1
Orthocladiinae					
Trichocladius sp.	2	-	3	5	2
Unidentified pupae	-	-	1	1	1
Gastropoda					
Physa sp.	-	1	1	2	1
Total Organisms	20	50	51	121	40
Sample Volume (liters)	0.4	0.3	0.6	1.3	0.6

Station 6					
Sample Date - October 9, 1969					
Cladocera					
Ephippia*	616				
Chironomidae					
Tanypodinae					
Procladius sp.	45				
Chironominae					
Chironomus (*Chironomus*) sp.	20				
Glyptotendipes sp.	5				
Tanytarsus sp.	20				
Unidentified pupae	1				
Total Organisms	91				
Sample Volume (liters)	.6				

*Not included in totals.

TABLE 16 (Continued)

Station 6 (Continued)					
Sample Date - October 14, 1970					
Organism	Sample			Total	Mean
	a	b	c		
Cladocera					
Adults*	2				
Ephippia*	340				
Hydracarina	1				
Chironomidae					
Tanypodinae					
Procladius sp.	24				
Chironominae					
Chironomus (*Chironomus*) sp.	3				
Tanytarsus sp.	1				
Gastropoda					
Lymnaea sp.	1				
Total Organisms	30				
Sample Volume (liters)	0.5				
Station 7					
Sample Date - October 9, 1969					
Cladocera					
Ephippia*	2640				
Chironomidae					
Tanypodinae					
Procladius sp.	26				
Chironominae					
Chironomus (*Chironomus*) sp.	7				
Chironomus (*Cryptochironomus*) sp.	1				
Glyptotendipes sp.	5				
Tanytarsus sp.	5				
Total Organisms	44				
Sample Volume (liters)	1.2				
Station 8					
Sample Date - October 9, 1969					
Chironomidae (midges)					
Orthocladiinae					
Cricotopus sp.	139				
Trichocladius sp.	16				
Chironominae					
Glyptotendipes sp.	895				
Physidae (snails)					
Physa sp.	2				
Total Organisms	1052				

*Not included in totals.

TABLE 16 (Continued)

Station 8 (Continued)					
Sample Date - October 14, 1970					
Organism	Sample			Total	Mean
	a	b	c		
Hirudinea	10				
Cladocera					
Adults*	9				
Copepoda*	8				
Amphipoda					
Hyalella sp.	87				
Ephemeroptera					
Baetis sp.	2				
Coleoptera					
Dytiscidae					
Deronectes sp.	1				
Elmidae					
Optioservus sp.	2				
Chironomidae					
Chironominae					
Glyptotendipes sp.	78				
Orthocladiinae					
Cricotopus sp.	39				
Nanocladius sp.	9				
Trichocladius sp.	11				
Unidentified pupae	2				
Gastropoda					
Gryaulus sp.	101				
Helisoma sp.	20				
Limnaea sp.	225				
Physa sp.	74				
Total Organisms	661				

*Not included in totals.

TABLE 16 (Continued)

Station 9					
Sample Date - October 9, 1969					
Organism	Sample			Total	Mean
	a	b	c		
Ephemeroptera (mayflies)					
Siphlonuridae					
Siphlonurus sp.	25				
Hemiptera (true bugs)					
Corixidae (water boatmen)					
Sigara sp.	2				
Callicorixa sp.	4				
Notonectidae (backswimmers)					
Notonecta sp.	2				
Coleoptera (beetles)					
Dytiscidae (predaceous diving beetles)					
Agabus sp.	1				
Laccodytes sp.	1				
Diptera (flies)					
Chironomidae					
Orthocladiinae					
Cricotopus sp.	332				
Nanocladius sp.	694				
Chironominae					
Microtendipes sp.	58				
Glyptotendipes sp.	24				
Total Organisms	1143				

TABLE 16 (Continued)

Station 9 (Continued)					
Sample Date - October 14, 1970					
Organism	Sample			Total	Mean
	a	b	c		
Nematoda (roundworms)	1				
Oligochaeta (segmented roundworms)	1793				
Hydracarina (water mites)	8				
Ephemeroptera (mayflies)					
Baetidae					
Baetis sp.	95				
Trichoptera (caddisflies)					
Hydropsychidae					
Hydropsyche sp.	272				
Parapsyche sp.	2				
Zygoptera (dragonflies)					
Coenagrionidae					
Argia sp.	1				
Hemiptera (true bugs)					
Corixidae (water boatmen)					
Sigara sp.	1				
Coleoptera (beetles)					
Dytiscidae (predaceous diving beetles)					
Agabus sp.	12				
Laccodytes sp.	116				
Laccophilus sp.	2				
Hydrophilidae (water scavenger beetles)					
Tropisternus sp.	5				
Elmidae (riffle beetles)					
Optioservus sp.	3				
Diptera (flies)					
Chironomidae (true midges)					
Tanypodinae					
Conchapelopia sp.	12				
Procladius sp.	4				
Chironominae					
Glyptotendipes sp.	5				
Micropsectra sp.	18				
Paralauterborniella sp.	1				
Pseudochironomus sp.	1				
Orthocladiinae					
Cricotopus sp.	9				
Corynoneura sp.	14				
Nanocladius sp.	172				
Unidentified pupae	10				
Tabanidae (horse flies)	1				
Empididae (dance flies)	1				
Total enumerated	2559				
Fraction of sample enumerated	1/8				
Computed total in sample	20472				
Number of field screenings	3				
Stream area sampled in sq ft	12				
Number of organisms per sq ft	1706				

TABLE 17

MAXIMUM, MINIMUM, AND AVERAGE VALUES OF QUALITY FACTORS IN RECLAIMED WATER
(COMPUTED FROM MONTHLY REPORTS BY THE SOUTH TAHOE PUBLIC UTILITY DISTRICT)
(All values in mg/ℓ except Turbidity, pH, and Coliform)

Date	BOD_5	COD	Suspended Solids	MBAS	Turbidity JTU	pH	Chlorine Residual Instantaneous	Coliform* (mpn)	Nitrogen				Phosphate	Alkalinity	Hardness	Total Dissolved Solids	Chloride	Sulfate
									Organic	Ammonia	Nitrate	Nitrite						
1968																		
Apr	4.8	22.0	11	.06	2.0	9.0	3.9	9.2	0[a]	27[a]	0.6[a]	-	0.70	273[a]	-[a]	248[a]	35[a]	-
	.5	7.7	1	.01	.5	7.6	0.1	2.2	0	20	.01	-	0.04	229	-	192	4	-
	1.8	15.7	3	.02	1.2	8.3	2.4	2.7	0	23	.18	-	0.38	256	190	220	24.3	-
May	3.5	19	5	.28	1.3	7.9	4.3	16.0	0[a]	18.6[a]	12.0[a]	5.7[a]	2.70	230[a]	184[a]	360[a]	37[a]	25[a]
	0.5	5	0	0	0.2	6.6	0.9	2.2	0	0	0.1	0.4	.03	145	130	328	15	24
	1.9	12	1	.12	.6	7.2	2.1	5.0	0	14.7	6.8	2.2	1.14	177	156	344	30	22
Jun	6.7	17.0	4	.24	1.0	8.2	8.0	5.1	-	13.8[a]	12.3[a]	0.8[a]	1.6	246[a]	160[a]	348[a]	33[a]	28[a]
	0.4	3.6	0	.10	0.2	6.9	.4	2.2	-	.12	4.5	0.6	0.2	164	140	294	25	23
	4.2	8.6	1	.15	.4	7.4	2.4	2.4	-	5.57	8.0	.7	.9	199	151	322	29	25
Jul	7.80	18.1	7.0	.20	1.0	8.1	4.3	16.0	-	13.6[a]	9.6[a]	3.5[a]	1.8	232	181[a]	342[a]	63.8[a]	52.0[a]
	.01	2.1	0.5	.09	0.1	7.0	1.0	2.2	-	6.3	1.8	1.6	0.4	187	134	179	21.3	22.8
	4.08	12.5	1.5	.14	0.3	7.5	2.3	6.8	-	9.8	5.8	2.2	1.2	231	150	271	39.3	32.9
Aug	1.5	17.3	3.0	.19	0.3	8.4	6.6	16.0	-	8.5[a]	7.2[a]	3.9[a]	1.20	264	188[a]	376[a]	39[a]	28[a]
	.1	7.9	0.0	.12	0.1	7.0	1.6	2.2	-	7.9	5.8	0.7	0.02	173	112	190	31	2
	0.6	13.0	.3	.18	0.2	7.5	3.5	6.9	-	8.2	6.3	2.7	.45	228	152	275	35	16
Sep	1.4	13.3	2.0	0.19[a]	0.4	7.7	14.7	16.0	-	9.3[a]	8.0[a]	1.3[a]	0.80	259	176[a]	412[a]	32[a]	30[a]
	0.0	4.5	0.0	0.08	0.1	6.8	1.6	2.2	-	0.5	2.5	1.3	0.00	205	122	295	28	24
	0.6	9.0	0.4	0.14	0.1	7.3	5.8	2.8	-	4.1	6.0	1.3	.15	252	160	366	31	26
Oct	3.2	18.7	1.0	-[a]	1.9	8.8	21.1	16.0	-	20.0[a]	0.4[a]	0.48[a]	0.64[a]	300	158[a]	382[a]	39.0[a]	28[a]
	0.1	5.0	0.0	-	0.1	6.8	0.0	2.2	-	6.8	0.0	0.08	0.07	212	112	248	30.0	28
	1.0	12.5	0.0	0.09	0.7	7.9	5.5	6.0	-	13.8	0.16	0.28	0.35	249	128	319	33.6	28
Nov	1.8	25.3	8.0	0.26[a]	2.9	9.1	9.9	2.2	-	-[a]	0.60[a]	0.92[a]	4.90[a]	250	160	306[a]	39	45
	0.0	7.0	0.0	0.09	0.5	6.9	0.0	2.2	-	-	0.00	0.01	0.06	42	72	298	19	13
	0.7	14.8	0.7	0.15	1.4	8.1	4.3	2.2	-	14.2	0.23	0.17	1.25	186	125	305	28	33
Dec	0.8[a]	13.4	-	0.15[a]	1.7	7.8	3.3	5.1	-	-	0.63	0.29	0.52	227	200	-	34	35
	0.0	2.3	-	0.10	0.5	6.5	0.0	2.2	-	-	0.00	0.00	0.01	137	44	-	14	15
	0.4	7.5	-	0.12	0.9	6.9	2.1	2.4	-	-	0.17	0.03	0.20	250	250	-	26	25
1969																		
Jan	3.1	18.6	-	0.35[a]	6.2	8.9	3.1	5.1	-	-[a]	0.48[a]	0.15	0.54	340	304	-	49	36
	0.2	3.8	-	0.10	0.8	6.4	0.0	2.2	-	-	0.00	0.01	0.01	166	48	-	12	10
	1.6	10.1	-	0.19	2.1	6.9	1.6	2.2	-	2.7	0.22	0.04	0.18	247	158	-	31	22
Feb	-[a]	24.8	-	0.23[a]	1.4	7.2	4.5	16.0	-	-	0.40	0.14	0.49	316	178	-	31	60
	-	3.7	-	0.11	0.2	6.1	0.0	2.2	-	-	0.00	0.00	0.03	150	54	-	20	18
	1.6	10.9	-	0.18	0.8	6.8	2.3	3.3	-	-	0.11	0.03	0.17	244	130	-	24	35
Mar	1.7	16.3	-	0.20[a]	0.9	8.5	7.6	5.1	-	-	0.60	0.47	0.51	319	206	-	32	48
	0.5	3.2	-	0.01	0.1	6.6	0.8	2.2	-	-	0.00	0.00	0.10	131	54	-	23	14
	1.1	9.1	-	0.12	0.3	7.3	3.0	2.4	-	-	0.30	0.13	0.24	239	138	-	26	28
Apr	1.1	10.9	-	0.13[a]	0.7	8.5	5.3	2.2	-	-	2.70	0.78	0.49	333	170	-	35	26
	0.0	3.1	-	0.06	0.1	6.6	0.6	2.2	-	-	0.63	0.01	0.03	142	70	-	15	15
	0.5	5.8	-	0.09	0.2	7.6	2.9	2.2	-	-	1.25	0.33	0.25	215	145	-	22	19

*< 2.2 is minimum value detected.

TABLE 17 (Continued)

Date	BOD	COD	Suspended Solids	MBAS	Turbidity	pH	Chlorine Residual Instantaneous	Coliform (mpn)	Nitrogen				Phosphate	Alkalinity	Hardness	Total Dissolved Solids	Chloride	Sulfate
									Organic	Ammonia	Nitrate	Nitrite						
1969 Cont.																		
May	1.0	15.4	-	0.27[a]	1.2	8.1	4.0	2.2	-	-	1.75	0.58	0.70	272	170	-	33	38
	0.1	4.7	-	0.10	0.2	6.8	0.5	2.2	-	-	0.00	0.01	0.07	137	80	-	18	15
	0.5	9.7	-	0.19	0.5	7.4	1.4	2.2	-	-	0.39	0.10	0.29	213	135	-	22	22
Jun	4.1	10.6	-	0.14	1.0	8.8	2.7	16.0	-	15.3	4.40	1.25	0.37	252	156	-	25	28
	0.2	3.8	-	0.00	0.1	6.7	0.4	2.2	-	11.5	0.00	0.00	0.02	149	74	-	11	15
	1.2	7.2	-	0.09	0.3	7.6	0.9	3.0	-	14.0	0.90	0.19	0.20	206	120	-	17	19
Jul	1.8[a]	18.9	-	0.23[a]	1.0	9.4	3.0	5.1	-	13.4[a]	6.70	5.50	[illegible]	243	166	-	30	48
	0.4	3.5	-	0.07	0.1	6.6	0.4	2.2	-	11.1	0.38	0.09	0.00	102	38	-	17	17
	0.8	11.1	-	0.16	0.4	7.5	1.3	2.5	-	12.1	2.45	2.40	0.26	173	110	-	22	27
Aug	4.9[a]	16.2	-	0.27[a]	0.8	8.1	3.8	5.1	-	-[a]	7.8	2.80	0.20	247	154	-	28	56
	0.2	3.2	-	0.01	0.1	6.5	0.6	2.2	-	-	0.0	0.00	0.00	178	120	-	17	15
	1.5	8.5	-	0.13	0.3	7.1	1.5	2.3	-	15.7	2.2	0.26	0.12	214	141	-	24	29
Sep	3.8	14.2	-	0.14[a]	0.4	7.4	2.8	2.2	-	17.9[a]	3.3	1.98	[illegible]	250	174	-[a]	60	56
	0.2	0.9	-	0.00	0.1	6.8	0.2	2.2	-	10.7	0.0	0.02	0.00	120	118	-	17	18
	1.2	8.1	-	0.07	0.2	7.0	1.9	2.2	-	14.2	1.1	0.32	0.06	200	144	320	26	29
Oct	1.4[a]	12.8	0	0.20[a]	0.8	8.1	3.7	8.8	-	19.8	2.4	1.58	0.29	430	176	450	28[a]	29
	0.1	0.6	0	0.01	0.1	6.7	1.2	2.0	-	10.9	0.1	0.01	0.01	214	108	170	20	12
	0.9	5.2	0	0.12	0.2	7.1	2.4	2.2	-	15.9	1.1	0.26	0.13	270	149	326	23	21
Nov	3.9[a]	21.7	0	0.35[a]	1.3	8.7	6.0	2.2	-	22.4	3.9	0.36	0.27	290	170	520	31[a]	56[a]
	0.4	1.7	0	0.08	0.3	6.6	0.9	2.0	-	6.0	0.0	0.01	0.00	175	134	152	22	33
	1.8	8.7	0	0.22	0.5	7.4	3.0	2.0	-	17.1	1.1	0.12	0.08	230	154	355	26	44
Dec	6.7[a]	24.0	0	0.18[a]	1.5	8.3	4.7	5.0	-	27.1	1.2	0.23	0.68	293	178	390	28[a]	52[a]
	0.2	2.9	0	0.00	0.3	6.6	0.7	2.0	-	13.0	0.0	0.00	0.02	156	114	220	21	30
	1.7	9.8	0	0.07	0.6	7.4	2.7	2.1	-	19.4	0.3	0.06	0.17	215	156	324	25	37
1970																		
Jan	2.4[a]	18.1	-	0.09[a]	1.8	8.4	6.0	2.2	-	25.6	1.1	0.58	0.75	233	166	320[a]	33[a]	36[a]
	0.2	1.1	-	0.07	0.3	6.8	0.4	2.0	-	8.6	0.0	0.00	0.06	159	106	280	15	19
	0.7	7.5	-	0.08	0.7	7.0	3.1	2.0	-	16.4	0.6	0.13	0.28	194	149	303	23	27
Feb	5.0[a]	20.7	0.0	0.14[a]	0.6	8.2	6.6	2.0	-	25.4	1.3	0.05	[illegible]	255	178	500[a]	25[a]	31[a]
	0.5	2.4	0.0	0.10	0.2	7.1	0.7	2.0	-	16.8	0.0	0.00	0.09	135	106	300	18	16
	2.3	8.9	0.0	0.12	0.4	7.7	2.2	2.0	-	19.8	0.4	0.03	0.20	211	156	300	22	20
Mar	4.5	30.7	0.0	0.55[a]	1.1	8.1	4.1	38.0	-	23.9	0.4	0.48	0.63	279	184	260[a]	29[a]	31[a]
	0.7	3.4	0.0	0.11	0.3	6.5	0.0	2.0	-	13.3	0.0	0.00	0.01	180	102	260	22	17
	2.3	14.3	0.0	0.27	0.6	7.2	1.5	3.4	-	19.7	0.2	0.16	0.17	227	156	260	25	21
Apr	5.0[a]	18.3	0.0	0.35[a]	1.0	7.8	6.1	24.0	-	31.1	0.3	1.00	0.19	270	176	-	32[a]	54[a]
	0.8	4.5	0.0	0.14	0.3	6.8	0.7	2.0	-	13.9	0.0	0.00	0.00	182	132	-	25	19
	2.4	11.9	0.0	0.27	0.5	7.1	2.5	2.7	-	20.9	0.1	0.11	0.07	218	154	-	28	36

TABLE 17 (Continued)

Date	BOD_5	COD	Suspended Solids	MBAS	Turbidity JTU	pH	Chlorine Residual Instantaneous	Coliform (mpn)	Nitrogen				Phosphate	Alkalinity	Hardness	Total Dissolved Solids	Chloride	Sulfate
									Organic	Ammonia	Nitrate	Nitrite						
1970 Cont.																		
May	4.8[a]	22.7	0.0	0.46[a]	1.0	8.3	3.6	2.0	-	18.9	1.4	0.15	0.30	325	182	-	43[a]	45[a]
	1.0	7.6	0.0	0.18	0.3	6.7	0.0	2.0	-	13.3	0.0	0.00	0.01	192	132	-	25	36
	3.5	13.5	0.0	0.32	0.4	7.1	2.3	2.0	-	16.5	0.2	0.04	0.09	227	161	-	33	40
Jun	2.9	24.5	0.0	0.46	2.0	7.9	6.3	5.0	-	21.1	0.2	0.07	0.61	230	200	-	32[a]	56[a]
	1.0	0.8	0.0	0.19	0.4	6.8	0.0	2.0	-	13.8	0.0	0.00	0.03	181	120	-	23	41
	2.0	12.3	0.0	0.34	0.8	7.1	2.7	2.2	-	18.1	0.0	0.03	0.19	200	143	-	27	47
Jul	4.3	28.7	0.0	0.40	1.0	8.9	5.5	2.0	-	26.2	0.6	0.35	0.75	275	150	-	32[a]	52[a]
	0.1	9.4	0.0	0.08	0.2	7.1	0.6	2.0	-	18.2	0.0	0.00	0.06	145	74	-	24	19
	1.4	15.2	0.0	0.22	0.5	7.6	2.4	2.0	-	21.2	0.2	0.06	0.32	230	131	-	28	39
Aug	3.1	20.0	0.0	0.22	0.4	8.3	4.3	2.0	-	21.2	1.2	0.46	0.65	315	200	388[a]	32[a]	55[a]
	0.1	5.1	0.0	0.05	0.1	6.8	0.0	2.0	-	15.1	0.1	0.01	0.06	176	126	272	24	19
	1.0	10.8	0.0	0.12	0.3	7.5	1.8	2.0	-	19.0	0.8	0.17	0.29	242	156	336	27	32
Sep	2.6	12.5	0.0	0.25	0.3	8.3	4.1	8.8	-	19.2	8.6	0.52	0.20	277	150	260[a]	43[a]	52[a]
	0.2	3.9	0.0	0.13	0.1	6.8	1.9	2.0	-	12.6	0.0	0.04	0.00	196	114	260	26	22
	1.0	9.1	0.0	0.19	0.2	7.4	3.0	2.2	-	16.5	1.3	0.34	0.07	231	135	260	30	34
Oct	1.7	13.2	0.0	0.17	0.2	7.6	3.1	15.0	-	19.7	1.3	0.34	0.39	296	196	440[a]	38[a]	48[a]
	0.3	4.9	0.0	0.06	0.1	6.9	0.8	2.0	-	13.3	0.1	0.02	0.00	195	116	304	24	19
	1.0	8.5	0.0	0.13	0.2	7.3	1.6	3.2	-	16.2	0.7	0.13	0.06	253	144	358	29	26
Nov	1.7	14.1	0.0	0.23	0.6	8.1	2.0	2.0	-	25.9	1.4	0.34	1.04	183	346	370	36[a]	33[a]
	0.1	2.0	0.0	0.05	0.2	6.9	0.8	2.0	-	11.7	0.1	0.02	0.01	326	102	246	22	22
	0.8	7.0	0.0	0.12	0.2	7.3	1.3	2.0	-	19.2	0.9	0.14	0.14	259	157	335	27	26
Dec	2.1	26.0	0.0	0.52	0.7	7.7	2.2	38.0	-	28.2	0.9	1.01	0.20	325	214	344[a]	51[a]	56[a]
	0.2	3.4	0.0	0.07	0.1	6.9	0.9	2.0	-	15.9	0.0	0.01	0.02	218	122	270	22	10
	1.2	13.5	0.0	0.29	0.4	7.4	1.5	3.4	-	21.4	0.4	0.09	0.10	263	163	305	30	32
1971																		
Jan	7.9	38.0	0.0	0.61	0.4	7.4	2.7	2.2	-	29.4	0.3	0.62	0.42	287	196	400	31[a]	58[a]
	0.0	8.0	0.0	0.15	0.1	6.8	0.9	2.0	-	14.9	0.0	0.00	0.03	199	112	186	19	20
	1.5	16.5	0.0	0.30	0.3	-	1.7	2.0	-	21.1	0.1	0.06	0.09	253	167	287	25	39
Feb	4.1	31.1	5.5	0.43	0.6	7.5	2.8	< 2.0	-	24.6	0.4	0.20	0.13	296	208	450	37[a]	40[a]
	0.1	7.3	0.0	0.17	0.2	6.8	0.7	< 2.0	-	18.1	0.0	0.00	0.02	207	104	180	24	23
	1.25	12.7	3.7	0.30	0.3	-	1.5	< 2.0	-	21.9	0.2	0.02	0.07	262	166	267	26	27
Mar	2.8	14.4	10.0	0.19	0.6	7.5	3.5	< 2.0	-	27.0	2.3	0.02	0.35	307	214	330	25[a]	26[a]
	0.0	4.8	0.0	0.01	0.2	6.8	1.3	< 2.0	-	15.6	0.0	0.00	0.06	172	136	120	19	18
	0.8	8.8	5.7	0.12	0.3	-	2.1	< 2.0	-	20.4	0.2	0.01	0.14	236	164	281	22	24
Apr	1.2	14.1	0.0	0.24	0.5	7.5	4.4	< 2.0	-	21.9	0.4	0.18	0.17	244	164	310	25[a]	29[a]
	0.2	2.6	0.0	0.08	0.2	7.1	1.4	< 2.0	-	11.8	0.0	0.01	0.03	169	126	200	18	16
	0.8	8.4	0.0	0.14	0.3	-	2.5	< 2.0	-	17.9	0.2	0.04	0.09	203	147	269	22	22

[a]Fewer than ten observations made during month.

TABLE 18

MAXIMUM GROWTH RATES AND CELL CONCENTRATIONS ATTAINED IN FIVE-DAY FLASK ASSAYS OF INFLUENT, IMPOUNDED, AND DISCHARGED WATER AT INDIAN CREEK RESERVOIR

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_5$	C_v %	SS mg/ℓ
1968									
10- 3[a]	ICR A	50	.713	.988	.8610	6.5	744.	17.5	24.25
	ICR B	50	.614	.982	.7642	10.7	435.	20.4	11.64
11- 4	ICR A	50	.656	.994	.7533	8.1	480.	12.4	16.28
		100	.531	.968	.6951	15.1	265.	8.8	23.44
	ICR B	50	.696	.971	.9022	15.9	532.	29.8	19.68
		100	.649	.973	.8158	21.1	445.	25.6	24.31
1969									
4- 1	ICR A	1	.307	.914	.4814	16.7	151.	9.1	6.06
		10	.544	.938	.8530	7.4	343.	23.0	15.71
		100	.729	.986	.8826	12.0	659.	14.9	30.00
	ICR B	1	.288	.985	.3362	7.3	122.	9.1	5.06
		10	.437	.943	.6628	14.0	222.	18.6	10.41
		100	.683	.991	.7817	14.4	643.	5.9	23.43
4-28	ICR A	1	.304	.958	.3569	12.0	210.	21.0	7.15
		10	.355	.905	.6036	10.3	203.	22.5	8.29
		100	.371	.943	.5499	9.7	216.	21.1	9.40
	ICR B	1	.315	.861	.5832	20.0	180.	22.3	7.37
		10	.277	.946	.3772	40.3	233.6	7.2	9.44
		100	.386	.971	.4426	21.4	324	16.1	13.75
5-29	ICR A	1	.099	.742	.2079	31.0	60.	6.2	2.31
		10	.372	.953	.4611	22.4	148.	10.0	5.88
		100	.638	.975	.7392	12.4	467.	19.6	20.67
	ICR B	1	.168	.875	.2402	36.5	71.	18.3	2.70
		10	.388	.952	.5357	21.9	153.	20.5	7.24
		100	.609	.922	.7579	24.2	405.	52.4	21.09
	ICR C	1	.187	.901	.2517	31.6	83.	29.2	3.28
		10	.529	.945	.8086	13.3	237.	10.9	7.57
		100	.850	.988	1.0496	5.9	1061.	9.3	28.59
	L-III	1	.153	.904	.2331	26.3	76.	12.2	3.76
		10	.499	.929	.7774	10.0	246.	25.4	10.74
		100	.157	.826	.2869	33.2	61.	12.3	5.86
6- 4	ICR B	1	.270	.847	.3728	36.7	96.	21.8	4.34
		10	.567	.963	.8133	17.3	229.	2.8	8.70
		100	.727	.997	.8068	5.7	552.	7.4	17.68
	ICR C	1	.250	.913	.3782	29.3	85.	4.4	3.06
		10	.194	.824	.2697	18.8	70.	8.9	3.42
		100	.253	.949	.3398	14.7	93.	15.2	3.38
	L-III	1	.321	.934	.4841	19.9	98.	14.2	4.28
		10	.640	.972	.7802	20.6	312.	33.6	11.81
		100	.168	.744	.2979	43.8	32.	10.0	3.22
6-19	ICR B	1	.388	.845	.6560	26.6	127.	4.6	3.80
		10	.499	.962	.6998	19.3	263.	11.7	8.79
		100	.779	.988	.8996	5.7	862.	21.7	27.30
	ICR C	1	.299	.894	.5190	17.9	128.	15.5	4.22
		10	.347	.880	.6439	15.9	149.	14.2	5.56
		100	.298	.879	.5545	10.4	129.	17.8	6.29
	L-III	1	.287	.937	.4335	26.5	126.	12.5	4.31
		10	.224	.864	.3790	20.8	88.	15.6	4.18
		100	.082	.710	.1368	70.6	41.	17.3	3.08
6-24	IRC B	1	.096	.637	.2240	47.9	87.	29.4	4.41
		10	.298	.835	.4306	15.0	220.	54.0	10.17
		100	.521	.985	.6181	20.0	344.	10.9	15.33
	IRC C	1	.096	.693	.1665	52.6	90.	23.4	4.45
		10	.242	.884	.4246	24.3	160.	11.9	6.14
		100	.274	.875	.5027	19.4	164.	10.4	7.10
	L-III	1	.120	.729	.2277	39.9	90.	18.6	4.68
		10	.359	.945	.4311	20.8	209.	34.3	10.48
		100	.058	.521	.1272	57.5	51.	14.7	3.32

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_s$	C_v %	SS mg/ℓ
7- 1	ICR B	1	.094	.647	.1802	78.1	66.	17.7	2.21
		10	.044	.638	.1058	27.8	63.	9.5	2.67
		100	.069	.702	.1388	35.0	75.	13.3	5.67
	ICR C	1	.082	.778	.1481	49.4	71.	12.7	2.58
		10	.042	.434	.1221	58.1	68.	13.1	3.52
		100	.181	.906	.2651	27.6	115.	19.7	7.19
	L-III	1	.020	.243	.1093	91.4	65.	9.1	2.68
		10	.116	.616	.3305	47.6	67.	3.4	4.34
		100	.011	.119	.0941	113.6	52.	17.7	4.60
7-10	ICR B	1	.155	.954	.1862	5.5	228.4	9.7	5.43
		10	.287	.957	.4279	14.1	396.3	3.2	11.21
		100	.482	.993	.4936	3.2	773.8	13.3	24.79
	ICR C	1	.121	.982	.1321	6.7	205.8	3.8	5.42
		10	.090	.945	.1349	13.6	187.	2.0	6.05
		100	.061	.271	.0704	41.9	111.2	31.5	3.67
	L-III	1	.113	.963	.1390	17.1	218.6	2.9	7.05
		10	.204	.912	.3130	17.0	304.8	17.0	9.24
		100	.030	.607	.0484	40.5	118.	10.2	3.75
7-17	ICR B	1	.130	.929	.1667	36.5	257.3	16.9	6.45
		10	.208	.981	.2697	3.9	364.6	4.3	10.78
		100	.240	.461	.5757	42.7	693.4	44.9	56.00
	ICR C	1	.107	.961	.1479	17.8	239.7	4.3	6.53
		10	.104	.966	.1317	11.1	241.6	4.1	7.41
		100	.153	.930	.2523	5.9	332.	4.0	9.89
	L-III	1	.251	.951	.3899	4.7	454.	2.3	11.16
		10	.429	.936	.6966	3.9	826.8	10.9	17.32
		100	.114	.959	.1337	33.2	172.4	9.8	7.33
7-22	ICR B	1	.376	.942	.5861	13.0	272.7	9.7	4.61
		10	.657	.982	.8418	8.2	842.2	14.0	11.96
		100	.424	.973	.5774	5.4	339.2	11.9	8.49
	ICR C	1	.387	.937	.6323	6.0	278.6	2.9	4.40
		10	.609	.966	.8484	14.5	646.8	10.1	12.61
		100	.106	.869	.1884	9.0	95.7	7.3	3.53
	L-III	1	.493	.972	.6646	10.2	444.2	15.6	6.00
		10	.258	.951	.3981	7.3	175.	5.4	3.19
		100	-.020	-.600	.0069	156.5	57.6	3.5	1.07
7-29	ICR B	1	.082	.918	.1261	21.8	169.7	4.8	3.47
		10	.315	.980	.4234	5.1	357.2	2.4	10.05
		100	.603	.973	.8281	4.6	1262.4	12.7	34.45
	ICR C	1	.081	.931	.1180	39.8	160.7	2.1	3.29
		10	.062	.910	.0858	24.1	157.8	2.1	2.92
		100	.212	.948	.3243	8.1	250.	5.4	9.26
	L-III	1	.078	.970	.1001	14.3	151.4	3.2	2.21
		10	.092	.890	.1163	32.9	128.6	10.4	1.27
		100	.037	.820	.0619	44.3	101.7	2.7	1.87
8- 5	ICR B	1	.222	.914	.3435	14.9	130.4	6.1	3.83
		10	.521	.985	.6735	3.3	414.	2.1	8.98
		100	.672	.984	.8624	4.4	759.	8.8	14.25
	ICR C	1	.161	.962	.2323	10.2	99.	3.2	3.24
		10	.210	.976	.2812	2.7	121.8	4.6	3.13
		100	.286	.852	.4166	43.3	177.9	4.3	4.62
	L-III	1	.196	.945	.3073	5.4	114.6	3.1	2.82
		10	.007	.274	.0334	38.9	51.5	3.9	0.44
		100	.036	.546	.0919	26.7	58.2	13.9	0.98
8-12	ICR B	1	.189	.954	.2848	5.1	143.3	4.8	-
		10	.541	.985	.6953	4.2	523.8	8.2	10.00
		100	.711	.975	.9658	3.6	1019.6	16.7	25.71
	ICR C	1	.067	.829	.1343	22.3	83.3	1.8	3.03
		10	.091	.842	.1908	9.5	92.2	2.8	4.44
		100	.094	.799	.2076	15.0	80.8	5.7	3.02
	L-III	1	.105	.923	.1614	5.9	92.8	8.9	3.08
		10	.299	.979	.3905	6.5	201.4	3.0	3.92
		100	-.028	-.485	.0447	92.4	48.8	3.1	1.95

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_s$	C_v %	SS mg/ℓ
8-19	ICR B	1	.187	.726	.3853	56.2	167.5	20.4	
		10	.572	.952	.8208	19.3	773.6	21.8	
		100	.977	.982	1.2644	12.1	5455.	6.9	
	ICR C	1	.102	.633	.2571	59.9	117.7	11.4	
		10	.113	.806	.2224	36.5	128.8	8.1	
		100	.094	.735	.1905	35.2	120.6	14.2	
	L-III	1	.152	.938	.2215	26.6	152.6	6.9	
		10	.375	.939	.4653	27.9	410.5	34.2	
		100	.010	.161	.0751	73.6	80.3	10.5	
9- 2	ICR B	1	.218	.920	.3576	14.2	112.9	11.7	
		10	.246	.929	.3859	16.7	142.3	9.0	
		100	.252	.942	.2899	15.1	430.2	21.8	
	ICR C	1	.253	.954	.3367	18.0	180.8	10.4	
		10	.137	.568	.1795	51.3	187.3	36.4	
		100	.153	.911	.1988	43.5	291.6	8.7	
	L-III	1	.231	.928	.3685	23.3	146.2	5.3	
		10	.184	.821	.2306	53.5	150.2	25.3	
		100	.101	.811	.1959	29.4	71.	7.0	
9-10[c]	ICR B	1	.169	.631	.3584	36.1	160.5	49.0	0.92
		10	.377	.956	.5421	12.4	318.6	17.0	2.72
		100	.572	.982	.7066	16.2	699.6	11.5	15.37
	ICR C	1	.116	.707	.2222	56.4	119.	21.3	1.30
		10	.331	.912	.4154	31.3	277.7	36.9	3.37
		100	.249	.585	.8251	11.2	168.	16.0	7.97
	L-III	1	.313	.831	.5723	32.8	266.6	30.2	2.06
		10	.280	.830	.5440	13.9	195.	30.6	1.47
		100	-.026	-.176	.0692	15.0	66.6	33.2	0.41
9-16	ICR B	1	.296	.810	.5862	26.8	239.4	28.1	3.28
		10	.227	.668	.5710	8.2	164.7	53.6	3.82
		100	.981	.947	1.4498	18.7	449.2	18.9	34.10
	ICR C	1	.265	.780	.6024	14.6	210.	22.1	2.07
		10	.592	.924	.9643	12.8	713.	23.3	4.50
		100	1.007	.957	1.5081	9.4	3906.	4.4	25.56
	L-III	1	.390	.803	.7523	26.4	356.5	35.0	3.95
		10	.138	.642	.3784	33.9	128.8	14.9	1.38
		100	.056	.456	.0927	121.7	94.9	27.6	0.15
9-25	ICR B	1	.149	.577	.1712	99.3	147.5	45.6	1.29
		10	.615	.853	.8450	35.5	896.	80.5	5.71
		100	1.182	.929	1.9552	5.6	6988.	5.5	42.11
	ICR C	1	.087	.410	.1554	103.2	101.1	38.2	1.66
		10	.310	.633	.5968	47.8	243.	60.2	4.51
		100	1.199	.962	1.7778	3.7	589.4	6.8	41.32
	L-III	1	.345	.816	.7402	8.0	308.6	19.9	3.13
		10	.544	.913	.9124	11.4	613.2	24.7	4.98
		100	.041	.415	.1013	44.1	62.8	26.9	2.04
10- 2	ICR B	1	.048	.492	.1539	37.4	66.1	5.9	7.48
		10	.302	.728	.4875	37.0	162.2	42.4	4.83
		100	1.249	.987	1.5265	8.6	5720.	7.7	28.48
	ICR C	1	.062	.425	.1888	23.3	65.0	7.2	2.86
		10	.204	.795	.3554	31.5	95.0	31.8	4.94
		100	1.092	.995	1.2168	7.7	349.4	6.2	24.33
	L-III	1	.483	.928	.8061	7.3	326.9	12.1	3.61
		10	.278	.619	.4344	76.3	153.2	64.4	2.49
		100	-.126	-.824	-.0234	-225.6	27.2	14.0	1.73
10-16	ICR B	1	.066	.776	.1210	69.0	134.3	4.8	4.32
		10	.180	.898	.3237	12.8	169.4	4.1	6.86
		100	.261	.806	.5838	7.7	176.9	8.2	35.70
	ICR C	1	.086	.745	.2069	4.3	142.	6.1	3.61
		10	.112	.716	.2810	23.1	170.6	2.6	6.19
		100	.209	.711	.5511	11.4	154.5	8.8	26.81
	L-III	1	.095	.713	.2523	8.0	145.3	3.0	5.36
		10	.097	.756	.1740	24.4	66.	20.5	4.85
		100	-.043	-.132	.5135	9.7	35.6	7.3	0.64

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_s$	C_v %	SS mg/ℓ
10-16	ICR B	1	.525	.827	1.0744	20.8	611.2	28.1	4.06
		10	.743	.902	1.2501	9.5	1358.	12.2	5.41
		100	1.072	.948	1.5803	13.9	5357.5	23.2	4.43
	ICR C	1	.525	.915	.8652	12.9	608.2	25.6	4.40
		10	.686	.921	1.1797	7.0	1219.2	4.7	6.88
		100	1.028	.981	1.3619	7.0	4236.	5.0	4.88
	L-III	1	.623	.917	1.0720	7.9	871.	21.0	5.22
		10	.496	.941	.5700	19.4	572.8	58.3	1.29
		100	-.013	-.151	.0778	117.2	71.9	6.7	0.95
10-24	ICR B	1	.303	.812	.4595	6.9	249.8	26.7	
		10	.263	.903	.3874	25.1	229.8	13.1	
		100	.057	.570	.1336	54.6	449.6	17.3	
	ICR C	1	.373	.957	.5148	10.5	191.	11.5	
		10	.259	.937	.2986	27.2	214.0	12.1	
		100	.170	.917	.2362	29.2	235.1	12.8	
	L-III	1	.281	.905	.4263	25.2	218.5	10.2	
		10	.271	.899	.4000	37.4	196.	7.4	
		100	.155	.773	.2362	49.1	100.5	18.2	
10-30	ICR B	1	.028	.481	.0656	32.3	95.	11.7	
		10	.139	.945	.1759	23.1	141.4	9.3	
		100	.107	.802	.1800	43.6	187.	10.2	
	ICR C	1	.069	.738	.1358	46.8	116.	12.7	
		10	.239	.885	.3764	22.6	209.4	26.0	
		100	.385	.973	.5308	9.4	766.4	8.8	
	L-III	1	.078	.476	.1983	63.4	122.7	24.9	
		10	.144	.709	.2090	60.3	155.1	34.0	
		100	-.016	-.220	.0744	57.3	187.7	9.5	
11-13	ICR B	1	.152	.806	.2840	32.2	215.6	9.4	4.02
		10	.179	.954	.1998	17.1	315.	12.6	5.17
		100	.516	.982	.6575	0.4	1645.2	15.9	45.46
	ICR C	1	.118	.835	.1423	28.0	216.6	12.2	3.26
		10	.196	.976	.2312	15.2	273.8	5.5	2.63
		100	.474	.989	.5470	3.0	1485.6	14.6	29.59
	L-III	1	.120	.920	.1493	14.3	210.5	10.3	3.98
		10	.108	.756	.1498	66.8	292.1	18.7	3.46
		100	.089	.750	.1551	17.2	1120.	7.4	7.44
11-19	ICR B	1	.131	.826	.2142	26.7	196.8	6.8	2.84
		10	.150	.898	.2074	18.4	183.8	7.6	2.71
		100	.608	.979	.7184	20.0	1387.6	3.5	19.54
	ICR C	1	.014	.186	.0874	42.0	160.7	8.6	2.87
		10	.216	.976	.2658	18.1	252.8	6.1	4.77
		100	.596	.987	.7103	15.8	1277.8	2.3	20.25
	L-III	1	.108	.812	.1318	54.1	211.8	13.2	2.87
		10	.135	.865	.1876	29.6	184.2	10.7	2.95
		100	.144	.454	.2228	79.6	273.2	7.9	-
11-26	ICR B	1	.176	.935	.2473	35.6	253.6	11.5	3.30
		10	.168	.953	.2218	24.8	216.6	3.6	5.00
		100	.481	.910	.8527	8.3	1188.4	6.6	11.25
	ICR C	1	.126	.916	.1665	5.0	188.	13.9	3.90
		10	.166	.978	.1775	5.6	234.7	2.8	4.42
		100	.557	.992	.6220	10.9	1194.5	11.7	10.90
	L-III	1	.136	.935	.1751	21.9	197.8	7.2	3.60
		10	.196	.986	.2217	19.0	214.1	5.0	4.17
		100	.067	.703	.1484	38.8	161.	3.5	2.17
12- 3	ICR B	1	.115	.845	.1327	36.6	204.9	17.1	3.48
		10	.201	.968	.2508	8.2	268.0	3.4	2.92
		100	.525	.987	.6585	4.7	804.8	3.6	19.23
	ICR C	1	.096	.718	.1388	32.0	222.6	17.9	2.12
		10	.186	.926	.2366	22.0	296.2	15.1	3.21
		100	.755	.981	1.0107	2.1	2156.	1.4	17.13
	L-III	1	.171	.958	.2084	25.4	228.8	4.1	2.58
		10	.235	.949	.3110	18.0	281.3	6.8	3.81
		100	.900	.906	1.6228	2.6			2.33

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_s$	C_v %	SS mg/ℓ
12-16	ICR B	1	.147	.842	.2319	20.1	88.4	19.3	0.38
		10	.091	.696	.2159	30.0	78.2	10.4	1.30
		100	.269	.830	.3354	44.6	152.6	37.0	3.32
	ICR C	1	.073	.711	.1558	45.7	65.6	10.4	0.52
		10	.117	.872	.2037	23.4	88.2	4.4	1.28
		100	.329	.976	.4035	16.9	183.2	16.3	3.82
	L-III	1	.126	.872	.2035	33.6	85.8	9.9	0.75
		10	.139	.819	.2508	21.7	91.3	14.0	1.06
		100	.123	.908	.1626	22.4	73.2	15.2	0.97
1970									
1- 5	ICR C	1	.056	.845	.075	21.0	111.0	6.9	2.05
		10	.234	.963	.332	8.6	205.0	8.7	3.93
		100	.538	.990	.656	5.1	646.0	2.7	7.81
	L-III	1	.059	.816	.110	37.7	109.8	3.3	1.42
		10							1.10
		100	.049	.449	.122	115.7	63.4	28.6	1.25
2-18	ICR C	1	.086	.522	.274	28.5	165.7	23.6	2.41
		10	.177	.836	.358	4.3	261.0	9.5	4.19
		100	.149	.770	.344	13.5	317.7	6.1	5.08
	L-III	1	.157	.824	.335	9.3	256.7	7.6	4.34
		10	-.027	-.239	.151	26.8	110.8	9.9	1.02
		100	.074	.784	.112	36.7	181.9	12.4	0.98
3- 3	ICR C	1	.314	.955	.462	11.6	212.7	10.6	3.88
		10	.273	.958	.405	12.3	179.9	2.3	3.97
		100	.302	.977	.385	10.5	145.4	9.4	2.47
	L-III	1	.285	.937	.466	4.9	200.2	4.8	4.52
		10	.243	.940	.385	5.3	189.4	9.9	3.23
		100	.213	.946	.258	20.3	179.4	9.8	0.92
3-18	ICR C	1	.121	.953	.157	23.8	123.2	3.7	2.71
		10	.160	.943	.207	32.5	148.2	5.5	2.70
		100	.219	.816	.453	17.4	235.0	14.7	1.62
	L-III	1	.156	.977	.196	13.8	133.5	5.3	2.98
		10	.160	.932	.224	24.8	136.8	9.9	2.66
		100	.175	.981	.225	9.9	194.8	4.4	1.88
3-26	ICR C	1	.066	.856	.094	31.6	91.9	4.6	2.19
		10	.080	.867	.108	17.9	101.8	12.3	2.23
		100	.088	.649	.242	24.7	121.7	11.1	1.40
	L-III	1	.189	.925	.316	12.1	156.5	2.1	3.12
		10	.454	.977	.512	12.8	609.6	16.5	11.47
		100	.626	.971	.858	12.9	1598.0	10.1	9.55
4-15	ICR C	1	.251	.939	.377	12.4	165.6	15.2	3.28
		10	.254	.924	.425	12.6	170.7	5.6	3.90
		100	.282	.961	.418	4.2	311.9	2.7	5.35
	L-III	1	.226	.976	.302	10.3	141.0	4.1	3.26
		10	.134	.905	.195	36.1	95.8	5.6	1.77
		100	.321	.917	.556	2.2	217.4	7.8	3.03
4-23	ICR C	1	.176	.969	.247	10.5	167.8	4.1	5.81
		10	.068	.393	.117	82.2	104.1	34.5	4.66
		100	.238	.937	.355	17.0	247.4	11.0	6.15
	L-III	1	.179	.976	.239	8.6	161.5	3.3	5.87
		10	.145	.951	.205	15.9	147.6	2.3	5.69
		100	.016	.335	.056	60.3	114.4	9.2	3.49
4-30	ICR C	1	.118	.974	.143	14.9	114.0	6.6	3.53
		10	.171	.954	.236	25.6	144.5	11.3	4.24
		100	.175	.953	.222	9.2	232.1	14.9	4.88
	L-III	1	.089	.895	.122	39.4	98.4	12.0	3.10
		10	.108	.907	.166	13.0	111.5	8.9	3.08
		100	.123	.867	.229	19.6	132.9	3.9	2.56
5- 7	ICR C	1	.193	.960	.286	7.7	176.6	2.9	2.51
		10	.217	.958	.306	15.6	200.4	5.1	3.12
		100	.322	.940	.522	3.5	272.4	4.0	2.52
	L-III	1	.173	.972	.224	17.5	162.8	3.8	2.35
		10	.051	.798	.084	32.6	100.1	3.6	0.93
		100	.304	.981	.385	12.2	202.2	5.1	1.59

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_5$	C_v %	SS mg/ℓ
5-19	ICR C	1	.086	.918	.145	10.8	164.4	2.8	4.18
		10	.170	.992	.181	7.9	214.2	4.6	5.34
		100	.250	.986	.279	9.8	381.6	8.1	6.56
	L-III	1							
		10	.045	.632	.102	25.5	104.2	11.9	1.21
		100	.247	.753	.604	7.4	238.4	3.0	2.88
5-27	ICR C	1	.157	.975	.193	17.2	125.7	5.8	2.81
		10	.163	.975	.190	11.2	126.2	6.2	3.13
		100	.167	.932	.272	13.7	140.1	2.9	2.20
	L-III	1	.161	.966	.196	21.0	121.8	9.5	2.98
		10	.077	.814	.155	27.5	87.3	5.7	1.66
		100	.079	.817	.161	33.1	109.7	3.8	1.78
6- 4	ICR C	1	.073	.934	.093	16.2	102.0	6.6	2.12
		10	.058	.709	.145	21.1	87.0	7.2	2.03
		100	.010	.203	.064	61.7	83.2	9.4	2.17
	L-III	1	.046	.561	.131	24.6	77.3	8.2	1.29
		10	.087	.853	.173	15.6	79.1	3.2	1.39
		100	.102	.652	.305	4.5	77.7	3.6	1.95
7- 1[d]	ICR C	1	.385	.933	.641	1.5	337.2	3.6	6.39
		10	.409	.959	.614	1.8	386.7	1.1	9.94
		100	.233	.989	.276	4.8	188.3	7.6	4.32
	L-III	1	.453	.955	.695	3.2	411.3	0.3	7.84
		10	.382	.990	.462	14.5	220.9	1.7	3.76
		100	.137	.983	.174	6.0	83.2	3.8	2.25
7- 7	ICR C	1	.109	.978	.132	6.2	79.5	7.4	1.95
		10	.081	.968	.108	21.9	73.6	2.3	2.05
		100	.102	.980	.120	16.0	67.9	1.2	1.76
	L-III	1	.317	.975	.418	9.9	147.3	4.8	3.03
		10	.169	.887	.275	31.5	92.0	3.8	1.76
		100	.170	.967	.234	4.7	88.3	8.2	1.78
7-16	ICR C	1	.147	.957	.163	30.4	97.9	12.0	2.37
		10	.220	.942	.338	19.3	123.6	8.5	2.22
		100	.190	.835	.402	8.9	141.7	4.7	1.26
	L-III	1	.177	.958	.223	11.8	108.8	13.5	3.20
		10	.200	.984	.256	9.1	132.9	4.1	2.50
		100	.535	.901	.981	2.4	432.7	7.0	0.35
7-21	ICR C	1	.178	.964	.251	15.2	112.1	7.5	2.30
		10	.168	.970	.214	13.0	114.4	6.1	2.68
		100	.054	.802	.103	33.9	58.9	5.6	2.36
	L-III	1	.126	.961	.160	36.6	90.1	5.8	2.25
		10	.078	.901	.134	32.5	72.1	4.9	2.21
		100	.099	.863	.128	58.3	82.5	1.4	2.03
7-30	ICR C	1	.084	.974	.112	13.9	87.2	1.7	2.51
		10	.107	.952	.139	19.2	91.7	7.7	2.89
		100	.157	.994	.170	5.2	85.7	1.4	3.00
	L-III	1	.182	.986	.219	7.3	126.8	2.3	3.47
		10	.342	.960	.397	20.2	218.7	22.6	5.08
		100	.098	.957	.128	13.5	70.3	8.7	2.26
8- 7	ICR C	1	.152	.758	.372	13.3	107.9	6.7	2.16
		10	.218	.973	.273	29.6	154.9	5.7	3.28
		100	.296	.994	.344	9.4	169.7	3.3	3.97
	L-III	1	.306	.980	.400	12.7	215.9	0.9	4.11
		10	.073	.818	.110	23.5	70.1	11.7	1.00
		100	.087	.953	.123	1.5	66.4	4.5	1.17
8-14	ICR C	1	.108	.919	.141	43.0	102.0	5.0	2.14
		10	.138	.992	.146	8.1	108.9	3.7	1.97
		100	.516	.916	.639	16.6	448.9	63.8	10.75
	L-III	1	.110	.939	.165	21.1	88.8	6.1	1.95
		10	.057	.818	.105	16.3	82.0	5.7	1.44
		100	.138	.930	.167	53.0	78.4	15.5	2.11

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_s$	C_v %	SS mg/ℓ
8-19	ICR C	1	.116	.879	.214	4.4	85.6	4.5	1.54
		10	.184	.946	.291	2.0	114.5	2.7	2.17
		100	.304	.936	.455	14.5	197.7	20.9	2.53
	L-III	1	.255	.946	.376	29.7	187.7	4.1	3.24
		10	.129	.974	.159	22.6	98.9	7.0	1.65
		100	.061	.500	.234	14.7	78.7	0.6	1.03
8-26	ICR C	1	.158	.983	.175	29.6	52.8	9.7	0.92
		10	.107	.983	.127	16.8	47.1	5.9	1.74
		100	.070	.846	.109	22.8	44.8	8.0	1.32
	L-III	1	.125	.928	.193	1.3	41.6	8.6	1.42
		10	.157	.914	.232	41.0	44.1	18.1	0.81
		100	.158	.990	.184	13.8	36.4	1.4	1.09
9- 4	ICR C	1	.119	.668	.342	13.0	55.2	5.9	0.57
		10	.112	.719	.296	2.2	56.7	4.7	0.97
		100	.208	.866	.412	4.8	78.8	6.6	1.32
	L-III	1	.142	.991	.146	4.7	44.5	5.0	0.72
		10	.150	.860	.192	26.6	85.2	18.6	0.72
		100	.072	.917	.088	32.6	47.7	0.9	0.83
9-10	ICR C	1	.062	.570	.079	60.0	52.4	20.4	0.53
		10	.166	.839	.280	24.5	68.4	23.8	2.03
		100	.282	.988	.330	10.0	96.9	3.1	1.86
	L-III	1	.111	.963	.148	9.0	58.7	6.1	0.56
		10	.081	.861	.115	30.4	47.9	8.2	
		100	.084	.968	.101	28.1	38.0	3.4	0.53
9-17	ICR C	1	.053	.403	.207	32.8	56.8	14.0	0.45
		10	.159	.916	.268	13.3	67.6	5.8	0.64
		100	.140	.896	.238	33.4	74.0	2.2	0.97
	L-III	1	.097	.975	.120	2.7	64.4	6.0	
		10	.082	.930	.129	7.5	60.3	4.0	0.36
		100	.081	.945	.117	16.7	39.9	3.4	0.39
9-23	ICR C	1	.146	.946	.190	38.8	[illegible]	5.8	2.80
		10	.165	.986	.197	5.0	145.2	0.4	3.28
		100	.074	.626	.169	61.6	110.7	3.0	2.19
	L-III	1	.059	.864	.084	8.7	120.4	7.1	
		10	-.016	-.373	.044	41.2	84.8	5.9	1.47
		100	.061	.823	.105	72.4	96.0	9.8	2.30
10- 1	ICR C	1	.066	.596	.203	31.8	65.9	8.6	2.00
		10	.080	.600	.264	6.3	65.2	2.0	2.06
		100	.075	.665	.216	15.5	68.5	4.3	2.76
	L-III	1	.219	.955	.294	35.5	131.5	19.1	4.91
		10	.144	.931	.215	19.3	100.5	12.1	2.85
		100	.079	.885	.092	19.5	82.7	10.2	2.27
10- 9	ICR C	1	.076	.764	.157	6.6	80.9	8.7	1.74
		10	.046	.754	.099	27.8	70.0	1.0	1.17
		100	.061	.895	.107	16.9	66.0	1.2	0.58
10-14	ICR C	1	.069	.895	.117	15.6	82.0	4.8	0.75
		10	.038	.749	.064	44.6	73.3	6.9	1.03
		100	.041	.897	.069	35.5	68.0	0.6	0.78
	L-III	1	.065	.466	.155	21.4	88.1	30.9	0.86
		10	.032	.591	.100	8.2	69.5	1.3	0.88
		100	.039	.562	.120	48.7	65.9	7.5	1.92
10-22	ICR C	1	.147	.908	.239	7.7	110.7	2.5	2.28
		10	.093	.696	.244	15.2	91.6	4.8	2.24
		100	.206	.939	.295	8.1	90.8	13.6	2.75
	L-III	1	.170	.950	.242	13.5	95.6	7.0	6.97
		10	.262	.981	.332	5.4	124.4	1.4	8.14
		100	.104	.775	.188	44.8	68.7	23.8	1.78
10-28	ICR C	1	.131	.905	.198	18.7	78.4	10.9	2.00
		10	.092	.852	.112	33.9	70.7	16.6	2.06
		100							
	L-III	1	.060	.941	.091	20.6	73.9	2.4	1.67
		10	.082	.830	.146	42.9	75.3	14.0	1.58
		100	.124	.939	.157	18.3	64.4	11.7	1.86

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_s$	C_v %	SS mg/ℓ
11- 6	ICR C	1	.225	.937	.366	11.1	176.5	1.7	5.03
		10	.228	.964	.335	7.0	184.8	0.4	5.00
		100	.222	.974	.288	8.4	165.9	11.5	3.49
	L-III	1	.236	.966	.313	19.4	203.3	11.5	5.11
		10	.108	.991	.122	16.7	124.1	2.6	2.75
		100	.076	.860	.092	40.4	83.3	14.1	2.14
11-11	ICR C	1	.179	.802	.408	3.4	127.2	0.3	1.89
		10	.182	.853	.371	1.2	131.9	7.1	2.50
		100	.148	.824	.286	27.2	107.5	14.0	2.36
	L-III	1	.024	.344	.095	78.3	97.6	11.2	1.85
		10	.045	.632	.107	19.5	96.7	7.5	1.29
		100	-.231	-.795	.049	72.1	18.9	19.1	5.65
11-18	ICR C	1	.017	.571	.043	19.6	56.1	3.1	16.06
		10	.057	.840	.078	11.2	63.9	6.1	16.47
		100	.064	.635	.194	13.5	68.1	5.0	18.27
	L-III	1	-.026	-.530	.020	87.9	47.6	8.5	15.63
		10	-.005	-.122	.055	111.2	48.0	8.5	14.94
		100	-.030	-.626	.018	251.6	43.3	7.8	16.79
11-2[illegible]	ICR C	1	-.040	-.600	.038	113.4	57.1	6.9	14.00
		10	-.017	-.361	.044	51.6	62.3	7.3	13.44
		100	.131	.758	.303	19.8	111.2	6.0	16.06
	L-III	1	.017	.698	.040	54.7	53.6	2.9	12.52
		10	.002	.049	.033	94.3	46.8	9.4	13.40
		100	-.025	-.492	.010	94.5	41.3	6.8	12.31
12- [illegible]	ICR C	1	.200	.793	.317	28.3	113.3	37.9	1.89
		10	.348	.939	.565	4.5	191.3	4.7	4.60
		100	.151	.919	.248	3.9	77.6	8.6	3.36
	L-III	1	.191	.962	.241	10.6	103.2	11.9	1.94
		10	.002	.021	.064	1.2	40.3	14.8	0.77
		100	-.005	-.172	.015	136.6	39.4	6.5	1.05
12-15	ICR C	1	.257	.950	.401	1.9	141.9	1.0	3.09
		10	.321	.953	.492	6.8	175.1	1.2	5.14
		100	.107	.608	.343	20.5	67.9	4.8	2.50
	L-III	1	.247	.862	.481	16.1	142.3	1.9	4.66
		10	.325	.913	.551	10.4	174.9	11.4	6.94
		100	.105	.874	.124	14.5	58.9	13.4	5.51
1971									
1- [illegible]	ICR C	1	.013	.072	.137	33.1	64.8	44.6	3.91
		10	.024	.098	.108	78.1	70.5	53.3	3.44
		100	.453	.969	.635	12.4	369.5	14.6	9.44
	L-III	1	.194	.767	.272	63.9	125.9	44.6	6.09
		10							
		100							
1-27	ICR C	1	.028	.377	.127	34.5	40.3	12.8	2.27
		10	.122	.834	.170	31.0	72.9	23.9	3.08
		100	.571	.935	.942	4.1	424.3	2.3	9.37
	L-III	1	.052	.759	.082	25.8	49.3	13.7	2.77
		10	-.009	-.218	.057	27.3	38.3	2.7	1.72
		100	-.199	-.816	.027	350.0	20.2	18.1	1.79
2-10	ICR C	1	-.101	-.794	-.028	-101.9	22.9	17.1	0.76
		10	-.107	-.825	-.079	-74.1	24.7	23.5	0.71
		100	.319	.711	.725	42.1	90.8	41.2	2.40
	L-III	1	-.119	-.669	.019	117.8	18.9	4.0	0.71
		10	-.115	-.591	.139	84.7	24.4	13.9	0.46
		100	-.210	-.686	.020	1657.6	20.7	63.6	0.86
2-22	ICR C	1	-.140	-.719	.091	24.8	9.6	3.8	0.11
		10	.202	.703	.304	95.1	48.1	54.5	1.27
		100	-.207	-.910	-.148	-15.0	13.6	17.8	0.66
	L-III	1	.173	.991	.206	3.4	101.9	1.7	4.74
		10	.015	.377	.031	34.7	50.3	8.6	2.74
		100	-.340	-.927	-.123	-30.2	5.9	14.1	2.47

TABLE 18 (Continued)

Date	Sample	Conc. %	$\hat{\mu}_{b\ell}$	Corr. Coef.	$\hat{\mu}_b$	C_v %	$\hat{X}_s$	C_v %	SS mg/ℓ
3- 9	ICR C	1	-.093	-.685	-.061	-27.8	24.8	29.0	
		10	.022	.220	.037	67.1	43.7	22.9	
		100	-.235	-.810	-.134	-11.8	12.5	35.1	
	L-III	1	.068	.796	.096	34.8	48.5	13.4	
		10	.366	.936	.592	8.3	143.1	10.8	
		100	-.199	-.741	.103	89.3	17.5	6.8	
3-15	ICR C	1	-.195	-.888	-.128	-57.0	29.9	25.8	
		10	.050	.905	.075	1.6	73.3	2.6	
		100	-.199	-.761	.021	160.2	24.0	35.4	
	L-III	1	.093	.915	.152	7.2	82.4	5.6	
		10	.055	.754	.131	6.9	80.5	4.7	
		100	-.215	-.803	.008	1439.5	20.4	9.6	
3-24	ICR C	1	-.030	-.378	.030	53.6	50.9	19.9	
		10	.103	.862	.157	6.6	89.6	14.1	
		100	.021	.376	.082	55.3	63.9	10.5	
	L-III	1	-.020	-.259	.059	1.7	55.9	17.8	
		10	-.009	-.139	.055	104.5	62.0	11.7	
		100	-.225	-.957	-.165	-30.7	21.9	17.5	
4- 5	ICR C	1	.517	.948	.816	0.8	290.4	4.8	
		10	.488	.893	.884	10.3	284.7	2.8	
		100	.358	.882	.677	16.6	159.1	6.7	
	L-III	1	.567	.912	1.006	1.0	317.9	6.6	
		10	.373	.797	.810	10.4	136.3	34.4	
		100	-.271	-.763	.059	386.8	11.1	37.6	
4-19	ICR C	1	.491	.956	.748	0.7	351.6	5.7	
		10	.522	.921	.889	7.8	295.7	15.7	
		100	.530	.906	.955	0.4	360.0	1.4	
	L-III	1	.438	.936	.716	7.2	286.3	5.0	
		10	.312	.875	.514	11.0	168.0	32.9	
		100	-.051	-.181	.422	8.3	30.3	6.3	
5- 5	ICR C	1	.341	.926	.579	4.2	303.3	2.7	
		10	.300	.927	.503	7.3	303.1	2.9	
		100							
	L-III	1	.349	.923	.597	7.8	337.7	0.8	
		10	.217	.947	.340	1.4	113.2	4.9	
		100	.027	.841	.044	38.5	44.7	1.4	

[a]Test alga S. gracile, hand counted during period 10-3-1968 to 7-1-1969.

[b]Test alga S. capricornutum, counted by Coulter Counter during period 7-10-1969 to 12-16-1969.

[c]Test alga culture of S. capricornutum contaminated by Chlorella sp. during period 9-10-1969 to 10-16-1969.

[d]From this time period three replicate samples replaced the five replicate samples that were previously used.

SELECTED WATER RESOURCES ABSTRACTS
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2.
3. Accession No. W

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13. Type of Report and Period Covered

12. Sponsoring Organization

15. Supplementary Notes

16. Abstract
Beginning in April 1969 field and laboratory analyses were made on approximately a weekly basis to observe the relationship between the quality of water in Indian Creek Reservoir and that of reclaimed water exported from the South Tahoe Public Utility District, which comprised some 70 percent of its annual input. Reclaimed water contained 0.01 - 0.04 mg/ℓ of phosphorus and more than 15 mg/ℓ of ammonia. Initially the reservoir would not support fish life but as the reservoir matured some 70 percent of influent nitrogen was lost to the atmosphere continuously by nitrification-denitrification in the system. By March 1970 the reservoir was an excellent trout fishery. Good general biological productivity indicated access to other sources of phosphorus, probably soil and surface runoff. Bioassays showed the growth stimulating ability of reservoir water exceeded that of influent reclaimed water. It is concluded that the reservoir responds to more complex factors than those measurable by analyses of reclaimed water; that the reservoir should be monitored further to determine whether it has stabilized or is subject to further change; and that the optimum degree of treatment necessary for recreational waters should be determined as a guide to design of appropriate waste treatment and water reclamation processes.

17a. Descriptors
*Eutrophication, *Denitrification, *Reclaimed Wastes, *Aquatic Productivity, *Bioassay, *Limnology, *Cycling Nutrients, *Benthos, Aquatic Microorganisms, Algae, Vascular Plants, Fish Population, Tertiary Treatment, Nutrients, Biomass

17b. Identifiers
*Indian Creek Reservoir, *Sewage Export, *South Tahoe Public Utility District, Lake Tahoe Area Council, EPA Demonstration Grant Lake Tahoe

17c. COWRR Field & Group 05C

18. Availability
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