Water Quality Status Report

Cascade Reservoir

(Valley County)

1975

Department of Health & Welfare
Division of Environment
Boise, ID 83720

Water Quality Series No. 20

WATER QUALITY STATUS REPORT

CASCADE RESERVOIR

VALLEY COUNTY, IDAHO

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Water Quality Series No. 20

Reprinted March 1980

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ABSTRACT

A water quality survey of Cascade Reservoir and its tributaries was conducted from May to November, 1975. The purpose of the survey was to assess the trophic condition of Cascade Reservoir, to examine the relative effects of point and nonpoint sources on the reservoir, and to acquire water quality data for reservoir model development.

The dissolved oxygen concentration reached lowest levels in August near the reservoir bottom. In general, the major tributaries had high DO values.

Temperatures throughout the reservoir reached maximum values in July, with the highest value of 25° C observed on the surface.

The pH values during the study period were generally in the 6.0 to 9.0 range. The pH normally decreased down through the water column.

The phytoplankton community peaked in numbers during August. The reservoir sustained algal blooms in August and September. Diatoms dominated early in the season and were later replaced by the nitrogen-fixing blue-green algae. The zooplankton also peaked in August. A general succession of zooplankton was noted with rotifers replacing the copepods and to some extent the cladocerans through the season. Biologically, the reservoir is in a beta-mesosaprobic condition.

Total and fecal coliform densities in the reservoir were generally low with the highest densities occurring in July and August. Boulder Creek and the McCall wastewater treatment lagoons appear to be the major sources of coliform bacteria.

Cascade Reservoir is generally of good water quality and is considered slightly eutrophic. Orthophosphate is at levels conducive to

increased algal populations which are observed in August and September. Inorganic nitrogen to orthophosphate ratios were about 3:1 for Spring; 4:1 for Summer; and, 3:1 for Fall reservoir conditions. These ratios indicate a nitrogen limiting condition for the reservoir.

The reservoir acted as a sink for total phosphorus during June, July, October, November and December. It was a source of total phosphorus for the remainder of the year. McCall constituted an average of 9% of the total phosphorus loading to the reservoir.

The increasing recreational value of the reservoir mandates that every effort be made to maintain or improve the water quality of the reservoir.

INTRODUCTION

Cascade Reservoir is located in the extreme western portion of Valley County, Idaho. Figure 1 shows the location of the reservoir in Idaho, the area included by this study, and major sample stations. Table 1 lists station location data. Figures 2 and 3 are more detailed maps of Cascade Reservoir. The North Fork of the Payette River flows south from Payette Lake into the reservoir. Lake Fork, Boulder Creek and Gold Fork River make up the remainder of the main inflows of water into the reservoir. Other tributaries to the reservoir include Rock Creek, Poison Creek, Duck Creek, Gibson Creek, Hurd Creek, Deer Creek, Silver Creek, Vay Wyck Creek, French Creek, Hazard Creek, Campbell Creek and Willow Creek on the western and southwestern sides. Mud Creek flows into Lake Fork Arm near the north end of the reservoir. Willow Creek, Davis Creek, and Grandmas Creek enter from the eastern side. These streams drain primarily Payette National Forest lands and some low valleys. Some inflow to the reservoir also occurs from the West Mountains, just west of the reservoir in Adams and Gem Counties, again draining Payette National Forest lands. The area receives about 24 inches (61 cm) of mean annual precipitation (Ross and Savage, 1967).

Numerous small springs emerge in Cascade Reservoir including a hot spring which reportedly is located near the dam (USBR, Personal Communication). The exact locations of most of these underwater springs are unknown; however, it is believed that they are of insufficient size to be a major inflow to the reservoir. It is assumed that the water quality of these springs is good.

The town of Cascade lies just to the southeast of the reservoir. It has a population of about 916 (1973 estimate, IDHW, 1974) and an elevation of 4,790 feet (1460 m). Lumbering and agriculture (predominantly livestock grazing) make up the majority of the land use of the drainage basin to the reservoir. Recreation is a significant input into the area's economy. According to the Idaho Fish and Game Department (1973), there is public access along the entire perimeter of the reservoir by county road system, part of which is closed in winter. There are excellent public campgrounds, water, tables and boat launching facilities at the south end of the lake on the edge of Cascade's city limits; however, the space is limited. There is a boat launching ramp on the southwest edge of the lake located in a subdivision. A large forest service camp is located on the mid-western shoreline. A forest camp is also available a short distance south of Tamarack Falls Bridge where it crosses the river at its upper end. A public boat ramp is situated on the Lake Fork Arm of Cascade Reservoir about two miles west of Donnelly. About halfway between Cascade and Donnelly there is an airstrip with camping facilities. Another airfield is located just south of Cascade.

One of the major uses of the reservoir is fishing, which occurs throughout the year.

Cascade Dam was completed in 1948 and water storage had begun in 1947 (USBR, 1975). The dam is an earth type and is 70 feet (21.3 m) in height (Idaho Department of Water Administration, 1971). The reservoir at capacity level covers 28,300 acres (11,453 ha) of land (USBR, 1975). The maximum total storage of the reservoir is 703,000 acre feet (8.7×10^8 m^3) at which point the elevation of the surface is 4828 feet (1472 m). This includes a maximum active storage volume of 653,000 acre feet (8.0×10^8 m^3)

and 50,000 acre feet (6×10^7 m^3) of dead storage. The 50,000 acre feet (6×10^7 m^3) of dead storage is never drawn from the reservoir. In fact, the reservoir has never been drawn down to near its minimum storage level.

The vegetation of the Cascade Reservoir watershed has been described in general terms by Kuchler (1964) as the following: the immediate area to the east of the reservoir is a low area called Sagebrush Steppe. This is a dense-to-open grassland to open shrub synusia. It was originally dominated by blue-bunch wheatgrass (Agropyron spicatum) and big sagebrush (Artemisia tridentata). Most of this area has been modified by farming, mainly pasture, some hay and small grains. The West Mountains, except for the highest elevations, are western Ponderosa Pine forests, dominated by Ponderosa Pine (Pinus ponderosa). This type is a medium dense to open forest of tall needleleaf evergreen trees with a fairly open ground cover of grasses and occasional shrubs. The higher elevations of the West Mountain and the mountains just east of Cascade Reservoir are dominated by Grand Fir (Abies grandis) and Douglas Fir (Pseudotsuga menziesii). It is a tall needleleaf evergreen forest. The forested areas are used for both silviculture and grazing.

Long Valley, in which Cascade Reservoir is located, is geologically a tectonic valley bounded on the east and west by fault zones. The mountains on the east of Cascade Reservoir are weathered granitic rocks of the Idaho batholith, while the West Mountains consist of upfaulted Columbia River basalt flows. These western rocks are less weathered than the eastern granitic rocks indicating a younger relative age. Cascade Reservoir occupies part of the clay, sand, and gravel filled structural basin called Long Valley. Long Valley is divided by an uplifted block in the vicinity of the City of

Cascade. The stage of erosion is late youth on the uplands and maturity in Long Valley. The Payette River is mature in this region because of the large amount of sediments deposited in the Pleistocene. Thus, in Long Valley the river has begun to cut laterally because it can no longer cut down. The dam that forms Cascade Reservoir is an excellent example of how a small, well placed dam can impound a large amount of water (from Ross and Savage, 1967).

The soils, according to the U.S. Department of Agriculture (1973), in Long Valley to the north, east and south of Cascade Reservoir are considered deep (more than 40 inches, 102 cm) and moderately deep (20-40 inches, 51-102 cm). They lie over gravel and are poorly to somewhat poorly drained, medium or slightly acid, loam, sandy loam and silt loam soils. The slope is nearly level (0-2%), and is formed in mixed alluvium with 25-28 inches (63-71 cm) annual precipitation. USBR (1975) found these soils to be slightly acid to neutral pH. This area roughly approximates the Sagebrush Steppe vegetation type.

The soil to the west of the reservoir is deep (more than 40 inches, 102 cm) to shallow (10-20 inches, 25-51 cm). It is well drained, medium and slightly acid, sandy loam and loamy sand. The slope is moderately steep (12-30%) and steep (more than 30%). The soil is formed in material weathered from granite receiving 25 to 60 inches (63-152 cm) of annual precipitation (U.S. Department of Agriculture, 1973). The western Ponderosa Pine Forest is predominant on this soil type.

Irrigated land between McCall and Cascade Reservoir is estimated at about 33,000 acres (13,355 ha).

Purpose of Study

The main purpose of the Division of Environment's involvement in this survey was to assess the nutrient loadings in Cascade Reservoir for background data to enable proper assessment of the City of McCall's National Pollution Discharge Elimination System (NPDES) permit requirements. Secondarily, the United States Bureau of Reclamation (USBR, 1975) indicated a need for further studies to appraise long term reservoir conditions and trends and to help define nonpoint sources. This study will help elucidate some of the questions raised by the 1975 study.

Past Studies in Area

The Idaho Department of Health (now Department of Health and Welfare, Division of Environment) conducted a sanitary survey of Cascade Reservoir in July, 1961. Comprehensive limnological studies were initiated by the Department in August, 1971. Bacteriological samples from 22 stations were collected in August, 1971; July, 1972; and July and August, 1973. Samples for chemical analysis were also collected in August, 1973. A mimeographed report concerning the results of Cascade Reservoir and of Payette Lakes studies was completed on November 2, 1973 (Ralston and Wroten, 1973).

Two earlier reports on Payette Lakes (which feed the North Fork of the Payette River) have been published by the Idaho Department of Health in 1964 and 1970.

In 1975, USBR published a report of their 1974 survey of Cascade Reservoir as part of their southwest Idaho Water Management Study. They recommended: "reduction of nutrients from pasture lands bordering the reservoir, further study of developments along the shoreline . . . , and further study of the lake area."

The United States Environmental Protection Agency (EPA) in conjunction with the U.S. Air National Guard conducted a monthly eutrophication survey of the lake and major tributaries from October, 1974 through October, 1975. This was part of a national effort. A final report has not yet been published. These data closely resemble those collected by this department.

The United States Geological Survey (USGS) monitors flow at six stations along the North Fork of the Payette River and major tributaries between McCall and Cascade. They also monitor water quality at several stations on the North Fork below the City of Cascade.

Future Population and Economic Growth Potential

The Idaho Department of Health and Welfare (1974) reported the population of Cascade at 833 for 1970. Ralston and Wroten (1973) state that in 1961 there were fewer summer homes around Cascade Reservoir, but that at the time of their report most of the land around the reservoir had been subdivided and a large number of homes built.

USBR (1975) also noted a recent increase in summer homes around the reservoir and concluded that, "if recreational homesite development continues at the present rate around the lake area and no waste treatment facilities are provided, 'cultural eutrophication' of the lake could be accelerated."

The year-round population of the Cascade area is fairly stable. During the summer there is an increase in use, much of which is from retired persons staying the entire summer. Weekend increases in population may occur throughout the year, being greatest in summer. Economic changes in the McCall area could result in additional permanent population to Cascade. Cascade's estimated 1973 population was 916 (IDHW, 1974).

The U.S. Department of Agriculture (1976) estimates that approximately 6,400 acres (2,590 ha) in Valley County will change from crop to urban usage between 1975 and 1980. They also estimate that 1,200 acres (486 ha) will change from range and woodland to urban usage. It was also estimated that 1,200 acres (486 ha) will change to recreation and homesite usage between 1975 and 1980. A major portion of this change may occur around Cascade Reservoir.

The USBR has at least four recreation areas planned around Cascade Reservoir. A 30-unit campground is presently being constructed at Poison Creek. A boat ramp, picnic area and fishing dock for the handicapped are to be included. All campgrounds will have vault-type privies. A day-use area with 25 planned picnic units is planned for the Sugarloaf area soon. A 30-unit campground is planned in a few years for construction in the Boulder Creek Area. This will also include a 15-unit picnic area and boat ramp. A private marina is planned for Crown Point which will include a lodge with 50-bed capacity, restaurant and a minimum of 50 slips for boats.

IDHW (1974) gave the 1970 census (permanent residents) for McCall as 1,758. Our Division has estimated summer residents at 1825 and tourists as 743 for a total summer population of 4326. The Facilities Plan prepared by Intermountain Engineers (1976) projects McCall's population to be 6390 (permanent), 5935 (Summer), and 2416 (tourists), for the year 2028.

MATERIALS AND METHODS - Lake Survey

All eleven Cascade Reservoir stations (see Table 1 for locations) were sampled from a 16' boat. Field parameters sampled during the May and June surveys included dissolved oxygen and temperature (taken with a YSI Model 54 DO meter); pH (using a Photovolt 126A pH meter); transparency reading (obtained with a standard 8" secchi disk); and depth (measured with a weighted rope). Beginning with the July survey, a Martek Mark 5 Digital Water Quality Analyzer was used for dissolved oxygen, pH, temperature and specific conductance. Instruments were calibrated before and checked after each sampling period. These parameters (except for transparency) were determined at three levels (surface, middle, and bottom) and later at every meter of reservoir depth.

Plankton were collected at Stations B, G and D with the use of a Wisconsin style plankton net.

Vertical plankton hauls were taken through the photic zone from the compensation point to the surface. This distance was calculated by multiplying the secchi disk (transparency) reading by three. Plankton were then rinsed with distilled water into glass containers and immediately preserved with 5% formalin and stored until sample analysis was made.

In the laboratory the sample was thoroughly mixed, diluted depending on population density, and 1 ml placed in a Sedgwick-Rafter counting chamber for identification and enumeration. Phytoplankton identifications were made using the following references: Palmer (1959), Prescott (1962 and 1970), Smith (1950), Taft and Taft (1971), Tiffany (1952), Weber (1971), and Whitford and Schumacher (1973). Zooplankton were identified with Edmondson (1959).

Enumeration was made with the 10X objective lens and 20X ocular lens with Whipple grid image area and a laboratory counter.

Numbers of organisms per milliliter of concentrated plankton were calculated using the following formula:

$$\text{No. per ml.} = \frac{C \times 1000 \text{ mm}^3}{L \times D \times W \times S}$$

Where: C = number of organisms counted
L = length of strip (Sedgwick-Rafter cell length in mm)
D = depth (Sedgwick-Rafter cell depth in mm)
W = width of strip (Sedgwick-Rafter cell width in mm)
S = number of strips counted

The resulting number of plankton/ml was divided by the total volume of the plankton haul to obtain the number of plankton/ml of lake water sampled.

Procedures followed those outlined in the 1971 edition of Standard Methods and Weber (1973).

Phytoplankton densities are expressed in numbers of cells with the exception of colonial forms which are differentiated into filamentous and nonfilamentous colonies.

Water samples for Chlorophyll a analyses were taken at Stations B, G and D at three levels each (surface, middle, and just above the bottom of the reservoir). All algae contain Chlorophylla a (a plant pigment), and measuring this pigment can yield some insight into the relative amount of algal standing crop.

The surface samples were collected in a wide-mouth container and the depth samples were taken with a Van Dorn water sampler. When possible, 100 ml of water was immediately filtered through a Millipore type HA 0.45u filter (without grid marks) with the use of a Millipore filter holder assembly and hand syringe. The filter paper was then placed in a petri dish, wrapped with aluminum foil and placed on dry ice. This process was done out of the direct sunlight.

The filters were transported to the State laboratory (Boise) and stored (frozen) until analyzed. Laboratory analysis followed Weber (1971). The pheophyton correction was not used on the May and June samples, but was used on subsequent samples. During the September survey algal bloom conditions were recorded with color infrared photographs taken of the water surface at 7 locations. The photographs were taken with a 35 mm SLR camera at a distance of about 2 m.

Chemical samples were taken from the lake surface during the May period and from the surface, middle and bottom during the remainder of the study. Depth samples were collected with a Van Dorn sampler and placed in two Nalgene polyethylene one liter screw cap bottles. These were immediately placed on ice to cool to 4° C. The nutrient samples were placed in 1 liter disposable polyethylene cubitainers and preserved with 2 ml of H_2SO_4, reducing the pH to near 2 to inhibit biological activity. These samples were also placed on ice. The chemical samples from Stations A (middle, S. end), C (middle, W. Crown Point), D (west Grandma's Cr.), E (west Station D), G (north end, mouth of narrows), and K (mouth, North Fork Payette River) were transported to the State laboratory (Boise) as soon as possible and analyses run according to procedures in the latest edition of Standard Methods (APHA, 1971). Samples from Stations B (log boom, near dam), F (northwest Sugarloaf Island), H (mouth of Gold Fork Arm), I (mouth of Boulder Cr. Arm), and J (mouth of Lake Fork Arm) were run in the U.S. Bureau of Reclamation Laboratory, Boise, in accordance with Standard Methods.

Replicate samples collected at several stations were split between the two labs for quality control. Replicate sample results were in good agreement except for ammonia and Kjeldahl nitrogen. For these two parameters, the results of the State laboratory were usually significantly higher than those of the USBR and previous data collected by U.S. EPA (unpublished data).

All of the bacteriological samples from the reservoir were collected by the USBR by boat and analyzed in their mobile laboratory soon after collection. The coliform tests were run by the Millipore filter technique as described in APHA (1971).

MATERIALS AND METHODS - Stream Surveys

All field parameters were determined by the use of portable meters. Dissolved oxygen and temperature were determined using a Model 54A Yellow Springs Instruments dissolved oxygen analyser. This unit was checked three times a day for accuracy and recalibrated when necessary using the modified Winkler procedure.

Temperature readings were checked with a glass thermometer calibrated to National Bureau of Standards specifications each time a station was sampled.

The pH values for all tributary and point source stations were determined by the use of a Photovolt portable pH meter, Model 126A. Calibration checks were made at the same time as D.O. checks mentioned above.

Water samples for chemical analysis were sampled from bridges at a point near the center of the bridge. The only exception was the North Fork Payette River at McCall. This station (L) was sampled from the north bank with the use of an extendable hand "dipper." The samples were collected in two (2) Nalgene polyethylene 1 litter bottles.

All nutrient samples for chemical analysis were preserved with 2 ml of concentrated sulfuric acid and stored on ice. These samples were collected in one liter polyethylene disposable containers.

All other samples, chemical and bacteriological, were stored on ice, at 4° C. Holding times for chemical analysis were within limits specified in EPA (1974). All bacteriological analyses were performed at Cascade by the USBR mobile laboratory. All tests were in accordance with EPA (1974) and/or APHA (1971) prescribed procedures.

Flow measurements were obtained from established USGS stream flow measuring stations with continuous recorders at Stations L (below McCall) and U (below Cascade Dam). USGS staff gages were read at Stations O (Paddy Flat Bridge), P (Lake Fork), Q (Boulder Creek), and S (Gold Fork). These data were then translated into flows (in cfs) with the use of rating tables. At all other tributaries which had no flow measuring devices associated with them, the flows were determined with the use of a wade rod and current meter.

RESULTS AND DISCUSSION - Waste Sources

McCall State Fish Hatchery

Idaho Department of Fish and Game's hatchery at McCall rears summer chinook, cutthroat and rainbow trout to the smolt stage before being released. The total annual hatchery production averages about 3,200 lbs (1451 kg) of fish, which is below the minimum poundage required for EPA for a NPDES permit. Because the McCall hatchery is used as an intermediate transfer point for trout, these fish are given little or no feed. This point source was felt to be minimal. Typically, it would be expected that suspended and settleable solids would be slightly elevated during the cleaning of the raceways. The daily average flow was about 2 cfs.

Because cleaning activities were not underway at any of the times when the North Fork was monitored, the hatchery effluent was not sampled.

McCall Lagoons

The wastewater treatment lagoons (Station M) serving the City of McCall were built in 1967-68. The flow through the lagoon system varies from season to season with the lowest flows observed for the study period occurring during the summer. This condition was brought about by minimal amounts of infiltration of groundwater and/or stormwater into the sewer lines and also a high evaporation rate.

The nutrient concentrations (especially phosphorus) in the effluent leaving the McCall lagoon system are sufficient to promote growths of aquatic vegetation (see Figures 13a and 13g).

Increasing phosphorus concentrations are noted at downstream Stations N (North Fork Payette River, below McCall lagoons) and O (North Fork Payette River, Paddy Flat Bridge) (see Figures 13a, 13c, 13g and 13i) but results are erratic and difficult to predict. Sixty-six percent of the samples taken just below the lagoons (Station N) show phosphorus concentrations above the 0.01 mg/l critical level for algal bloom potential (Kreizenbeck et al., 1975). The June and August concentrations were below this critical level but the July level was 0.03 mg/l. Figure 13g shows that the orthophosphate loadings were well above background levels on the May, July, September and November surveys. The McCall lagoons appear to have influenced those loadings, more noticeably during the last half of the survey. We cannot account for the significant increases that occurred during the May and July survey. On these dates the station below the lagoons was much higher (35 and 50 pounds respectfully, 15.8 and 22.7 kg) than the background value (Station L, above the lagoons) added to the municipal discharge (Station M)(Figure 13g).

The source of the additional nutrient input is unknown but we suspect that a significant amount comes from the McCall dump which is located along the North Fork Payette River below the lagoons and above Station N.

The input of orthophosphate from the McCall lagoons (see Figure 13g) compared with the total inflow into the reservoir (see Table 5) was an average of about 30% of the total during the survey. McCall was responsible for an average of 9% of the total phosphorus entering the reservoir compared with measured inflows.

BOD5 values show a corresponding increase, but not at significant levels. There was no dissolved oxygen sag noted in the North Fork of the Payette River at the three monitoring stations. The only station on the North Fork of the Payette River that showed a dissolved oxygen percent saturation (85%) less than the 90%, which is the minimum level acceptable (IDECS, 1973), was Station L (above the lagoons).

Total and fecal coliform concentrations were very low in the river above the lagoons (Station L), but significant increases were noted at Stations N and O below the lagoons. Some of the concentrations were higher than those found in the McCall effluent (see Figures 8a, 8b, 9a and 9b). These elevated counts might be influenced in part by the State fish hatchery and/or the McCall dump as well as possible seepage from private dwelling septic tank drainfields which were installed along the river prior to the promulgation of any regulations or standards.

A pronounced Aufwuchs or periphyton community was observed where the McCall wastewater effluent enters the North Fork of the Payette River. At the initial point, the growth was about 1 foot (0.3 m) wide and fanned out to a width of 9 to 12 feet (3 to 4 m) for approximately 300 feet (100 m) downstream. The growth paralleled the west side of the river before disappearing. It is assumed that the nutrients from the effluent are responsible for the growth of periphyton.

Major Tributaries

Only those tributaries considered to influence the reservoir system were monitored. The following tributaries appear to represent almost all the flow coming into the reservoir. Field measurements and estimates approximate very closely monthly inflow records kept by the U.S. Bureau of Reclamation (see Table 3 for inflow data). See Figure 17 for temperature data and Figure 18 for pH data on the tributaries. To convert cubic feet per second (cfs) to cubic meters per second (m^3s), multiply cfs x 0.02852.

North Fork Payette River (Stations L, O and N)

This stream is the single most important tributary of Cascade Reservoir. Flows during the study period ranged from a high of 1,700 cfs to a low of 300 cfs. Refer to the previous section on waste sources for additional information concerning the North Fork. Orthophosphate loadings entering Cascade Reservoir from the North Fork of the Payette River are shown on Figure 13 (Station O). We suspect that the McCall dump is a nutrient source. Although the nutrient concentrations are erratic, the levels are high enough at this station to support algal blooms in the reservoir.

Lake Fork Creek (Station P)

Originating at Little Payette Lake, this tributary had flows ranging from 11 cfs (7/23/75) to 400+ cfs (5/28/75) during the study period. The stream can be diverted for irrigation prior to reaching Cascade Reservoir at the northeast end, thus making flows at Station P variable. Also, irrigation wastewater (mainly from grazing) can return to Lake Fork Creek which would account for occasional high concentrations of nutrients. Temperatures correspond closely to those found at Station O on the North Fork of the Payette River.

DO concentrations were above 90% saturation on all dates except July 23, 1975, when an 81% saturation level was observed.

<u>Boulder Creek</u> (Station Q)

This tributary also enters Cascade Reservoir from the upper end (NE). Flows measured during the study period ranged from 9 cfs (11/4/75) to 37 cfs (5/28/75). Nitrogen concentrations appear low in Boulder Creek at Station Q, but O-PO_4 are at levels conducive to algal blooms (Figure 13c).

Temperatures are generally a little higher than found on the other tributaries for the corresponding dates. This might be brought about by irrigation return water. Only one DO % saturation below 90% was observed; 62% was recorded on June 24, 1975.

BOD values never increased over levels considered as normal background (approximately 5 mg/l).

Boulder Creek did have total and fecal coliform numbers exceeding State Standards on June 24, 1975, August 27, 1975, and November 4, 1975, (see Figure 8b). The sources of these bacteria are unknown, but assumed to be related to agricultural activities since the sewage discharge from the community of Donnelly had been eliminated in the Fall of 1975.

The U.S. Bureau of Reclamation (1975) noted a discharge of sewage into Boulder Creek in a report on Cascade Reservoir. A new wastewater treatment plant serving Donnelly is now operational. This system is designed to eliminate one source of organic and inorganic nutrients from reaching Cascade Reservoir.

Rock Creek (Station R)

This creek appears to be contributing minimal levels of nutrients and flow to Cascade Reservoir. Flows from the study period ranged from 0.2 cfs (9/23/75) for the late summer dry season to 8.5 cfs (6/24/75) during spring "run off." Temperature and DO readings were at acceptable levels during the study period (see Figures 8b, 9c, 12f and 13h for Station R data).

Gold Fork River (Station S)

Flows in this tributary at Station S generally represent the second greatest source of inflow water to Cascade Reservoir. The flow range was from 120 cfs (9/23/75) to 1200 cfs (6/24/75) and shows an increase of ten times the high flow over the low. The pH, DO and temperature readings obtained at Station S were at levels generally associated with clean water.

None of the parameters contained in the State Water Quality Standards (IDECS, 1973) were violated during the study period. Gold Fork serves as a source of phosphorus (Figures 13b, 13i and 23). For the period of the survey Gold Fork contributed slightly more poundage (average 44 pounds/day, 20 kg/day) of total phosphorus than did the North Fork Payette River (average 41 pounds/day, 19 kg/day) (Figure 23).

Logging activities on private and United States Forest Service land in the Gold Fork drainage appears to have increased sediment deposition when compared to the North Fork Payette River above the reservoir. As this area experiences regrowth of groundcover, the migration of soil and fine gravel material should be greatly reduced.

Mud Creek (Station T)

The flows in Mud Creek were small, ranging from 22 cfs in November to 53 cfs in July, 1975. Orthophosphate concentrations exceeded the 0.01 mg/l algal bloom potential level on all sample dates except September 23, 1975. Dissolved oxygen, biochemical oxygen demand, pH and temperature were within accepted State Standards.

WATER QUALITY BELOW CASCADE DAM

North Fork Payette River (Below dam, Station U)

The North Fork station located below Cascade Dam (Station U) shows the condition of the water as it leaves the reservoir. Comparing Station O (North Fork above the reservoir) and Station U shows that the reservoir tends to warm the water slightly (Figure 17). Water can be released from the reservoir from either the top or lower part. By comparing the temperature (Figure 17) of Station U with lake profiles at Station B, it appears that during June and July the warm (14 and 23.8^{o} C, respectively) water from the reservoir surface influenced the discharge below the dam. On the other sample dates there was little temperature difference in the lake profile and the water at Station U.

The reservoir depressed dissolved oxygen levels by an average of nearly 1 mg/l for the survey period (Figure 12f). This resulted in dissolved oxygen levels below the 90% saturation State Standard during the July and November surveys (Figure 12h). The North Fork station above the reservoir always recorded dissolved oxygen saturations above the 90% State Standard.

The influence of the reservoir on the pH of the North Fork (Station U) was not great. It appears that the reservoir raised the pH below the dam by an average of only 0.1 pH unit (Figure 18).

The reservoir greatly reduced the number of total and fecal coliform bacteria in the North Fork Station U (see Figures 8a and 9b). Coliform densities were greatest June through August but were within the State Standards for this station.

During the study period an average of more than 20 pounds (9 kg) per day more orthophosphate entered the reservoir by all combined tributaries than left at Station U (Table 5). This indicates that the reservoir acts as an orthophosphate sink during most of late May to early November.

RESERVOIR SURVEY

STATUS OF BIOLOGICAL COMMUNITY

Saprobicity is essentially the reverse of primary production. At various stages of mineralization characteristic communities of plants and animals are present, and these communities have been used by biologists to determine the degree of pollution or enrichment of streams and lakes.

McHugh (1972) pointed out some problems with the current U.S. lake classification system (oligotrophic, mesotrophic, eutrophic, etc.) and suggested following the Saprobic System, a biological classification in general European usage. The difference in the systems is that the U.S. mainly defines lake type and the Saprobic System defines water quality. McHugh (1972) points out that there is no way to equate these two systems but that there is a rough coincidence of katharobic and oligosaprobic with oligotrophic and b-mesosaprobic with mesotrophic and eutrophic.

Our examination of the biological community was concerned mainly with plankton. Our major effort was placed on the phytoplankton which are the primary producers or autotrophs. A study carried out on oligotrophic Lake Superior by Stokes *et al.*, (1970) showed that, "periphyton can be five to six times as important in primary production as the phytoplankton." Our examination of the phytoplankton of Cascade Reservoir may not indicate total primary production, but should be a good indication of the nutrient levels present in the reservoir.

Plankton were collected, identified and enumerated and chlorophyll *a* samples were taken as described above. Twenty-four genera (at least 28 species) of phytoplankton were collected and identified during the survey.

Four phyla (divisions) of phytoplankton were found: Cyanophyta (blue-green algae), Chlorophyta (green algae), Chrysophyta (yellow-green algae, including diatoms), and Pyrrophyta (dinoflagellates).

Tables 2a-2f list the plankton found during the 1975 survey (May-November). USBR (1975) reported eleven genera of phytoplankton taken from the reservoir on August 6, 1974. Our July 22-23 sampling period is nearest this time of year and the genera found by the USBR are indicated on Table 2c by an (*). The tables also list the zooplankton found and show the densities of all plankton for each of the three sample stations (B, D and G) for the six dates sampled.

Figures 4a-4f show the monthly concentrations of phytoplankton and zooplankton as well as Chlorophyll a values plotted on logarithmic scale. Total phytoplankton values are plotted for the stations and dates sampled on Figure 5.

Our Chlorophyll a data roughly corresponded with total phytoplankton trends for the reservoir (see Figures 4a-4f). It should be noted that the May and June Chlorophyll a samples are probably higher than the actual concentrations because the pheophyton correction was not used by the laboratory. Trends appear realistic, in May with Station G having lower plankton population and Chlorophyll a concentrations than Stations D and B. The Chlorophyll a values increased through August as the phytoplankton populations peaked and then fell as the plankton populations fell. The November sample showed higher Chlorophyll a values for Station D which also agreed with higher algal populations. The difference in the Chlorophyll a values was not proportional with the extremely high values for total photoplankton (caused by a high concentration of blue-green algae). Apparently a disproportionate number of blue-green algae were taken in the plankton haul. We believe that the west winds across the reservoir concentrated plankton on the surface at Station D. These areas of concentrated plankton are called "wind streaks" and are described by Reid (1961).

According to the U.S. Environmental Protection Agency (1975a) an algal bloom is reached when the Chlorophyll a concentration reaches 20 mg/m^3. By this definition, Cascade Reservoir would have been considered to have algal blooms during August and September sampling dates. (This excludes the erroneous data for Station D in May and November already mentioned above.)

Algal blooms have been variously defined quantitatively by Lackey (1945), a value of 500 organisms/ml; and qualitatively by Plamer (1959) and Mackenthum et al., (1964), as a growth of plankton sufficiently dense to be readily visible. By using the 500/ml figure we had algal blooms during August and November. If we used the "readily visible" definition we had algal blooms from July to November.

A combination of all methods for determining the presence of algal blooms indicates that the late August sampling period had the worst bloom conditions observed during our study.

The Environmental Studies Board (1972) gave lake classification data for the following Chlorophyll a values: 0-4mg/m^3 is considered oligotrophic and 10-100 mg/m^3 is eutrophic. The use of 4.1 to 9.9 would be mesotrophic by this classification system. According to this classification system, Cascade Reservoir was eutrophic for the August-September period.

Algal populations peaked in August at a time when we found generally minimal amounts of orthophosphate. The algae were using the orthophosphate in their life cycles. The higher algal populations on the lake surface were inversely related to orthophosphate concentrations.

The Chlorophyta or green algae are mostly freshwater organisms. They are found almost everywhere there is some light and moisture available. During this survey Chlorophyta never greatly exceeded population densities greater than 1/ml. Early in the year the green algae had their greatest densities at the upper end of the Reservoir (Station G) while later in the season they were more common at Station B (near the dam). None of the green algae collected in the reservoir are major causes of algal blooms according to Palmer (1959). We found four species of green algae in late July compared with only one species reported by USBR (1975) for early August.

The Cyanophyta or blue-green algae are often common in waters with low oxygen levels and high temperatures and many of the species have the ability to fix atmospheric nitrogen.

Mague and Burris (1973) reported that the heterocystus blue-green algae are the primary nitrogen fixing algae. Aphanizomenon and Anabaena are of the heterocystus type and were the major blue-green algae present in Cascade Reservoir during this survey. Mague and Burris (1973) noted that the rate of nitrogen fixation is quite variable, perhaps explaining in part the variations in our data.

By July and into August, as the nitrogen fixing blue-green algae were increasing in relative abundance, the total inorganic nitrogen (TIN) concentrations also increased (see Table 3). Apparently the dominant algae were not utilizing as much TIN during this time.

Whitton and Sinclair (1975) state that in lakes which produce dense surface blooms as a result of nutrient enrichment, the blue-green algae are in direct competition with many eucaryotic species. These authors also point out the importance of the blue-green algae to produce as vacuoles in their cells which cause the cell to float towards the surface under low light intensities. As the blue-green algae nears the surface the increasing light intensity will cause the cells to sink. Therefore, in addition to allowing the algae to occupy a favorable position in the water column, these vertical migrations may allow it to increase its contact with nutrients. Whitton and Sinclair (1975) also suggest that the formation of surface blooms may represent a breakdown of this mechanism, the algae becoming stranded at the water surface.

Figure 6 shows that the Cyanophyta populations were low, below 1% of the total phytoplankton present in May. They increased to nearly 50% of the total in late July and formed a visible algal bloom on the surface of much of the reservoir. The percentage of blue-greens increased through November. Aphanizomenon and Anabaena are well known as major constituents of algal blooms (Palmer, 1959 and Whitton and Sinclair, 1975).

Color infrared photographs taken during our September survey show dense surface concentrations of phytoplankton (see Figure 22 for an example). The slides also show definite clumping of the Cyanophyta, mostly Aphanizomenon flos-aquae (Figure 22). This type of surface and near-surface clumping may also help account for the high populations recorded in November. Aphanizomenon and Anabaena (the two dominant forms of blue-green algae in the reservoir) are listed by Palmer (1959) as giving off grassy, musty, and septic odors when their populations are high enough. Our survey found the same species of Cyanophyta as USBR (1975).

The Chryosphyta include several groups commonly known as yellow-green algae, golden-brown algae and diatoms. All of the Chrysophyta found in the reservoir belong to the group known as diatoms, except for one genus, Dinobryon, which is considered a yellow-green algae. For the purposes of this report all Chrysophyta will be referred to as diatoms. Figure 6 shows that the diatoms followed very near the reverse of the population trend of the blue-green algae. Their highest population densities were found in May, the percentage decreased until July, when they were slightly more abundant than the blue-greens, then they became less significant until only a very small percentage of the phytoplankton were diatoms by late fall. Hansmann (1973) mentions that Tabellaria fenestrata is considered characteristic of nutrient rich conditions in streams; the same could hold true for lakes and reservoirs. The Tabellaria populations did not exceed 2/ml in Cascade Reservoir, but did increase through the summer as the nutrients increased. Melosira is mentioned by Palmer (1959) as a polluted water algae. Melosira was one of the major components of the diatom community. Melosira is also considered by Palmer to be a component of algal blooms. He also notes that large enough concentrations of Fragilaria and Melosira give off musty odors and Asterionella gives off spicy to fishy odors. These three genera were the dominant diatom forms during this survey. About 8 genera were found by our survey that were not reported by USBR (1975).

Diatom populations were inversely related to total inorganic nitrogen (TIN) concentrations. In May and June when the diatoms were at their greatest densities, the TIN values were at a low, indicating use by the algae. Later in the season, as diatom populations declined, the TIN concentrations increased.

The Pyrrophyta or dinoflagellates differ from the other algae mentioned in that they are motile by means of one or two flagella. Palmer (1959) lists Ceratium hirundinella as giving off fishy and septic odors when concentrations are high enough. As can be seen from Tables 2a-2f, the populations of

Ceratium hirundinella were never high, usually less than 1/ml. The populations did increase through the summer and peaked during September. None were found in the November sample. *Ceratium* was also reported present in the reservoir by USBR (1975).

The algal species present in Cascade Reservoir could cause odor problems as eutrophication increases. In low flow years, such as 1973, there have been significant odor problems on Cascade Reservoir (J. F. Mangan USBR, Personal Communication).

McHugh (1972) reported the phytoplankton *Anabaena spiroides*, *Aphanizomenon flos-aquae* and *Ceratium hirundinalla* as indicators of the beta-mesosaprobic condition. These were common in Cascade Reservoir.

By the Saprobic system of classification, Cascade Reservoir is considered beta-mesosaprobic which means that the reservoir is moderately polluted or enriched.

Animals other than zooplankton were not examined as part of this study. During the September 23, 1975 survey, however, several bryozoans (Lophopodidae: *Pectinatella magnifica*) were seen floating on or near the water's surface in the Lake Fork Arm of the Reservoir (see Figures 21a and 21b). This is apparently the first record for this species from Cascade Reservoir. Others were seen on the bottom in about 5-10' (1.5-3 m) of water. The Bryozoa were starting their winter decomposing state and were quite fragile. Several of the large gelatinous colonies were collected. They ranged in diameter from about 5 inches (13 cm) to about 1 foot (30 cm). These animals are microscopic but form colonies which are gelatinous masses. The colonies usually attach to objects on lake or slow stream bottoms where the light is dim. They prefer "unpolluted and unsilted" waters (Pennak, 1953) and feed on algae, protozoans and detritus.

According to Pennak (1953) they can become a problem in clogging screens and grates, pipes, valves, and meters.

Bushnell (1974) notes that Pectinatella magnifica is known only from "uncontaminated water" but also mentions that it attains its greatest size in eutrophic waters. McHugh (1972) notes that bryozoa find optimum conditions in beta-mesosaprobic waters. The Lake Fork Arm is considered a eutrophic water.

Parts of the bryozoans may serve as food for fish and other organisms. Many oligochaetes and other small invertebrates were found inhabiting the large colonies.

A discussion of the biological status of Cascade Reservoir would not be complete without listing the fish present.

According to Tom Welsh (Idaho Department of Fish and Game, Personal Communication), the following fish reside in Cascade Reservoir: finescale or longnose sucker, Catostomus catostomus (Forster); northern squawfish, Ptychocheilus oregonensis (Richardson); longnose dace, Rhinichtys cataractae (Valenciennes); speckled dace, R. osculus (Girard); redside shiner, Richardsonius balteatus (Richardson); mountain or Rocky Mountain whitefish, Prosopium williamson, (Girard); black crappie, Pomoxis nigromachulatus (LeSueur); brown bullhead, Ictalurus nebulosus (LeSueur); yellow perch, Perca flavescens (Mitchell); coho salmon, Oncorhynchus kisutch (Walbaum); kokanee salmon, O. nerka (Walbaum); rainbow trout, Salmo gairdeni (Richardson); and brook trout, Salvelinus fontinalis (Mitchell). Sculpins (Cottus) were observed in Lake Fork Creek during the survey.

On July 23, 1975, we noted dead brown bullheads floating on the reservoir. This die off of bullheads is caused by Columnaris disease. According to Dr. Bill Klontz (University of Idaho, Personal Communication) this disease is caused by a free-living Myxobacterium (*Flexibacter columnaris*) which is always present in the water. The disease affects the gills and skin of smooth skinned fishes and may also be an internal disease. The disease attacks the fish when the lake water has high temperatures and low dissolved oxygen levels. At the time the dead fish were observed high water temperatures (23° C surface), low dissolved oxygen (an average of 6.2 for the entire reservoir) concentrations, and relatively high pH values (range from 6.7 to 9.6) were recorded.

Dr. Klontz states that there is nothing that can be done to eliminate the disease from reservoirs and the public should be aware that this can be an annual expected event.

BACTERIOLOGICAL QUALITY

Bacteria have two functions in a lake ecosystem:

1. They are the prime agents of the return of dead organic matter (plant and animal bodies) to the soluble state. This releases carbon for photosynthesis, for example.
2. They are also the prime agents for the return of soluble organic nutrients to the biological system. By using such nutrients in their own growth, heterotrophic bacteria become particulate matter and are food for protozoa leading eventually to fish.

McCoy and Sarles (1969) are quick to point out that little is known concerning the problems of bacteria and eutrophication.

Representative coliform bacteria densities for Cascade Reservoir are shown in Figures 10a-10b. Generally coliform densities in the reservoir itself were low (see Figure 10b for a representative station). Most lake stations showed their highest coliform densities during July and August which correspond with the intensive recreational use period of the reservoir. Station I represents the Boulder Creek arm in the reservoir. This station recorded the only violation of the State water quality standards for total and fecal coliform, 200/100 ml and 50/100 ml at more than 100 feet from shore.

In August, total coliform values of 380/100 ml and fecal coliform values of 240/100 ml were found near the bottom at Station I. Our data indicate that the source of these bacteria is Boulder Creek. On the same date (August 27, 1975), Boulder Creek had fecal coliform densities of 480/100 ml. The temperature of Boulder Creek was 15° C. The temperatures recorded for the surface, middle and bottom depths were 19, 17.5 and 14.5°C respectively. The temperature stratification seems to have channelled Boulder Creek water along the bottom of the Boulder Creek Arm, hence the higher coliform values at the deeper stations. Nonpoint sources probably account for the higher coliform numbers at this station (see Figure 20).

A special coliform survey of 22 lake stations (mostly within 100 feet or 30 m of the shore) was conducted in September, 1975. Figure 3 shows the location of these stations as well as the shore survey stations of August. No violations of the State Water Quality Standards were found.

Fecal coliform densities were less than 4/100 ml except for Station 10 (Gold Fork Arm) which had 4/100 ml. Total Coliform densities ranged from a low of less than 2/100 ml to a high of 170/100 ml at Station 2. Most stations recorded values less than 24/100 ml.

Coliform densities for the major tributaries varied greatly. For example, some stations (O, R and N) showed their highest total coliform values during July (see Figures 9b and 9c) and Stations M, P, Q and S showed their lowest values at this time. Boulder Creek (Station Q) and the McCall Lagoons (Station M) have been discussed under the separate treatment of these sources.

The State Water Quality Standards (IDECS, 1973) state that fecal coliform concentrations shall not be greater than 50/100 ml for any single sample. This standard was violated on the following dates:

STATION	DATE	FECAL COLIFORM CONCENTRATIONS/100 ml
N. (N.Fk. Payette River Bridge below McCall)	6/24/75	400
	7/23/75	390
	8/27/75	190
	11/4/75	360
O (N.Fk. Payette River at Paddy Flat Bridge)	6/24/75	296
	7/22/75	700
	8/19/75	90
Q (Boulder Creek)	8/27/75	140
	11/4/75	267
		134
T (Mud Creek)	6/24/75	180
	8/27/75	120
R (Rock Creek)	8/27/75	176
	9/23/75	80

CHEMICAL AND PHYSICAL QUALITY

Biochemical Oxygen Demand

The biochemical oxygen demand (BOD) values for the reservoir and tributaries were low and variable, ranging from less than 0.1 mg/l to 4.1 mg/l with most values below 2.0 mg/l.

Generally higher BOD values were found at the surface than with depth and the highest values were observed in July and August which corresponds to peak algal production for the reservoir.

pH

The EPA National Eutrophication Survey, as well as this survey, found decreasing pH values with depth often enough to observe a possible trend. This trend generally persists during all sampling dates but some months and stations had greater variations than others.

All stations on the reservoir except Stations G (mouth of narrows), H (Gold Form Arm), J (Lake Fork Arm), and K (North Fork Arm) experienced pH values greater than 9.0 during the July survey. Over 60% of the stations had the highest pH values near the surface. Ralston and Wroten (1973) reported similar high pH values for July.

The Environmental Studies Board (1973) recommends a pH range of 6.5 to 8.5 for a nearly maximum level of protection of freshwater aquatic life and wildlife. They also note that pH values greater than 9 are likely to be harmful to perch and salmonids. As mentioned earlier, dead floating bullheads were found on the reservoir surface during July.

Nutrients

A review of the literature indicates that the nitrogen (N) and phosphorus (P) forms which are most readily available for algal utilization are total inorganic nitrogen (TIN = $NH_3 + NO_2 + NO_3$) and orthophosphate (O-PO_4).

Total inorganic nitrogen in the reservoir (Figures 14a and 14b) is generally below the 0.3 mg/l level considered by some to be critical (algal bloom potential level) (Tangarone and Bogue, 1975). From Figure 14 it can be seen that bottom TIN is frequently higher than the rest of the water column. Ammonia in some cases represents 50% of the available TIN.

The Lake Fork (J), Boulder Creek (I), and Gold Fork (H) arms of the reservoir appear to be nitrogen limiting for most sampling dates. Near the dam (Station B) does not appear nitrogen limiting in September (Figure 14b). Sediment samples taken during the June survey show the following erratic results:

Station (Shore)	Total Phosphate	Total Nitrogen Mg/g	NO_2-NO_3
Near Station A (S. end res.)	4.8	1120	170
Near Station F (Sugarloaf Flat)	1.2	1190	100
Near Station E (W. side res.)	23.5	6630	2100
Near Station P (Lake Fork)	4.2	830	150
Near Station J (Lake Fork Arm, res.)	1.1	360	50

The above data are quite variable but seem to indicate a significant source of nutrients along the west side of the reservoir. Rooted aquatic macrophytes are abundant along the shallow west side of the reservoir (USBR, 1975) and probably contribute to this nutrient concentration when they die.

The two sediment samples taken along Lake Fork may indicate a source of nitrogen for the reservoir. The nitrogen concentrations are higher upstream than in the reservoir itself. The lower concentrations in the reservoir could indicate a transfer of nitrogen from these sediments into the lake water.

During the August and September surveys dissolved oxygen concentrations were near zero on the reservoir bottom at Stations B (near dam), C (Crown point), D (E. Side), and E (W. Side). This near zero concentration of dissolved oxygen results in a reduction process which can make nutrients more soluble, thus released from the sediment. This can be seen in Figures 13d and 13e for orthophosphate, especially at Station B (near dam) where the near bottom value of orthophosphate was much greater than the water column above.

Figure 23 shows that the reservoir was a sink for total phosphorus for the months of June, July, October, November and December 1975. It acted as a source of total phosphorus January, February, March, April, May, August and September. The McCall lagoon effluent made up an estimated 9% of the known total phosphorus loading going into the reservoir. This figure was obtained by adding the known measured annual inflows to the reservoir 38,762 pounds (17,582 kg), minor tributaries and immediate drainage 22,189 pounds (10,065 kg)(EPA personal communications), and precipitation 4,134 pounds (1,875 kg) and comparing McCall's annual measured contribution of 6,035 pounds (2,737 kg) to the total inflows. McCall discharged less total phosphorus during the summer when compared with winter loadings (450-660 pounds/month) (204-299 kg) and (733-1027 pounds/month)(171-466 kg) respectively.

EPA (personal communication) gives an annual phosphorus loading of 0.38 $g/m^2/yr$. They note that this is less than Vollenweider (1975) gave for the eutrophic level but greater than his proposed oligotrophic level. If McCall initiated phosphorus removal and reduced their present contribution by 90%

this would presumably reduce the annual phosphorus loading to 0.35 $g/m^2/yr$. This would tend to make the reservoir less eutrophic.

The projected population figures of Intermountain Engineers (1976) would yield the following total phosphorus loadings from the McCall Facility:

	1998	2028
Summer	5154 pounds/month (2337 kg/month)	8296 pounds/month (3763 kg/month)
Winter	1050 pounds/month (476 kg/month)	1416 pounds/month (642 kg/month)

If this additional phosphorus input reached the reservoir it could alter the algal populations and increase the prevalence of algal blooms.

If phosphorus is controlled a higher percentage of nitrogen will enter the reservoir and alter the nitrogen to phosphorus ratios tending towards phosphorus limitation. This could result in less problems with blue-green algae.

We assume that the additional nutrients would speed eutrophication and lower the water quality of the reservoir.

Orthophosphate levels (Figures 13d, 13c and 13f) show slight trends of increased concentrations near the reservoir bottom but not to the degree of TIN. The O-PO_4 was generally above the level (0.01 mg/l) considered critical or phosphorus limiting for algal productivity (Sawyer, 1947). O-PO_4 appears low in August and September at some stations on the reservoir indicating this nutrient may have been tied up with the phytoplankton populations which peaked at the same time. Other stations still had detectable concentrations during this period.

The N to P ratio (11.3:1, Middlebrooks et al., 1975) which is used to determine nutrient limitation (Table 4) indicates that there is insufficient nitrogen present to allow optimum algal growth based on the amount of phosphorus present. However, algal assays run on composited water from several stations on Cascade Reservoir did not turn out as expected (personal communication letter of November 19, 1975, J. H. Gakstatter). These assays performed by EPA, Corvallis Environmental Research Laboratory, showed maximum yield (mg/l dry wgt.) with the addition of 0.05 mg/l P and 1.0 mg/l N. These results indicate that both N and P are limiting even though the minimum requirements in mg/l P appear to be met. This phenomenon suggests that some other parameter or condition may be limiting to the algal production of the assays (personal communication, Marv Allum, Corvallis). Our data gave N:P ratios of 2.85:1 for May-June, 4.4:1 for July-August, and 3.3:1 for September and November, 1975.

One additional source of nutrients for the reservoir is precipitation. Using data of Weibel (1969) and EPA (1975b) for an area approximating 30 inches (76 cm)/year, the following yearly input of total nitrogen and total phosphorus was calculated:

4,134 lbs (1,875 kg) total P/year
255,240 lbs (115,775 kg) total N/year

These amounts are significant compared to the other sources entering the reservoir.

Bhagat et al., (1975) reported that 6% of the nitrogen and #5 of the phosphorus for Silver Lake, Washington (a nonindustrial area) in 1974 was attributed to precipitation.

It appears that the projected growth of the McCall area will cause an increased nutrient load going to Cascade Reservoir. If phosphorus is controlled the increased amounts of nitrogen reaching the reservoir may make a less favorable environment for the blue-green algae.

Dissolved Oxygen

Nearly all dissolved oxygen (DO) values obtained from the tributaries were above the 90% saturation level (Figures 12g and 12h).

During the May survey the DO levels near the surface of the reservoir were about the same as for the entire water column, indicating a mixed condition. Stations A, B, D and E, located in the southern half of the reservoir, had lower DO on the bottom than in any other portion of the water column (near 0 mg/l). Some of the significance of this in releasing nutrients from sediments has already been discussed.

This same general trend was observed in June. In the areas where a decline in DO concentration was noted, the observed DO sag was not great. For Stations H and J (Gold Fork Arm and Lake Fork Arm) in June the bottom DO readings were slightly higher than observed at the surface: Station J, 8.2 (surface), 8.7 (4.5 m); and Station H, 8.8 (surface), 9 (5.5 m). Evidently the tributary water is influencing the lower strata.

The DO readings at the upper reservoir stations (F through K) generally reach their lowest levels in July. The remaining reservoir stations (A through E) reached lowest DO levels in August. Surface DO readings for the entire reservoir are generally at high levels (over 90% of saturation) except for certain stations in June and November. Mid-depth and bottom DO levels are generally not as high as surface levels with lowest levels recorded during the months already indicated.

Temperature

The temperatures were recorded at the same time as the DO readings and were generally lower on the bottom than on the surface (Figures 11a-11c).

Gold Fork Arm and Boulder Creek Arm, Stations H and I respectively, showed stratifications in June with the mid-depth DO and temperature reading more closely resembling the tributaries than any other portion of the water column. All stations showed the greatest temperature variation with depth in July with Stations A through H having a temperature spread of about 10° C. Stations I, J and K had only a 6° C. differential. The highest temperatures (25° C) were recorded on the reservoir surface during the July survey (Station F, near Sugarloaf Island). All surface stations were above 20° C during the July survey.

A thermocline occurred in July between 4 and 6 meters in depth, but because temperature was not measured every meter, its location can only be assumed.

During the September survey the temperature was recorded at each meter in depth and no thermocline was recorded.

The transparency (secchi disk reading) is roughly equivalent to turbidity and visibility, (Kaill and Frey, 1973), and somewhat corresponding to total phytoplankton densities, especially if one takes into account the presence of other sources of suspended solids throughout the season.

The transparency averaged 3 feet (1 m) in May at Stations B and D, the total phytoplankton levels were around 200/ml. At Station G the transparency was 4 feet (1.2 m) and the algal population was much less at about 26/ml.

In June all of the plankton populations were at a minimum and the transparency correspondingly increased. The July, August and September transparency readings varied, but were generally higher than the June sample even though the phytoplankton populations had increased. The net increase in transparency is probably due to a decreased amount of silt and other suspended solids entering from the tributaries to the reservoir.

Light conditions in November were not ideal and may have accounted for the lower readings.

Figures 16a and 16b show transparency values for the survey.

CONCLUSIONS

Our survey has concluded that Cascade Reservoir is slightly eutrophic or beta-mesosaprobic. The data indicate that any additional nutrients entering the reservoir will accelerate the eutrophication process. The McCall sewage treatment facility is a source of high nutrient loading. This source constituted about 9% of the known total phosphorus loading of the reservoir during 1975. As nutrient loadings are increased a greater impact on the reservoir will likely occur. Therefore, nutrient removal of the McCall effluent is justified at this time.

Nitrogen and phosphorus levels entering and leaving the reservoir fluctuated during this survey. We found that the reservoir is a source for phosphorus slightly more often than it is a sink. Inorganic nitrogen to orthophosphate ratios indicate a nitrogen limitation in the reservoir. This is, however, not significant to the blue-green algae.

Our survey has shown that the water quality of Cascade Reservoir is fair to good. We also conclude that the nonpoint sources to the reservoir need to be quantified.

Complete data for the survey are on file and available from the Idaho Department of Health and Welfare, Division of Environment, Boise.

RECOMMENDATIONS

1. This survey indicates that the total phosphorus in the McCall wastewater treatment lagoon effluent is an estimated 9% of the total annual inflow to Cascade Reservoir. Control of phosphorus at the 90% removal level would decrease the total annual phosphorus loading of the reservoir from the present 0.38 $g/m^2/yr.$ to 0.35 $g/m^2/yr.$ This lower total phosphorus loading would more closely approach the oligotrophic condition but may not appreciably reduce algal productivity in the reservoir. With the projected growth in usage of the Cascade lakeshore and of the McCall area and the accompanying increased loadings placed on the McCall waste treatment facility, phosphorus control would be even more desirable.
2. A nonpoint source survey is needed to quantify all unaccountable nutrients entering the reservoir. This should include the contribution of any subsurface sewage disposal systems, livestock grazing and agriculture found around the reservoir. The actual contribution of nutrients attributable to precipitation also needs to be evaluated.
3. A survey establishing the impact of the McCall "dump" would be of value in assessing the loadings of the North Fork of the Payette River. This solid waste disposal area should be converted to a sanitary landfill and located on a site away from the river.
4. The impact of the fish hatchery on the North Fork of the Payette River should be established.

ACKNOWLEDGEMENTS

The authors acknowledge the valuable assistance of the following people and organizations whose able assistance greatly aided in the overall data collection on which the report is based:

U.S. Bureau of Reclamation
Pacific Northwest Region
Boise, Idaho

Central District Health Department
Cascade Office

Idaho Department of Fish and Game
McCall Office

U.S. Environmental Protection Agency
Corvallis, Oregon
Las Vegas, Nevada
Seattle, Washington

Idaho Department of Health and Welfare
Division of Environment
Region II Staff
Boise Office

Sincere appreciation is also extended to Mr. Ron Spidell who spent long hours preparing all the graphs and figures contained herein.

Gene Ralston, Mike Smith, Ron Kreizenbeck, Mike Christie and John Mangan reviewed the manuscript and offered valuable criticism.

A special thanks to Mrs. Rita Borchardt and all of the clerical staff for their assistance in the completion of this report.

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APPENDIX A STUDY PLAN

STUDY PLAN FOR CASCADE RESERVOIR SURVEY

Background

This study plan provides a pr-oposed schedule and a delegation of responsibilities for a multi-agency water quality survey on Cascade Reservoir. The agencies to be involved in the survey include the Idaho Department of Health and Welfare, the Bureau of Reclamation, the Environmental Protection Agency, the Idaho Fish and Game Department, the Central District Health Department, and Idaho Department of Water Resources.

Purpose

1) To assess the eutrophic condition of the reservoir.

2) To examine the effects of point and non-point sources on the reservoir.

3) To provide relevant data for fisheries management.

4) To acquire water quality data for reservoir model development.

Overall Survey Period

The overall survey period will last from reservoir thaw to fall turnover (approximately mid-May to October).

Tenative Survey Periods

Fourth week in May
Fourth week in June
Fourth week in July
Fourth week in August
Fourth week in September
Fourth week in October

May Survey

In the May Survey samples will be collected in the reservoir and at inflow - outflow locations listed in Appendix A. Parameters monitored will be those listed in Appendix B. In this survey chlorophyll-A and possibly coliform tests will be conducted on surface and inflow samples, only. The coliform analyses will be provided by the Bureau of Reclamation (BOR) mobile lab which will be located on site. Depth samples in the reservoir should be collected at a maximum of ten (10) foot intervals or at strategic locations within the thermal stratas. Sedimentary phosphorus samples will be collected from exposed reservoir banks.

June Survey

In the June Survey samples will again be collected in the reservoir and at inflow-outflow locations. The parameters monitored will be the same as the May Survey, and in this survey chlorophyll-a and coliform testing will be provided for depth samples. Again, the BOR mobile lab will be used for coliform testing. Sedimentary phosphorus samples will be collected from the reservoir bottom with a dredge.

July Survey

The July Survey will be conducted much the same as the June Survey with the exception that sedimentary phosphorus samples will not be collected.

August Survey

In the August Survey, samples will again be collected at the inflow-outflow and reservoir locations. Sedimentary phosphorus samples will also be collected. In addition to the regular survey work, a number of special analyses will be completed during the August Survey. The Central District Health Department will collect bacteriological and nutrient samples on nine small streams which pass through developed areas along the reservoir. In addition to the stream survey, samples will be collected near the shore of developed areas by the Idaho Department of Health and Welfare. Also, the Environmental Protection Agency will provide special assistance in the areas of benthic oxygen uptake, sedimentary phosphorus rates, algal growth potential, and algal settling rates. The BOR and IDHW will also conduct temperature and dissolved oxygen profiles over several cross sections in the reservoir.

September Survey

The September Survey will be identical to the July Survey with only inflow-outflow and reservoir sampling required.

October Survey

The October Survey will be identical to the September Survey.

In addition to the above discussed work plans, superficial biological samples should be collected on each survey to establish the major algal family present and an estimate of the zooplankton to phytoplankton ratio by weight (or volume).

Although sampling locations may be specific agency responsibilities, the sampling of individual locations should be conducted in such a manner as to conserve time and resources. For instance, IDHW could collect all inflow-outflow samples, then deliver two of the samples to BOR for testing. Depth sampling in the reservoir could be coordinated such that one agency would collect bacteriological samples and the other collect the chemical samples.

AGENCY RESPONSIBILITIES

Idaho Department of Health and Welfare

1. Collection and testing of samples at eight inflow sampling locations during each survey.

2. Collection and testing of samples at six reservoir sampling locations during each survey.

3. Assist in temperature and dissolved oxygen, cross sectional profiles during the August Survey.

4. Collection of sedimentary phosphorus samples during the May, June, and August Surveys.

5. Collection of additional bacterial and nutrient samples for a shore survey during the August Survey.

Bureau of Reclamation

1. Collection and testing of samples at two inflow-outflow locations during each survey.

2. Collection and testing of samples at five reservoir locations.

3. Provide mobile lab for coliform analyses.

4. Provide partial weather data for reservoir.

5. Assist in temperature and dissolved oxygen, cross sectional profiles during the August survey.

6. Provide reservoir operation data.

Environmental Protection Agency

1. Provide benthic oxygen uptake rate analysis during the August Survey.

2. Provide algal growth potential and establish limiting nutrient during the August Survey.

3. Establish sedimentary phosphorus release rates.

4. Establish algal settling rates.

5. Assist in temperature and dissolved oxygen, cross sectional profiles in the August Survey.

6. Current location and measurement.

Idaho Fish & Game Department

1. Conduct temperature and dissolved oxygen profiles during the second week of June, July, and August in conjunction with IDF&G continuing studies on the reservoir.

2. Provide additional boat and operator during June, July, and August Surveys.

Central District Health Department

Collect coliform, orthophosphate, and nitrate samples on small tributary streams during the August Survey.

Idaho Department of Water Resources

Possible assistance in model development.

APPENDIX A

SAMPLING LOCATIONS

Station Number	Inflows and Outflows	Location	Latitude	Longitude	Agency Responsibility
L	N.F. Payette River	USGS #2390	445430	1160710	IDHW
M	McCall STP	Outfall			IDHW
N	N.F. Payette River	R.M. 69.4			IDHW
O	N.F. Payette River	Paddy Flat Bridge,R.M. 63.0	444724.0	1160842.0	BOR*
P	Lake Fork	Sec. Rd. Brdg., 2.75NNW Donnelly	444545.0	1160540.0	IDHW
Q	Boulder Creek	1mi. S. of Donnelly	444308.0	1160435.0	IDHW
R	Rock Creek	8mi NE, RT 1S Jec	443950.0	1160335.0	IDHW
T	Mud Creek	Brdg. 2 mi WNW Donnelly	444340.0	1160630.0	IDHW
S	Gold Fork	USGS #2435			IDHW
U	N.F. Payette	U.S. Hwy. 15	443126.0	1160236.0	BOR*

RESERVOIR SAMPLES

Station Number	Location	Latitude	Longitude	Depths	Agency Responsibility
J	Lake Fork Arm	444155.0	1160620.0	0, ½, bottom or by strata	BOR
H	Gold Fork Arm**	444018.0	1160536.0	0, ½, bottom or by strata	BOR
K	N.F. Payette Arm	444215.0	1160725.0	0, ½, bottom, or by strata	IDHW
I	Inlet between L.F. & G.F.	444120.0	1160550.0	0, ½, bottom or by strata	BOR
G	N.F. Payette Arm	443825.0	1160550.0	0, ½, bottom or by strata	IDHW
F	W of Sugarloaf	443710.0	1160535.0	4 depths at 10 ft. or by strata	BOR
D	Middle of Res.	443345.0	1160500.0	4 to 6 depths at 10 ft. or by strata	IDHW
E	Middle of Res.	443345.0	1160630.0	4 to 6 depths at 10 ft. or by strata	IDHW
C	Middle of Res.	443145.0	1160500.0	4 to 6 depths at 10 ft. or by strata	IDHW
A	Middle of Res.	443050	11604030.0	4 to 6 depths at 10 ft or by strata	IDHW
B	Log Boom	443140.0	1160315.0	4 to 6 depths at 10 ft. or by strata	BOR

* IDHW can collect sample and split with BOR for analysis.
** Different location from original BOR location.

For benthic oxygen uptake, sedimentary phosphorus rates, algal growth potential, and algal settling rates, three selected locations will be established at a later date in the following areas:

1. Upper segment of the reservoir (headwaters).
2. Central segment of the reservoir.
3. Lower segment of the reservoir (near the dam).

Locations for Cross Sections - Temperature & Dissolved Oxygen Profiles

1. N.F. of Payette Arm
2. Lake Fork Arm
3. Gold Fork Arm
4. In the reservoir near Sugarloaf Island
5. In the reservoir near the dam

Locations for Tributary Streams in Developed Areas

Station No.		
23	Willow Creek	(above development and at mouth)
24	Campbell Creek	" " " " "
25	Hazard Creek	" " " " "
26	VanWyck Creek	" " " " "
27	Deer Creek	" " " " "
28	Gibson Creek	" " " " "
29	Boulder Creek	" " " " "
30	Duck Creek	" " " " "
31	Poison Creek	" " " " "

SHORE SURVEY

Station No.	Description
1	Grassy Point, 500 yards south of main dock area.
2	South end of the lake.
3	Old Barn, at boat dock.
4	South of Silver Creek near boat dock (landing strip).
5	Middle of lake between Silver Creek and Grandma's Creek.
6	Public use area, off dock.
7	Cabin area west of Sugarloaf Island.
8	Sugarloaf Island, northwest side[1/]
9	Narrows off Poison Creek.
10	Gold Fork Arm, rear power line.
11	Paradise Cove, cabin area.
12	Mouth of Gold Fork Arm, near Mount Shadows #2, cabin area[1/]

1/ Several stations are identical to reservoir sampling stations.

SHORE SURVEY LOCATIONS (cont.)

Station No.	Description
13	Mouth of Willow Creek Arm.
14	Shallows in North Fork Arm.
15	Mouth of North Fork Arm (at bridge)1/
16	Lake Fork Arm - north end.
17	Lake Fork Arm, 1 mile south of bridge near public access area.
18	Lake Fork Arm, Private Cove.
19	Lake Fork Arm, near mouth1/
20	Mid-east side of lake near old house.
21	Dam1/
22	Main Boat Dock - 100 yards north.

1/ Several stations are identical to reservoir sampling stations.

APPENDIX B

1. Flow (cfs) - inflows and outflows only.
2. Ortho-phosphorus (mg/l).
3. Total phosphorus (mg/l).
4. Total inorganic phosphorus.
5. Total and fecal coliform (mpn/100 ml).
6. Ammonia Nitrogen (mg/l).
7. Nitrite Nitrogen (mg/l).
8. Nitrate Nitrogen (mg/l).
9. Organic kjedahl nitrogen (mg/l).
10. Dissolved oxygen (mg/l).
11. Temperature (^oC).
12. Phytoplankton (mg-C/l) - from ash free dry weight.
13. Zooplankton (mg-C/l) - fraction of ash free dry weight.
14. Chlorophyll-a

APPROXIMATE SAMPLE NUMBERS

	Bacteriological		Chemical	
Agency	Collected	Tested	Collected	Tested
MAY SURVEY				
IDHW	36 1/	0	36 1/	39 2/
IDHW (Sed. Phos. Only)	0	0	5	5
BOR	18	54	18	25 3/
JUNE SURVEY				
IDHW	36 1/	0	36 1/	39 2/
IDHW (Sed. Phos. Only)	0	0	5	5
BOR	18	54	18	25 3/
JULY SURVEY				
IDHW	36 1/	0	36 1/	39 2/
BOR	18	54	18	25 3/
AUGUST SURVEY				
IDHW	53 1/	0	36 1/	39 2/
BOR	18	71	18	25 3/
CDHD	18	0	18	18 4/
IDHW (Sed. Phos. Only)	0	0	5	5
IDHW	0	0	17	17 4/

SEPTEMBER & OCTOBER SURVEYS

IDHW	36 1/	0	36 1/	39 2/
BOR	18	54	18	25 3/

1/ Includes collection of two BOR inflow-outflow samples.
2/ Includes splitting five samples with BOR.
3/ Includes splitting five samples with IDHW.
4/ Orthophosphorus and nitrates only.

SPECIAL EQUIPMENT REQUIREMENTS

Depth Samplers
Flow Measurement Tape
Vacuum Filter
Additional Incubators
Benthic Oxygen Uptake Bell
Sedimentary Phosphorus Apparatus
Distance Finder
Current Meter and Locator
Tube Settler

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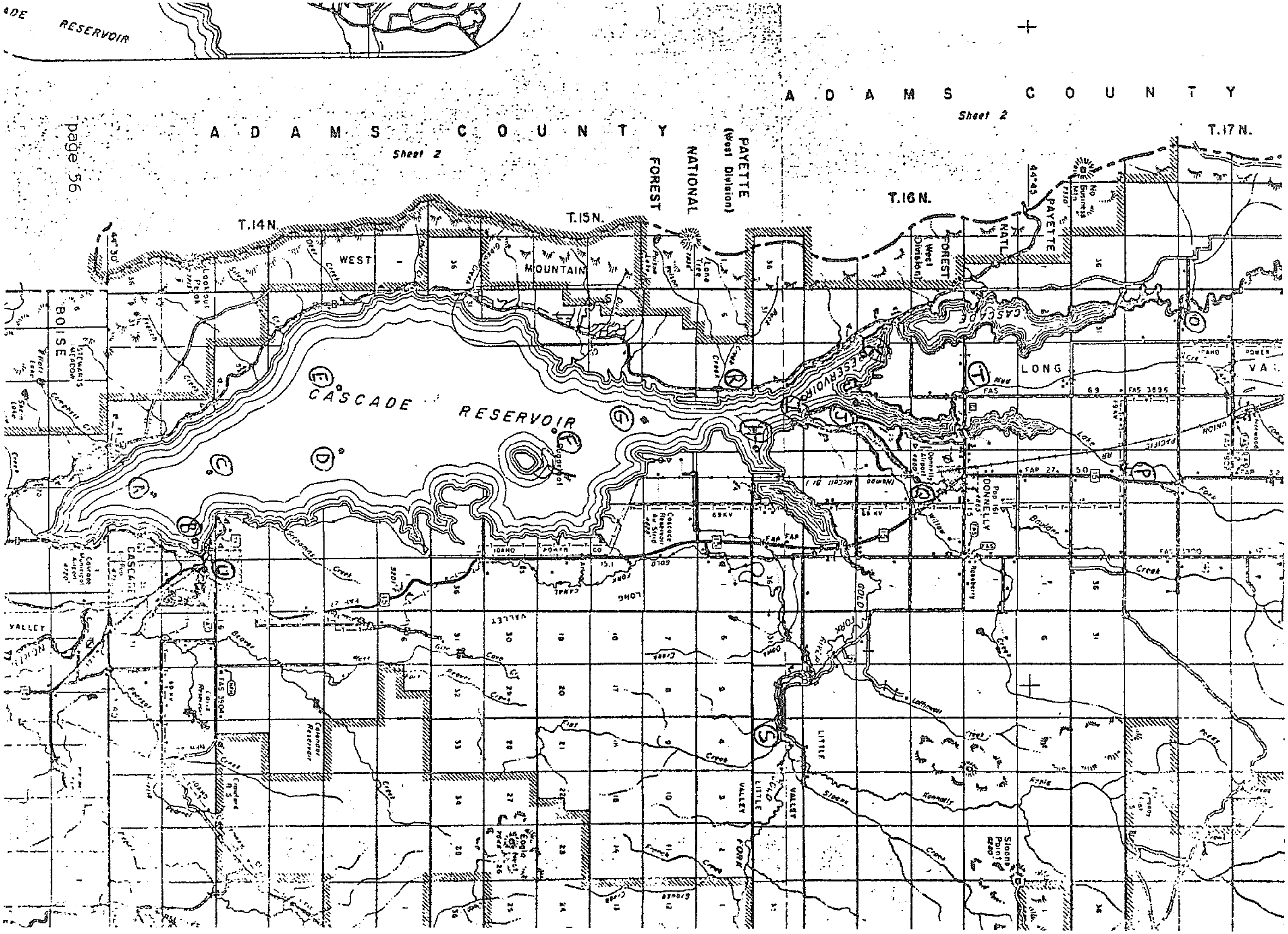
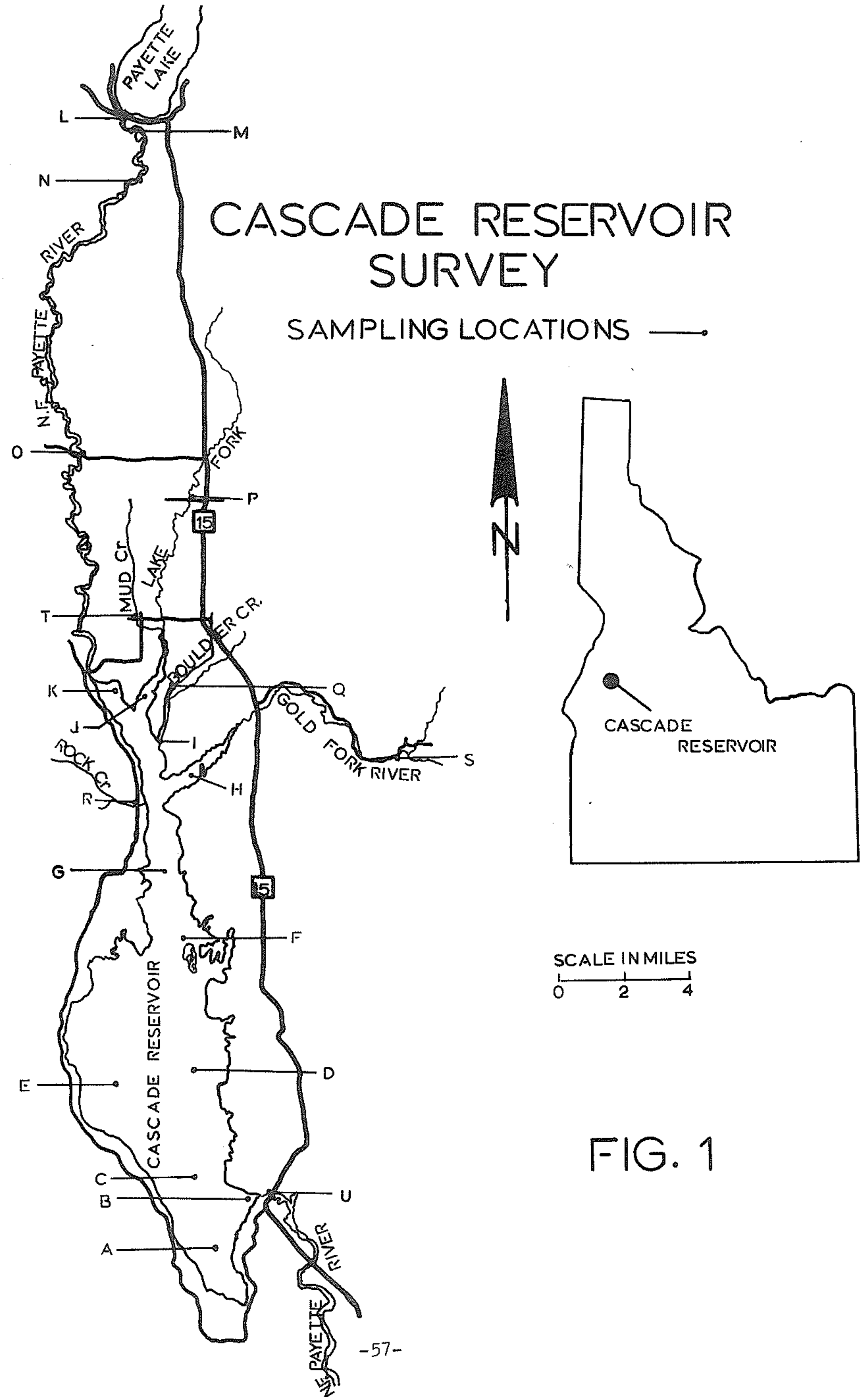

ADAMS COUNTY
Sheet 2
ADAMS COUNTY
Sheet 2
PAYETTE (West Division) NATIONAL FOREST
T.14N.
T.15N.
T.16N.
T.17N.
WEST MOUNTAIN
CASCADE RESERVOIR
CASCADE RESERVOIR
LONG VALLEY
DONNELLY
CASCADE
BOISE
VALLEY
LITTLE VALLEY
GOLD FORK

APPENDIX B FIGURES


CASCADE RESERVOIR
SURVEY
SAMPLING LOCATIONS
PAYETTE LAKE
N.F. PAYETTE RIVER
FORK
MUD Cr.
LAKE
BOULDER CR.
GOLD FORK RIVER
ROCK Cr.
CASCADE RESERVOIR
N.F. PAYETTE RIVER
15
15
N
CASCADE RESERVOIR
SCALE IN MILES
0 2 4
A
B
C
D
E
F
G
H
I
J
K
L
M
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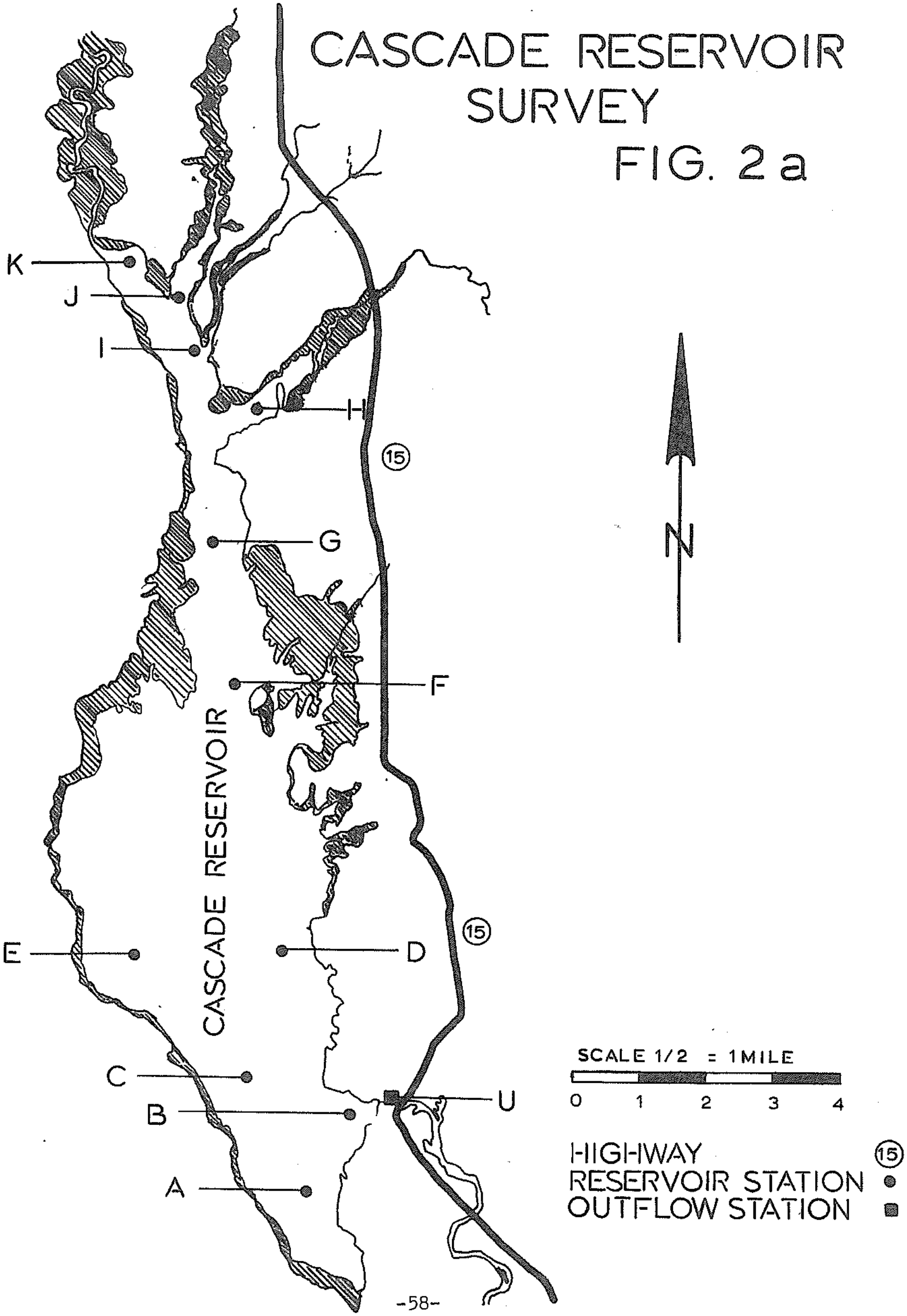
O
P
Q
R
S
T
U

FIG. 1


CASCADE RESERVOIR
SURVEY
FIG. 2a
K
J
I
H
G
F
E
D
C
B
A
U
15
CASCADE RESERVOIR
N
SCALE 1/2 = 1MILE
0
1
2
3
4
HIGHWAY
RESERVOIR STATION
OUTFLOW STATION

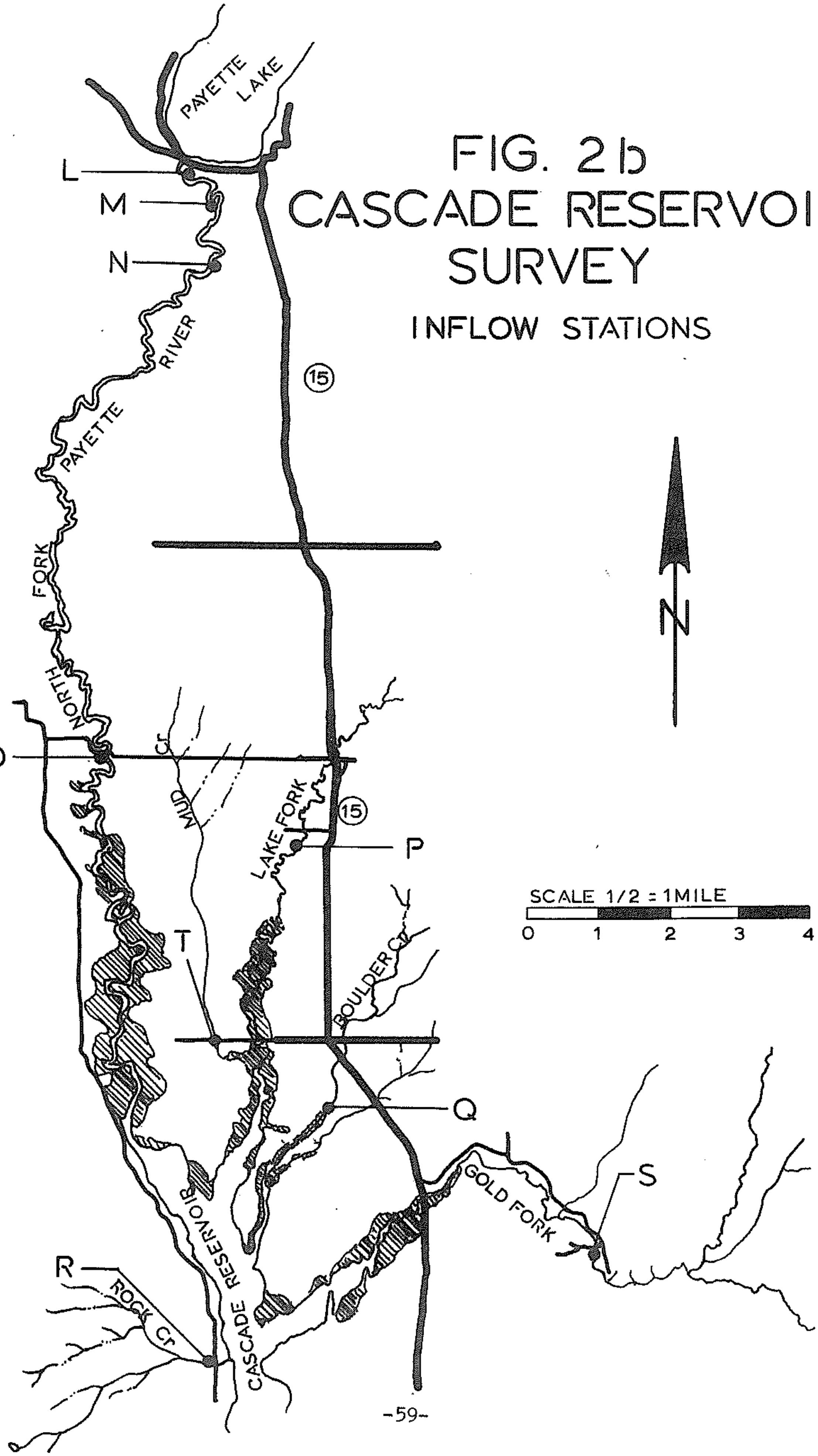
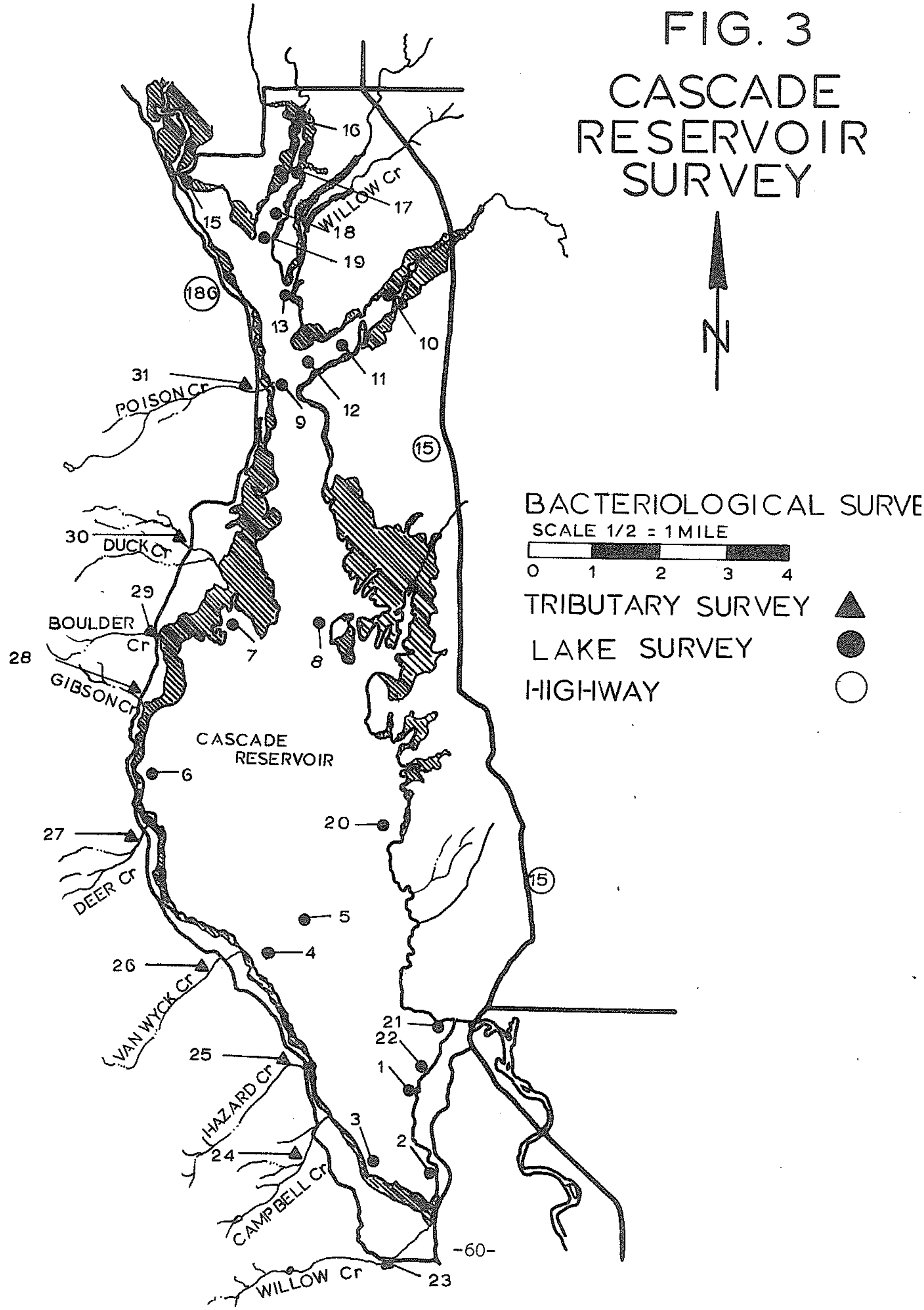


FIG. 2b
CASCADE RESERVOIR SURVEY
INFLOW STATIONS

FIG. 3
CASCADE RESERVOIR SURVEY



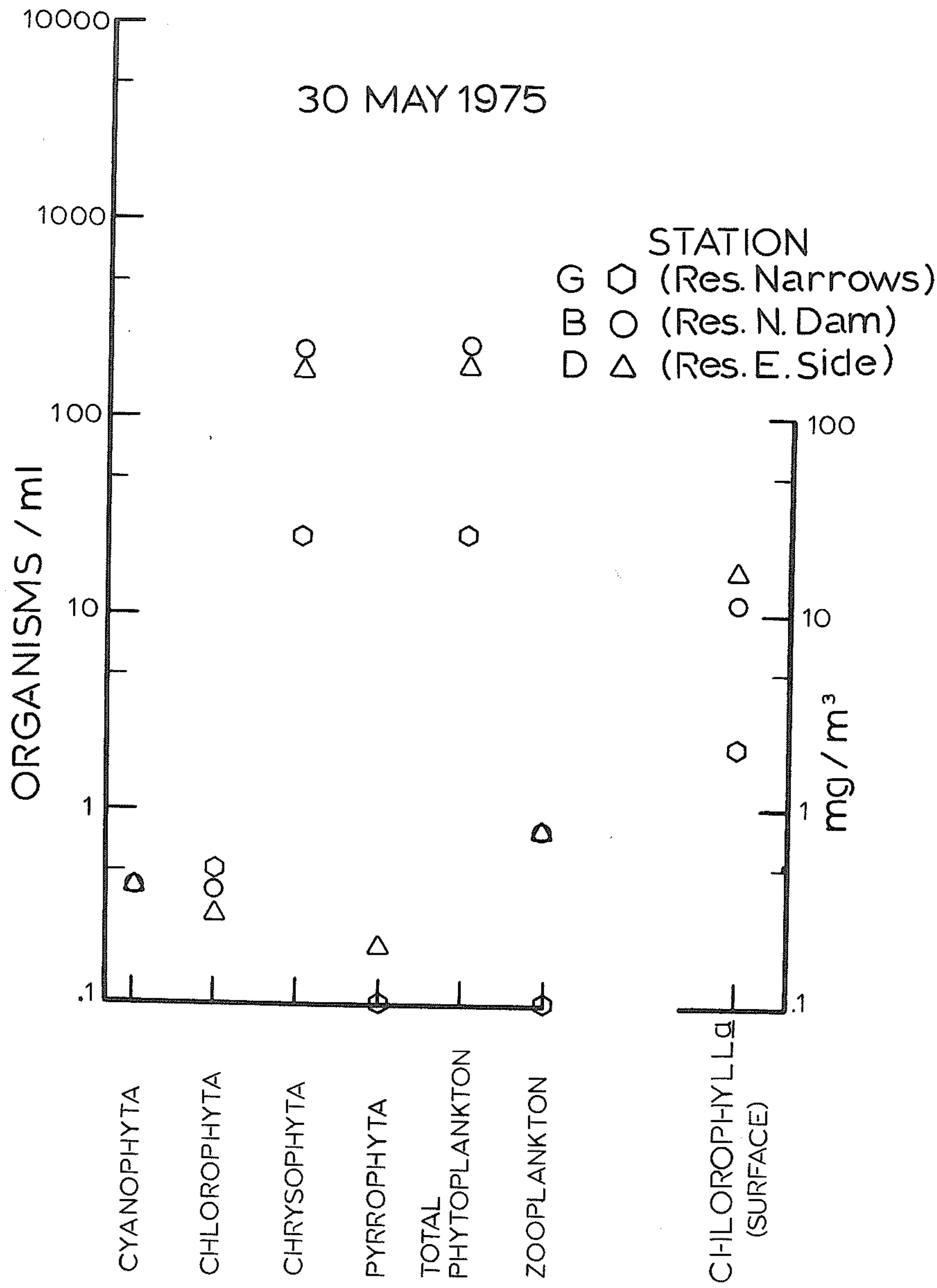


Figure 4a: Plankton densities and chlorophyll a concentrations for stations G, B and D, Cascade Reservoir, May 30, 1975.

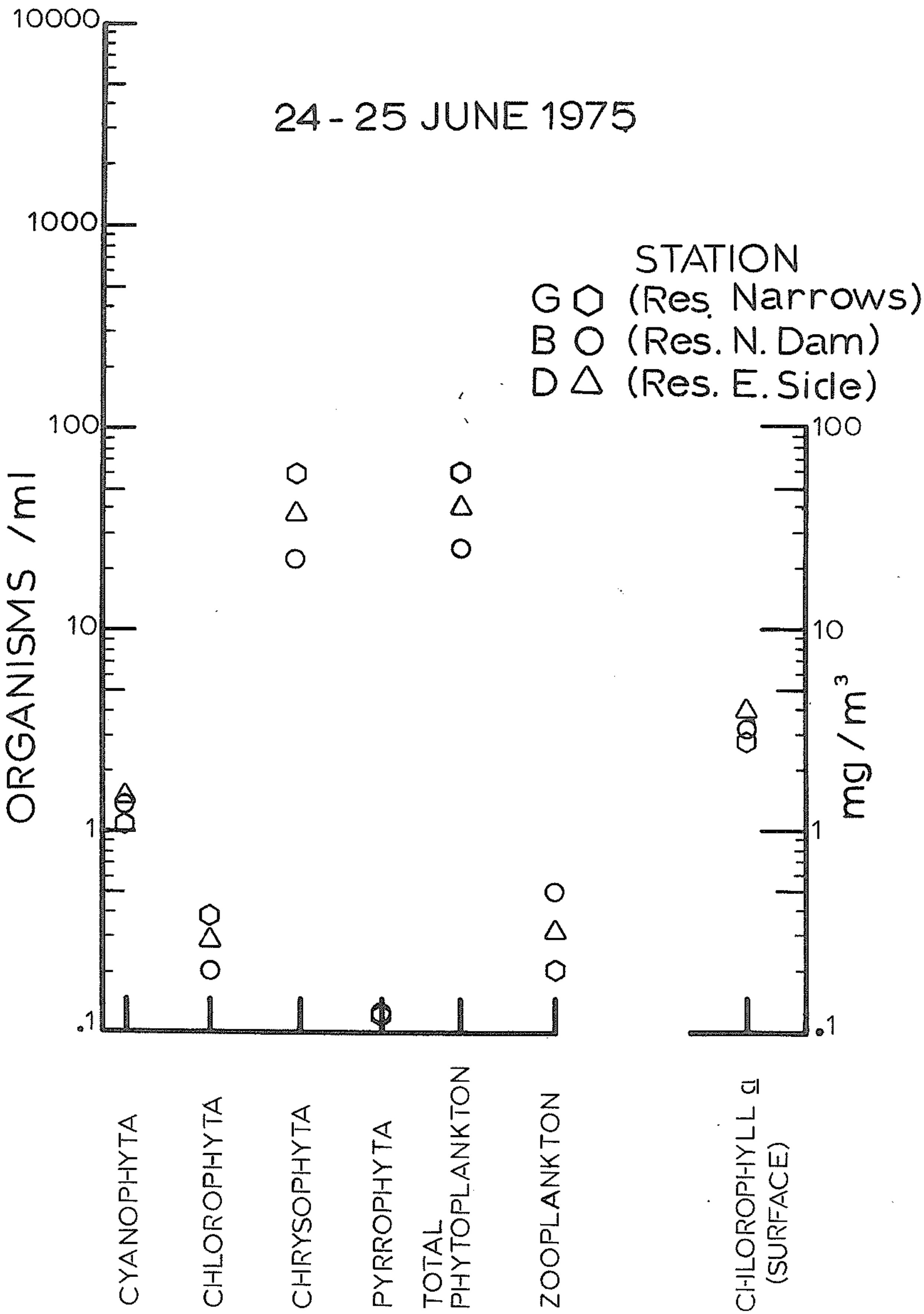


Figure 4b: Plankton densities and chlorophyll *a* concentrations for stations G, B and D, Cascade Reservoir, June 24-25, 1975.

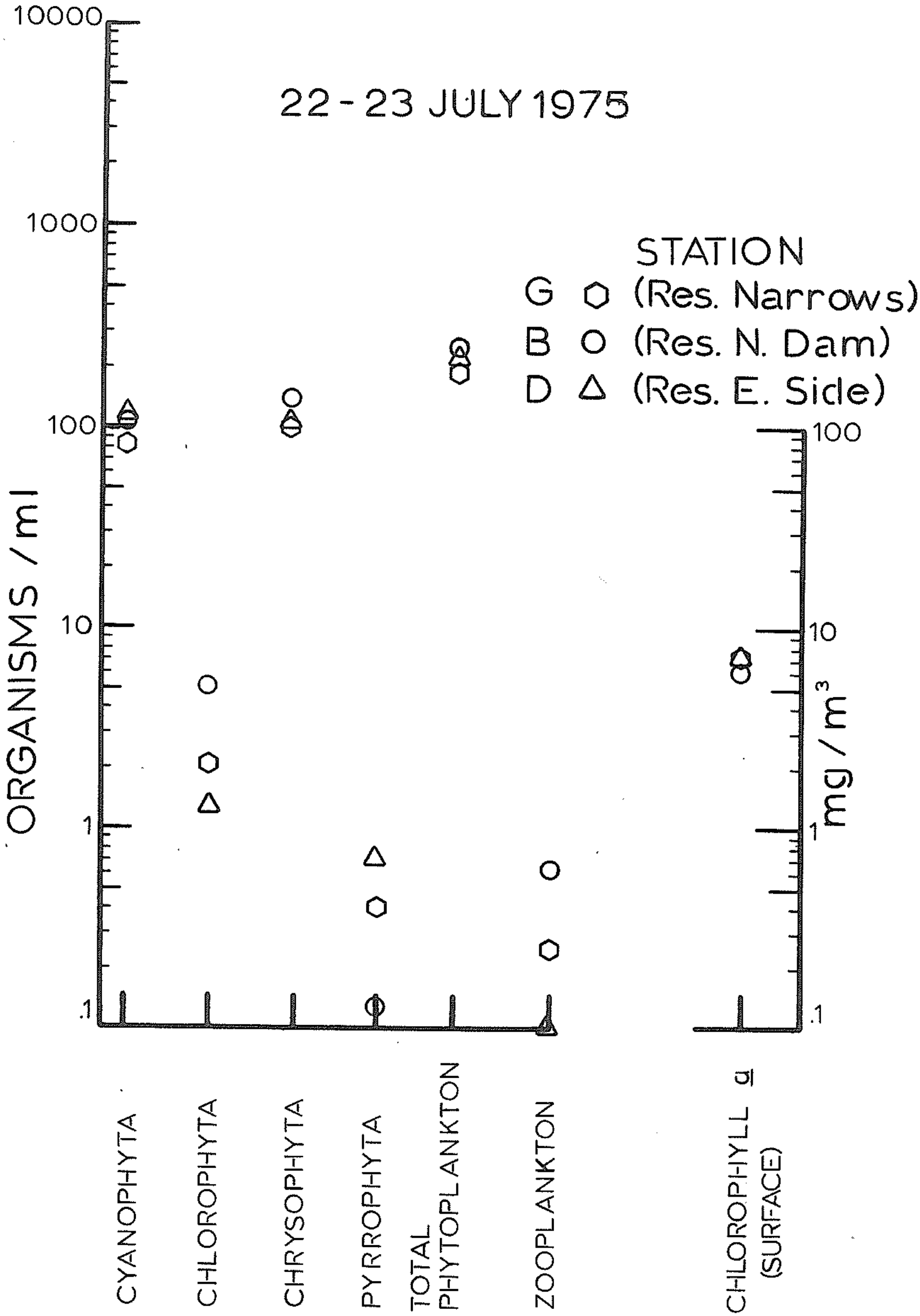


Figure 4c: Plankton densities and chlorophyll a concentrations for stations G, B and D, Cascade Reservoir, July 22-23, 1975.

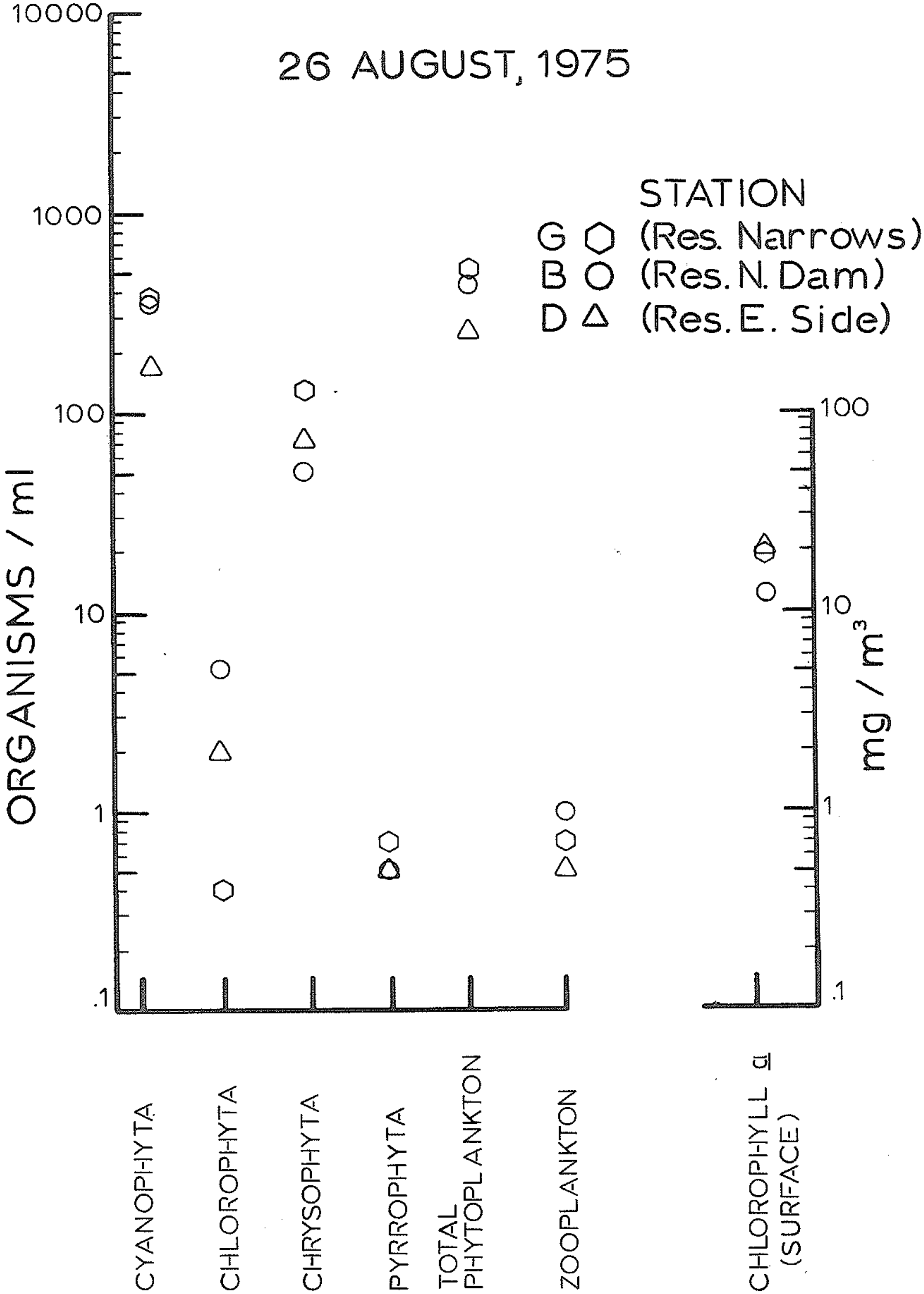


Figure 4d: Plankton densities and chlorophyll a concentrations for stations G, B and D, Cascade Reservoir, August 26, 1975.

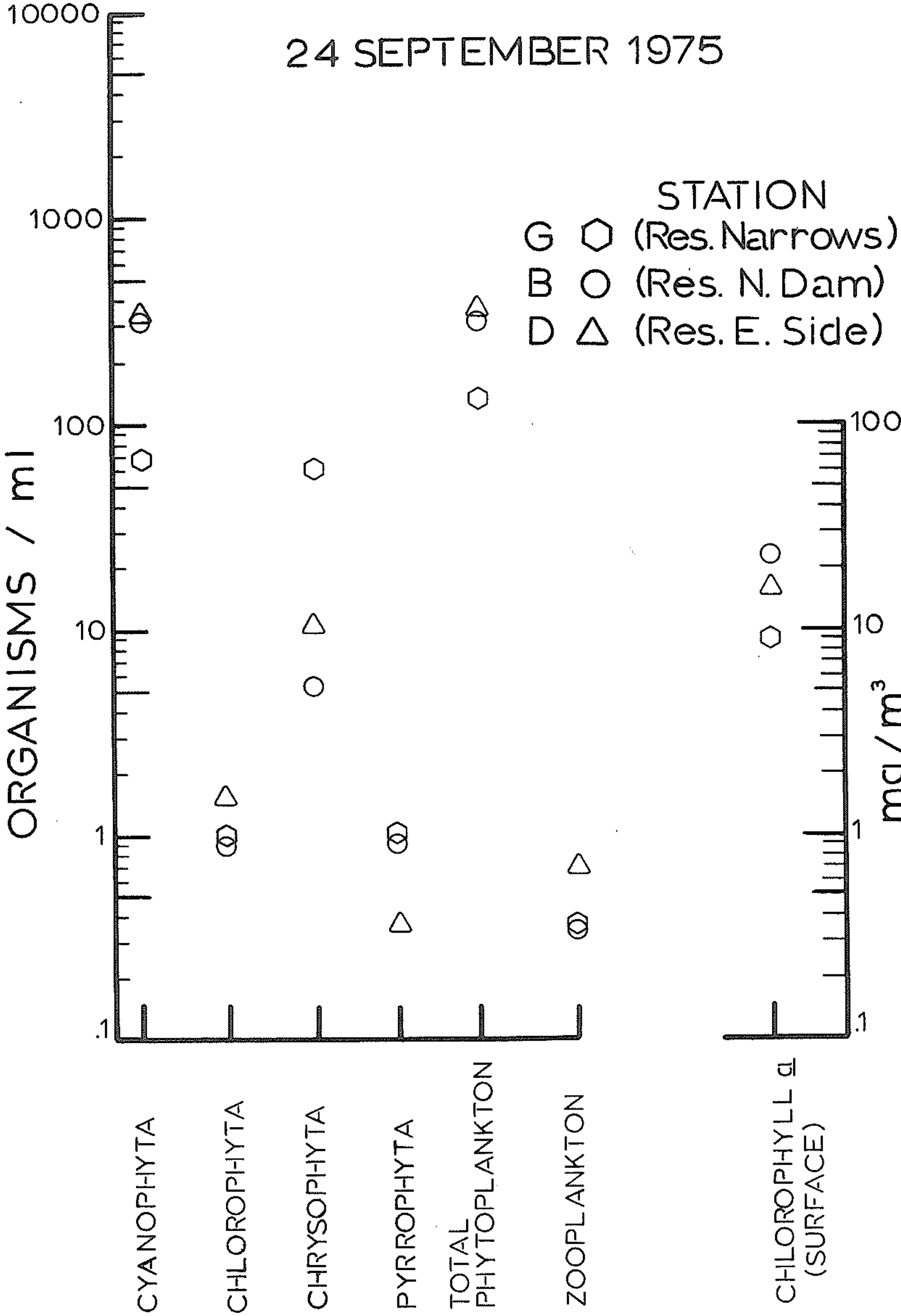


Figure 4e: Plankton densities and chlorophyll a concentrations for stations G, B and D, Cascade Reservoir, September 24, 1975.

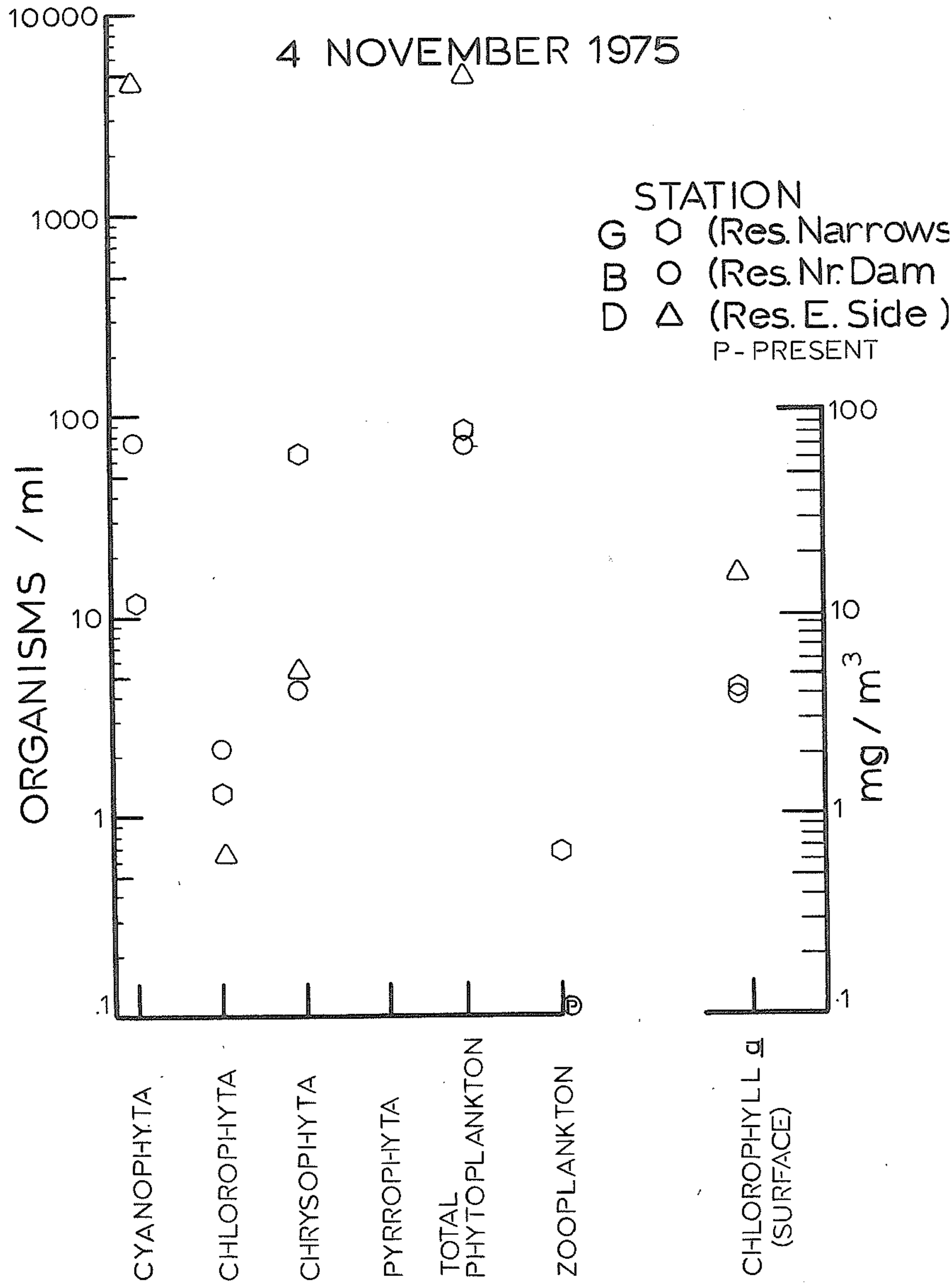


Figure 4f: Plankton densities and chlorophyll a concentrations for stations G, B and D, Cascade Reservoir, November 4, 1975.

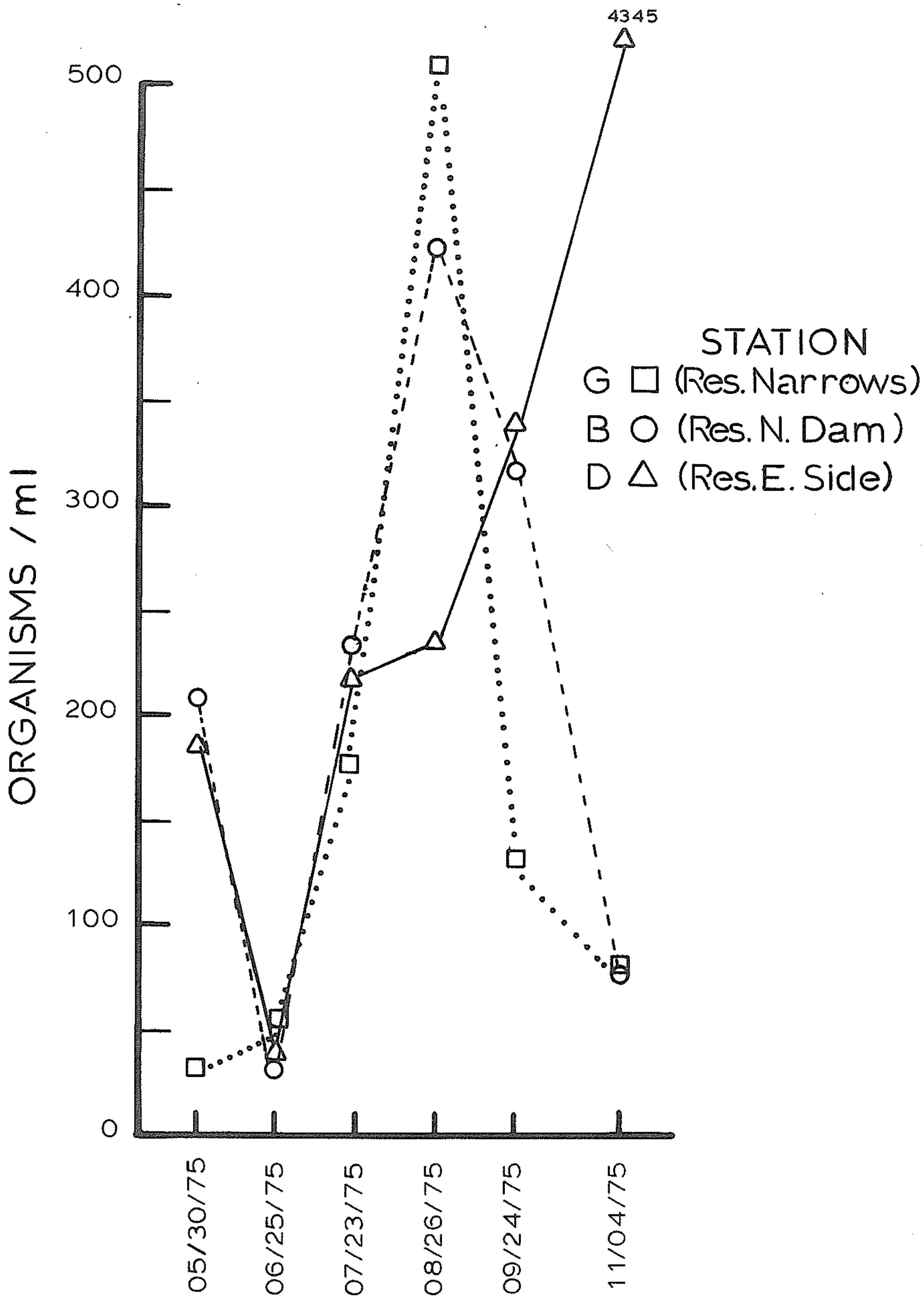


Figure 5: Total phytoplankton for stations G, B and D, Cascade Reservoir, May-November, 1975.

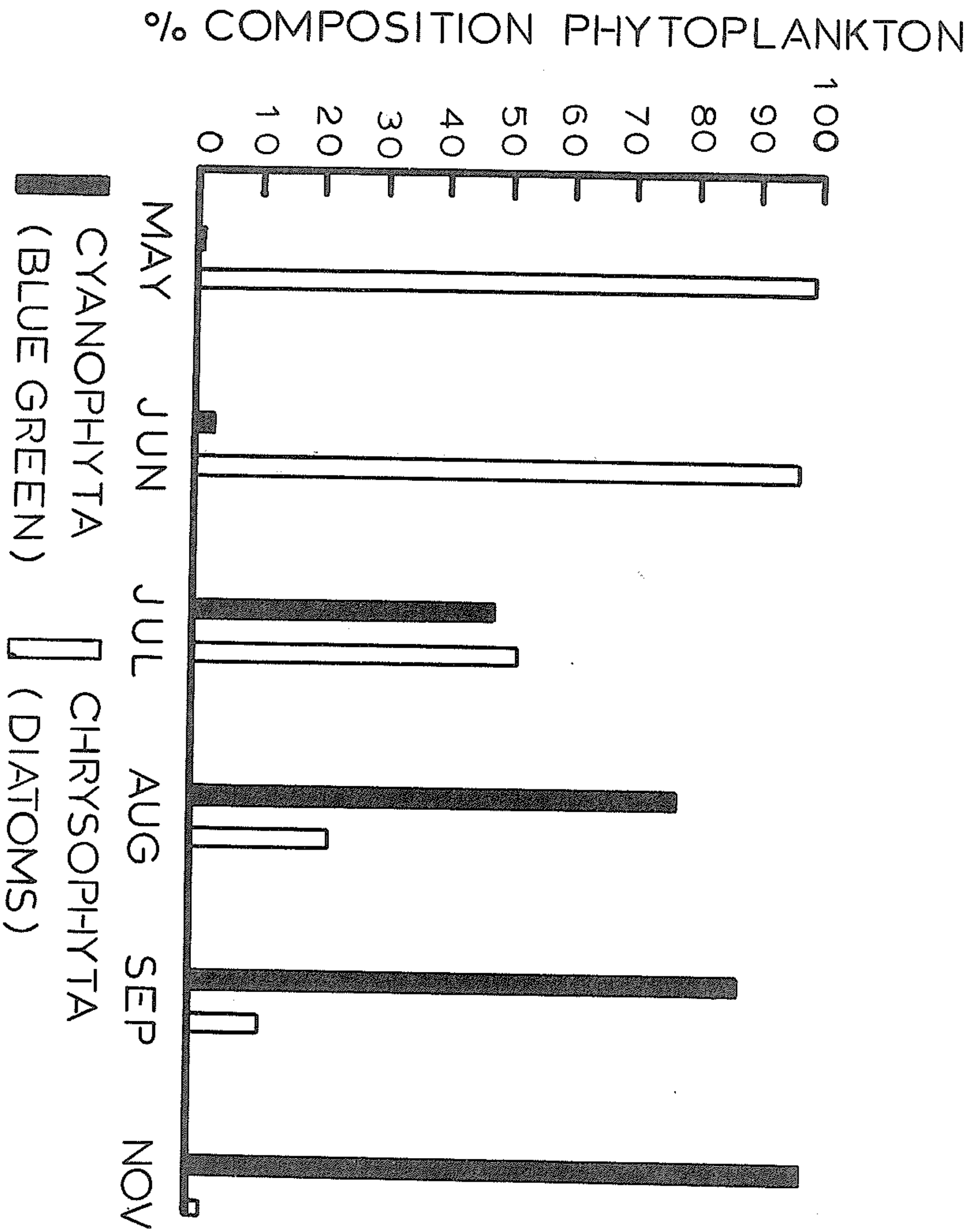


Figure 6: Present composition of Cyanophyta and Chrysophyta, Cascade Reservoir, May-November, 1975.

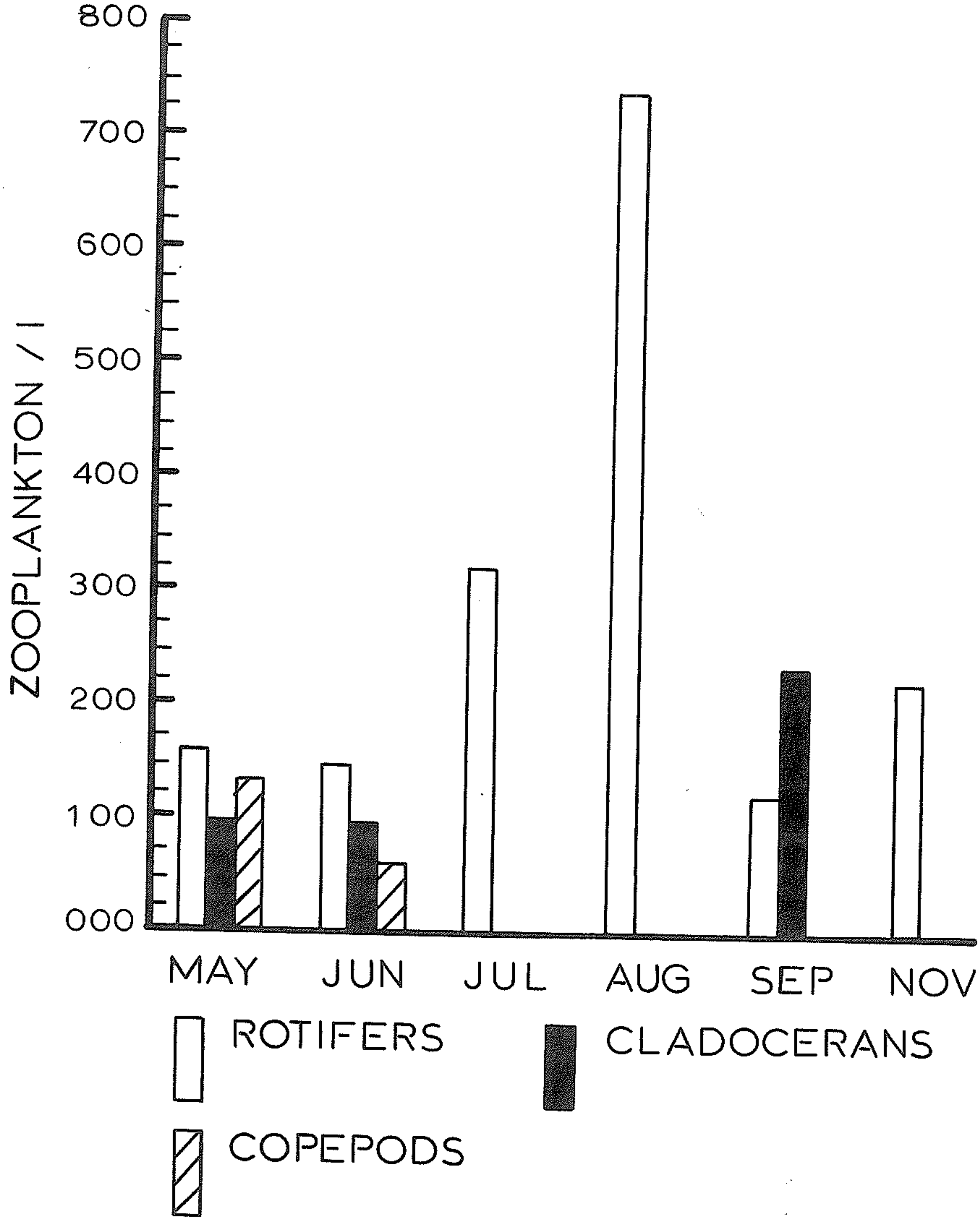


Figure 7: Zooplankton densities, Cascade Reservoir, May-November, 1975.

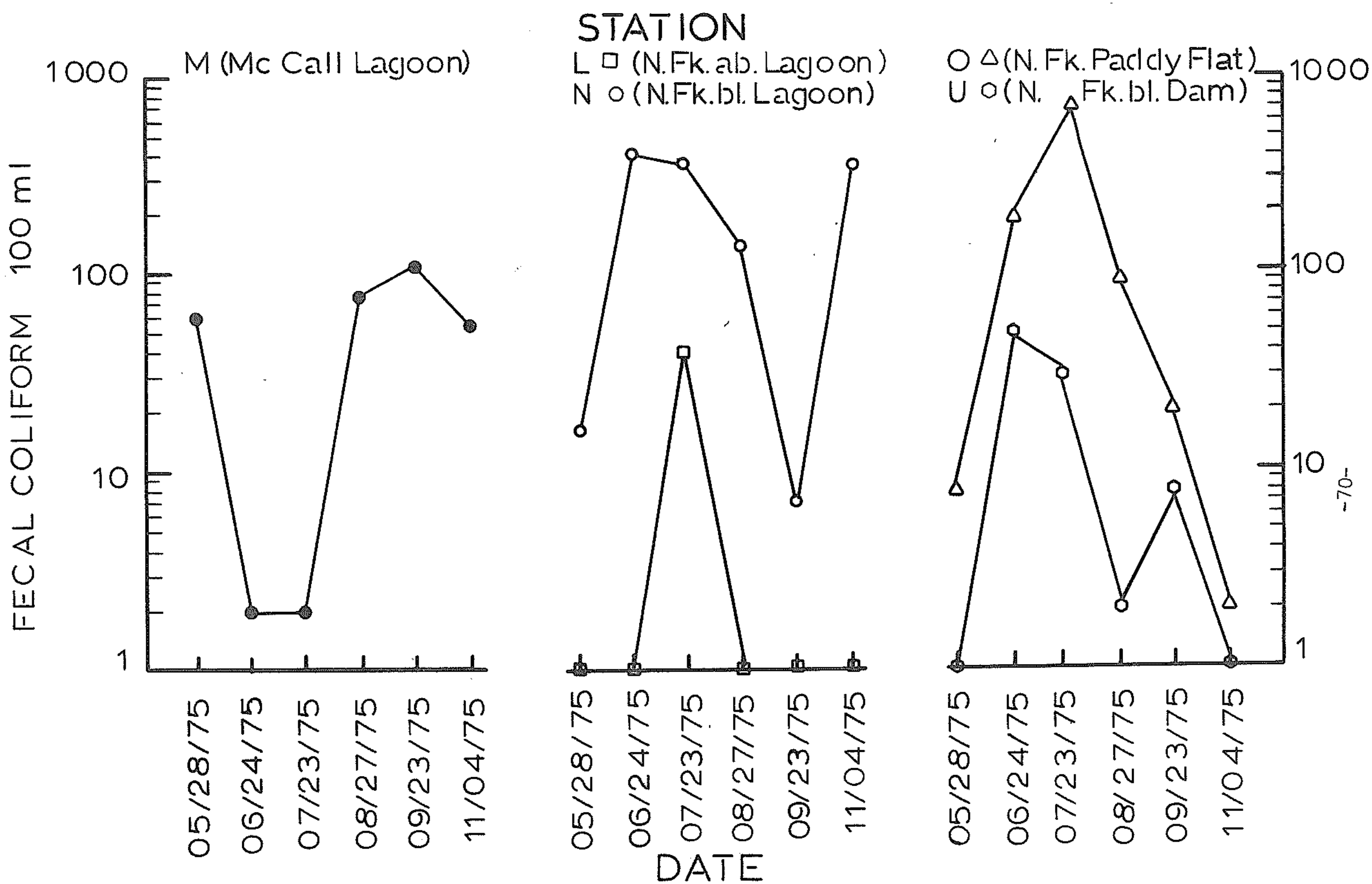


Figure 8a: Fecal coliform concentrations for stations M, L, N, O and U, Cascade Reservoir Survey, 1975.

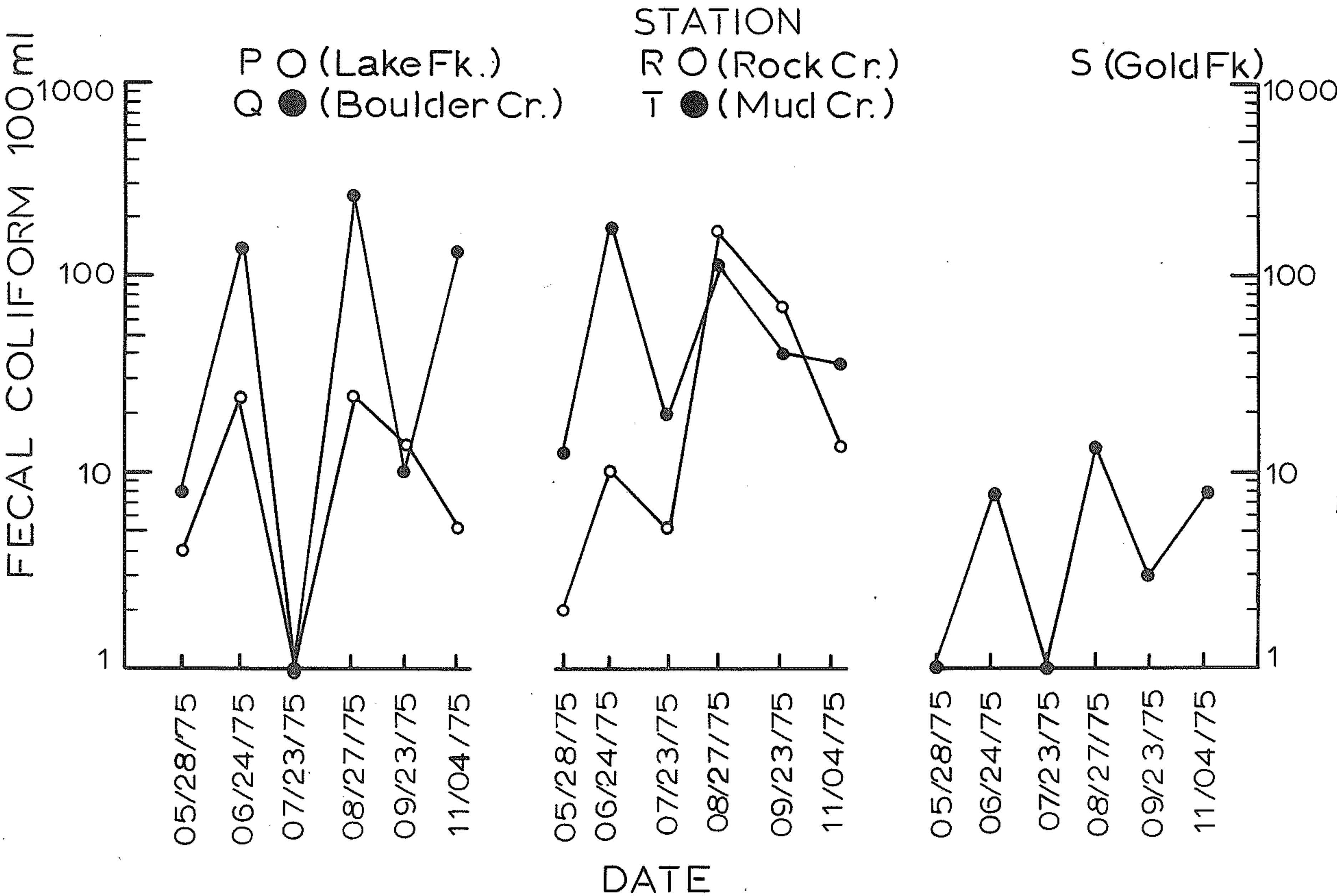


Figure 8b: Fecal coliform concentrations for stations P, Q, R, T and S, Cascade Reservoir Survey, 1975.

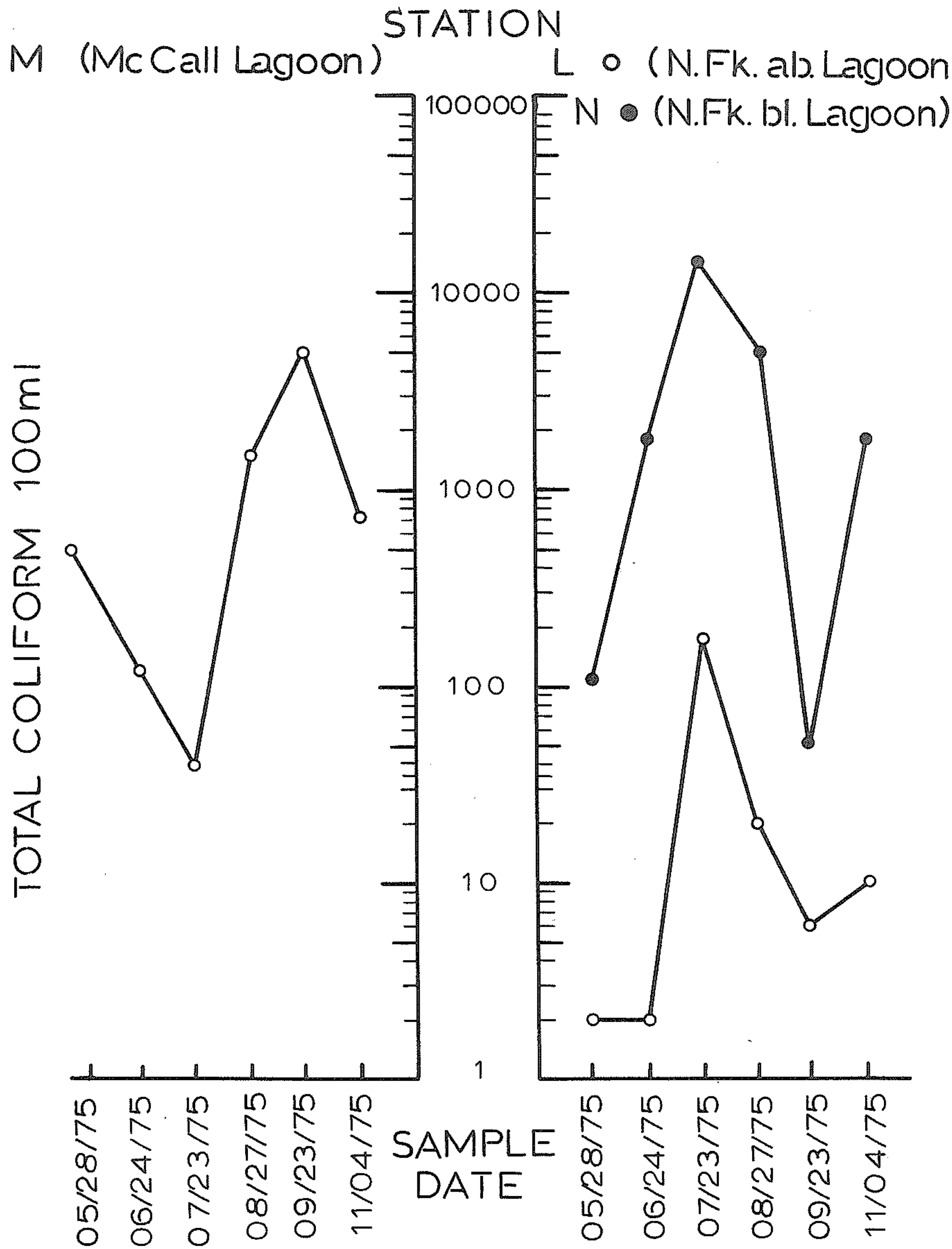


Figure 9a: Total coliform concentrations for stations L, M and N, Cascade Reservoir Survey, 1975.

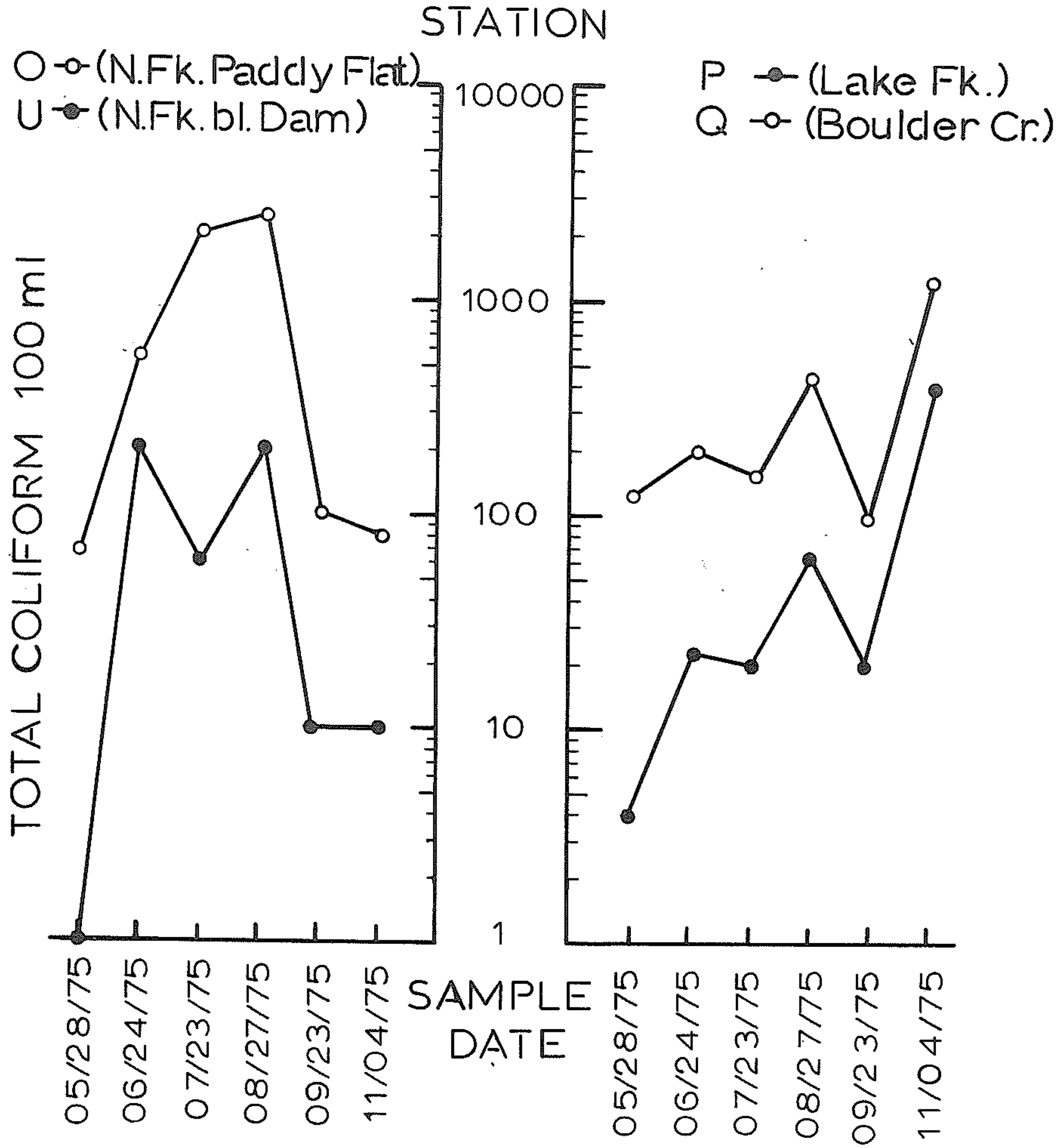


Figure 9b: Total coliform concentrations for stations O, U, P and Q, Cascade Reservoir Survey, 1975.

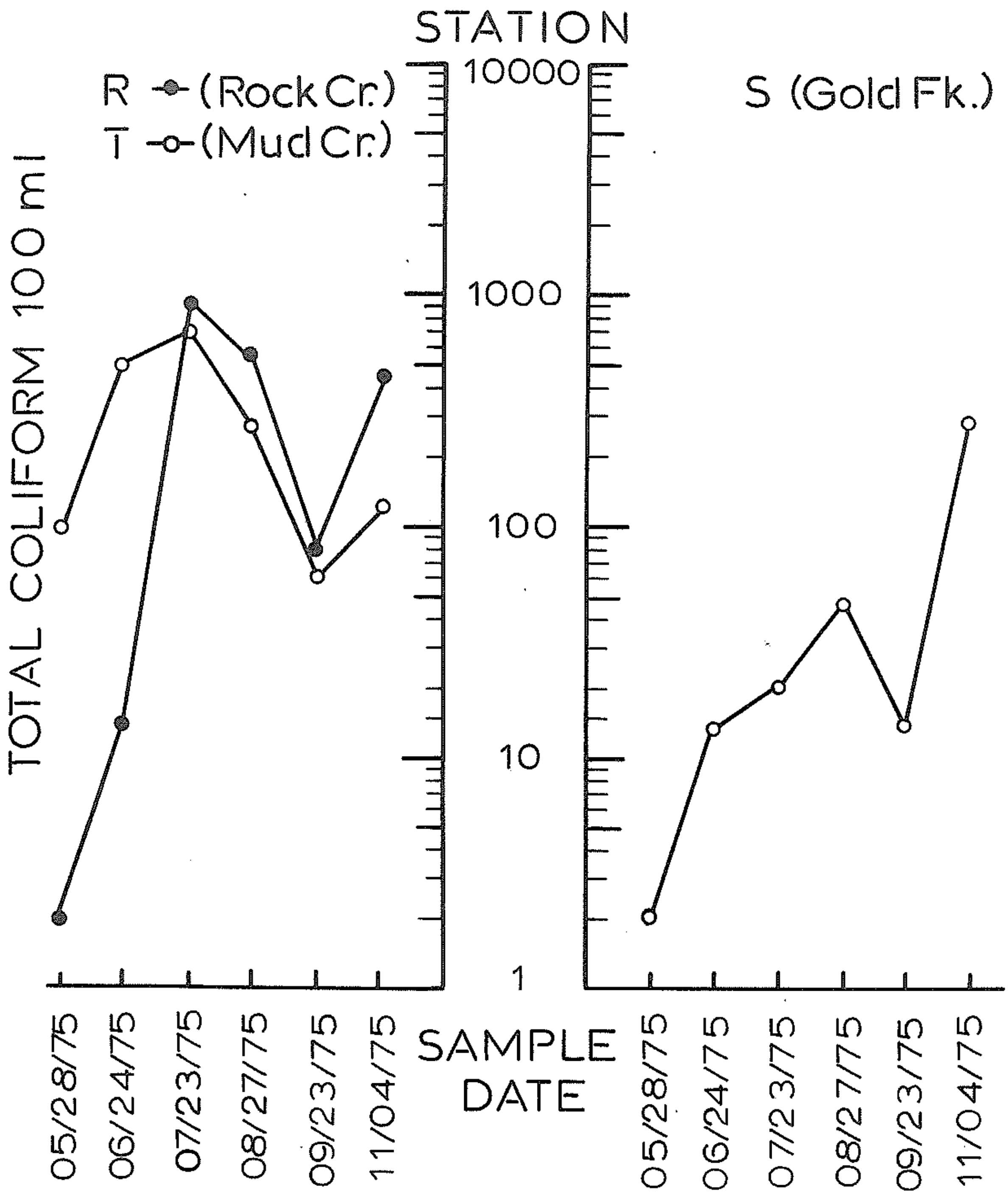


Figure 9c: Total coliform concentrations for stations R, T and S, Cascade Reservoir Survey, 1975.

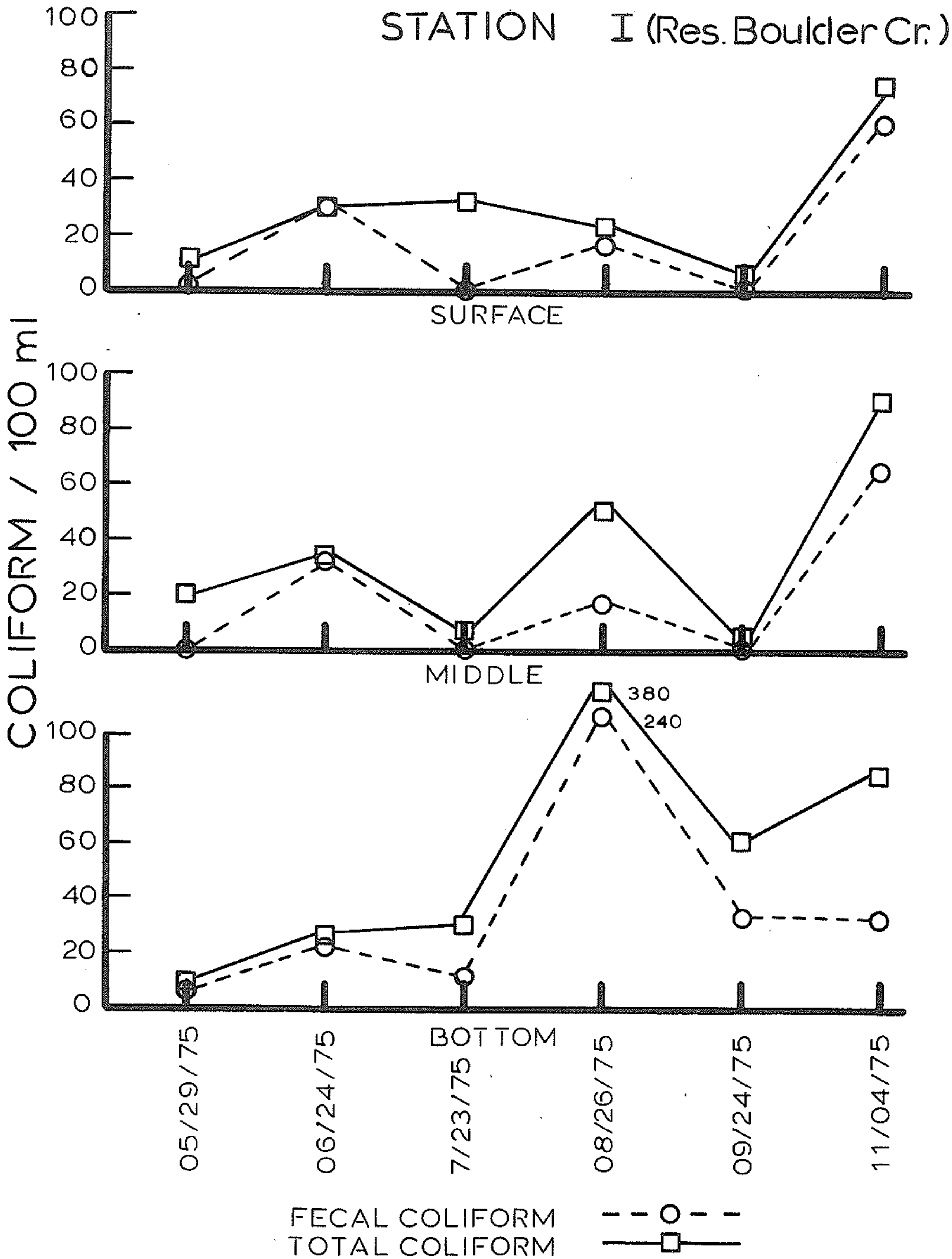


Figure 10a: Fecal and total coliform densities for station I, (Boulder Creek Arm), Cascade Reservoir, 1975.

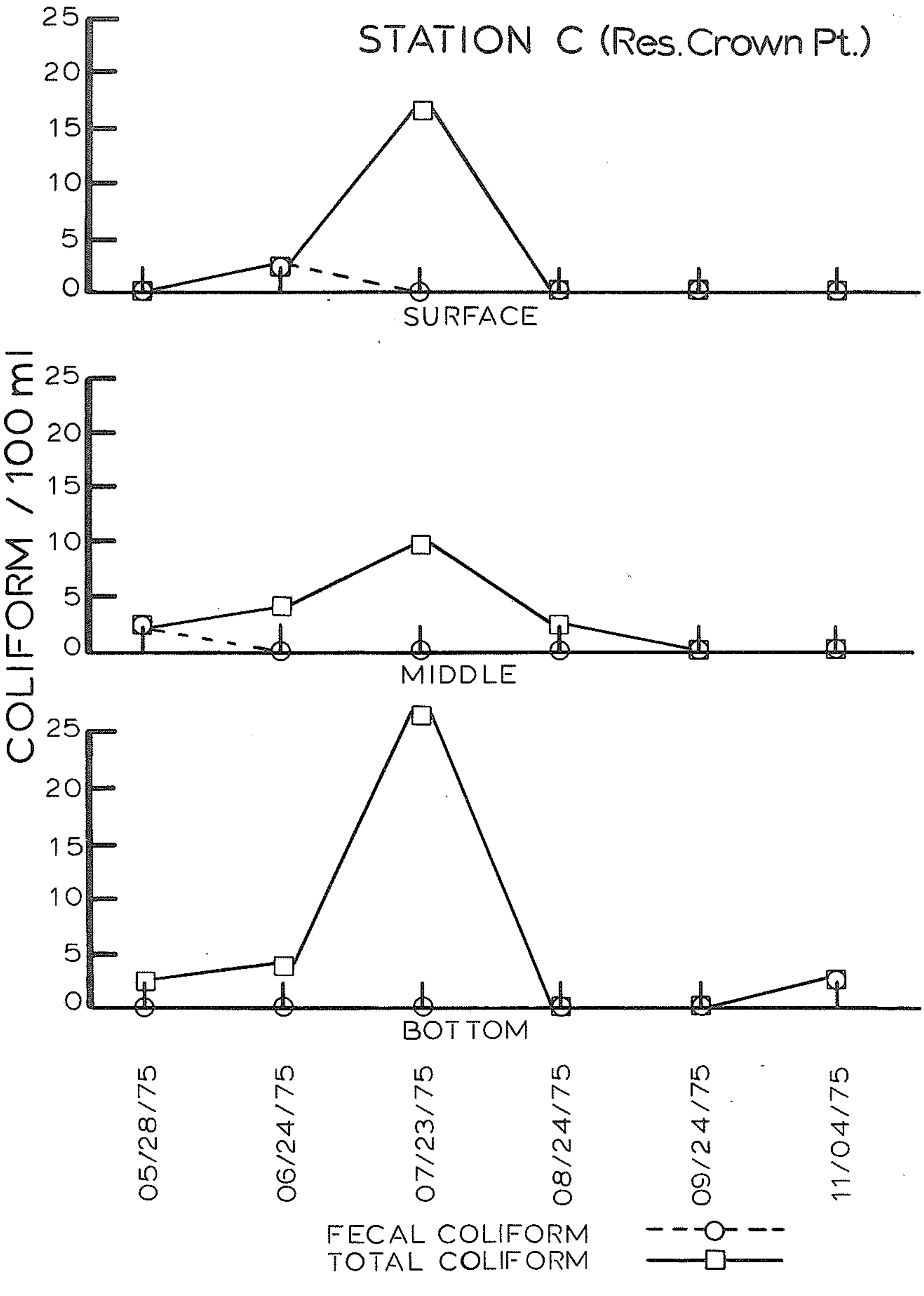


Figure 10b: Fecal and total coliform densities for station C, (Middle, off Crown Point), Cascade Reservoir, 1975.

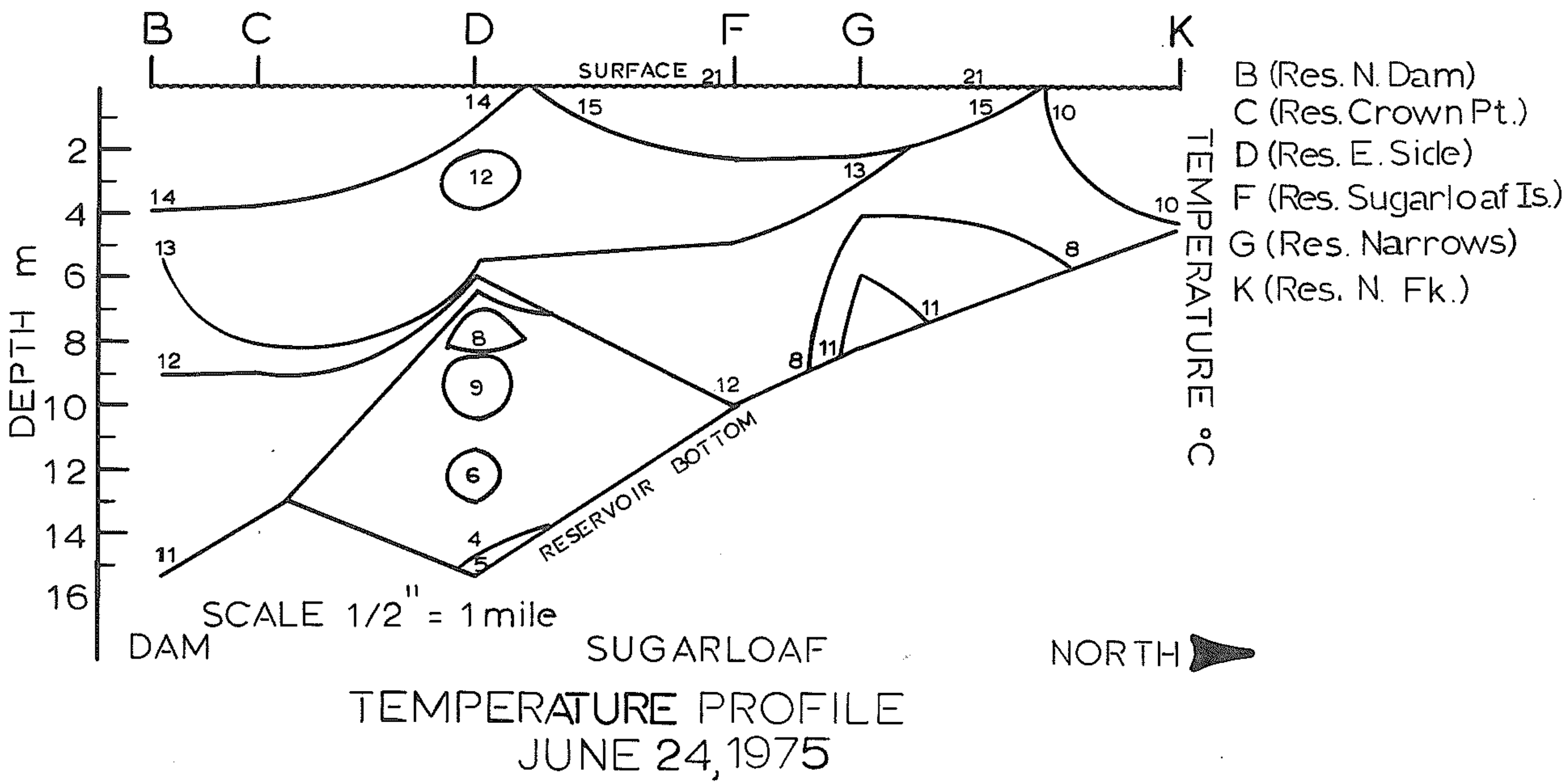


Figure 11a: Temperature profile for Cascade Reservoir, June 24, 1975.

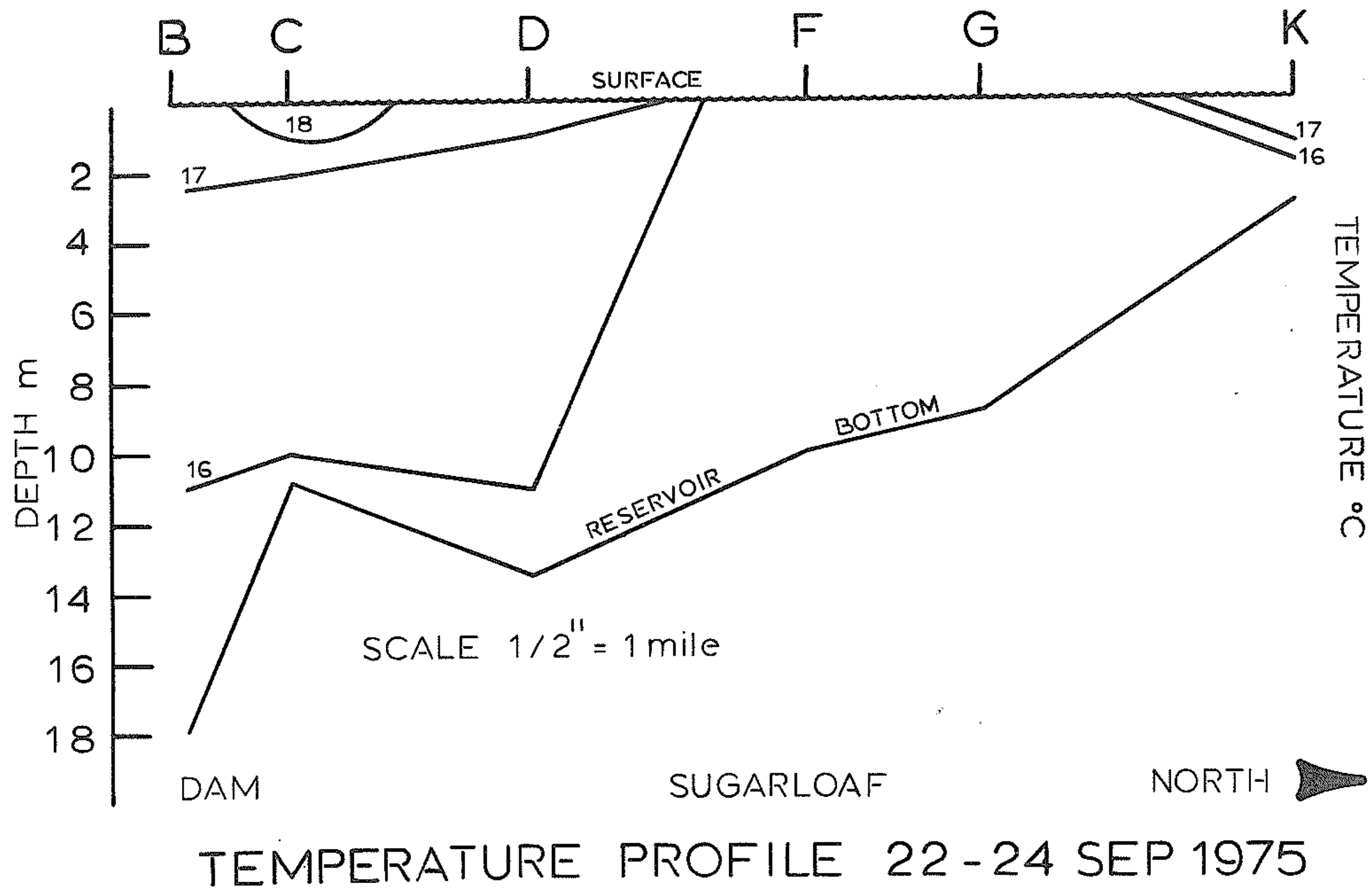
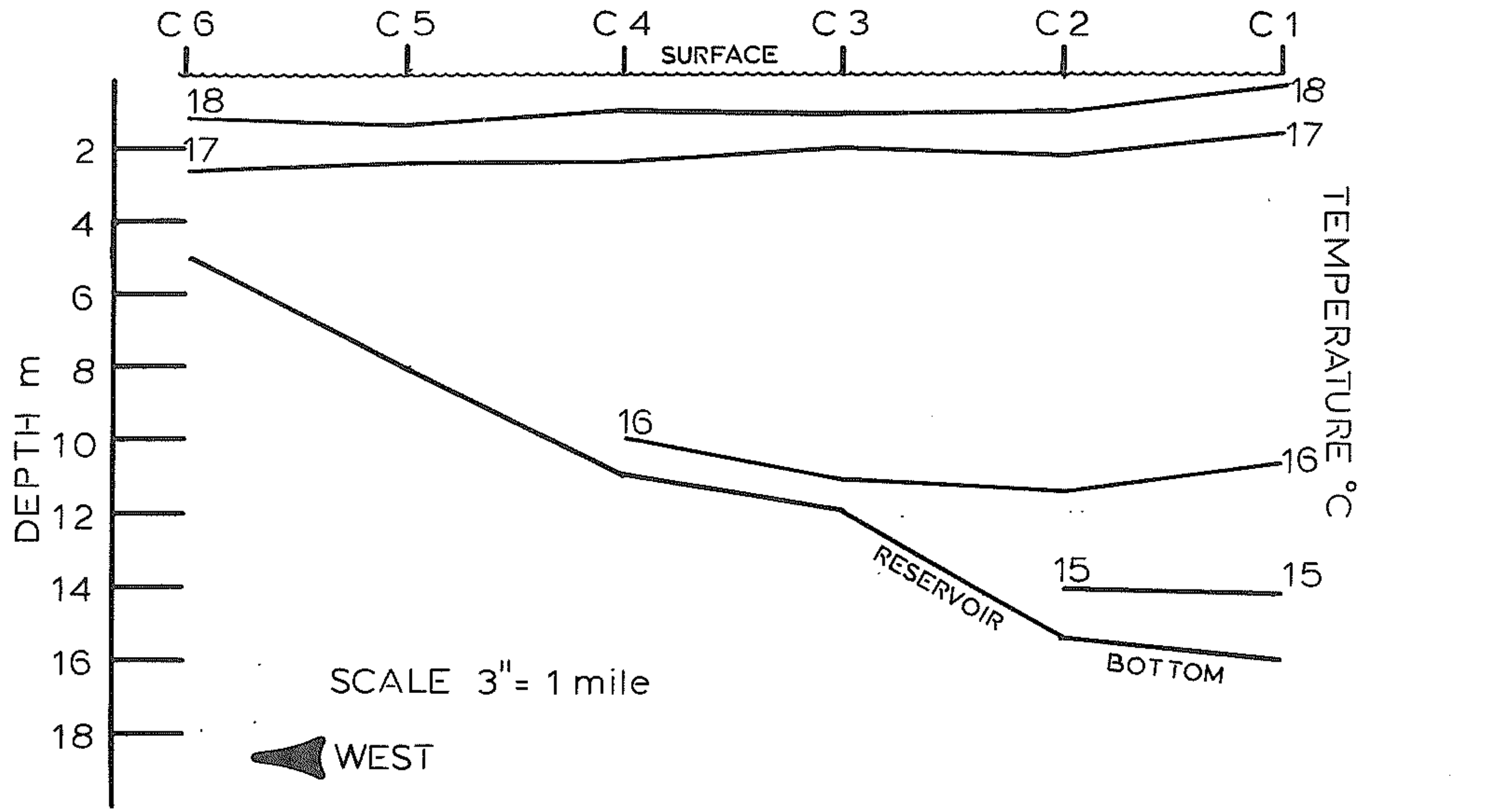


Figure 11b: Temperature profile for Cascade Reservoir, September 22-24, 1975.



STATION C TEMPERATURE 24 SEPTEMBER 1975
(Res. Crown Pt.)

Figure 11c: Temperature profile for transect C, Cascade Reservoir, September 24, 1975.

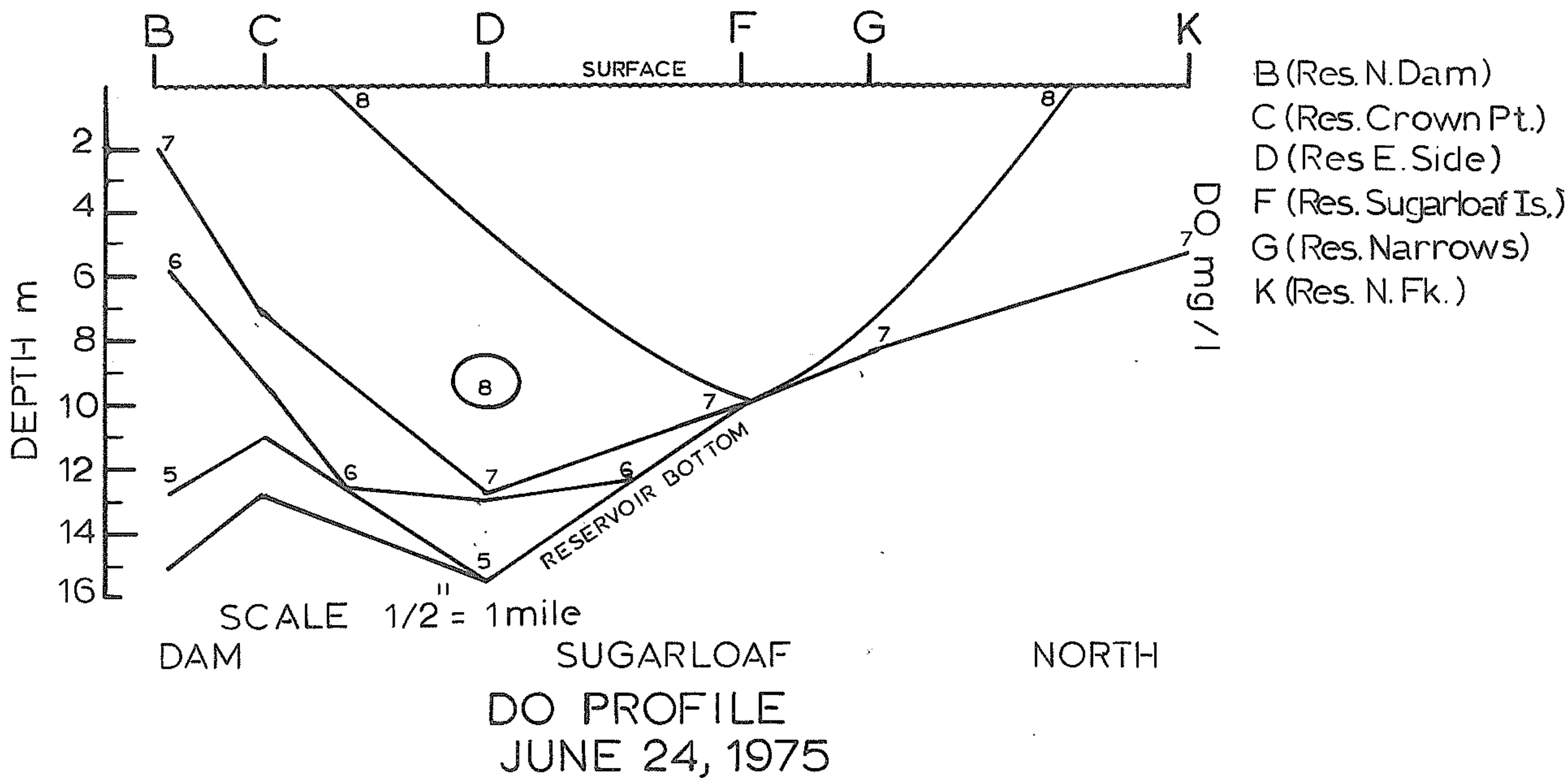


Figure 12a: Dissolved Oxygen profile, Cascade Reservoir, June 24, 1975.

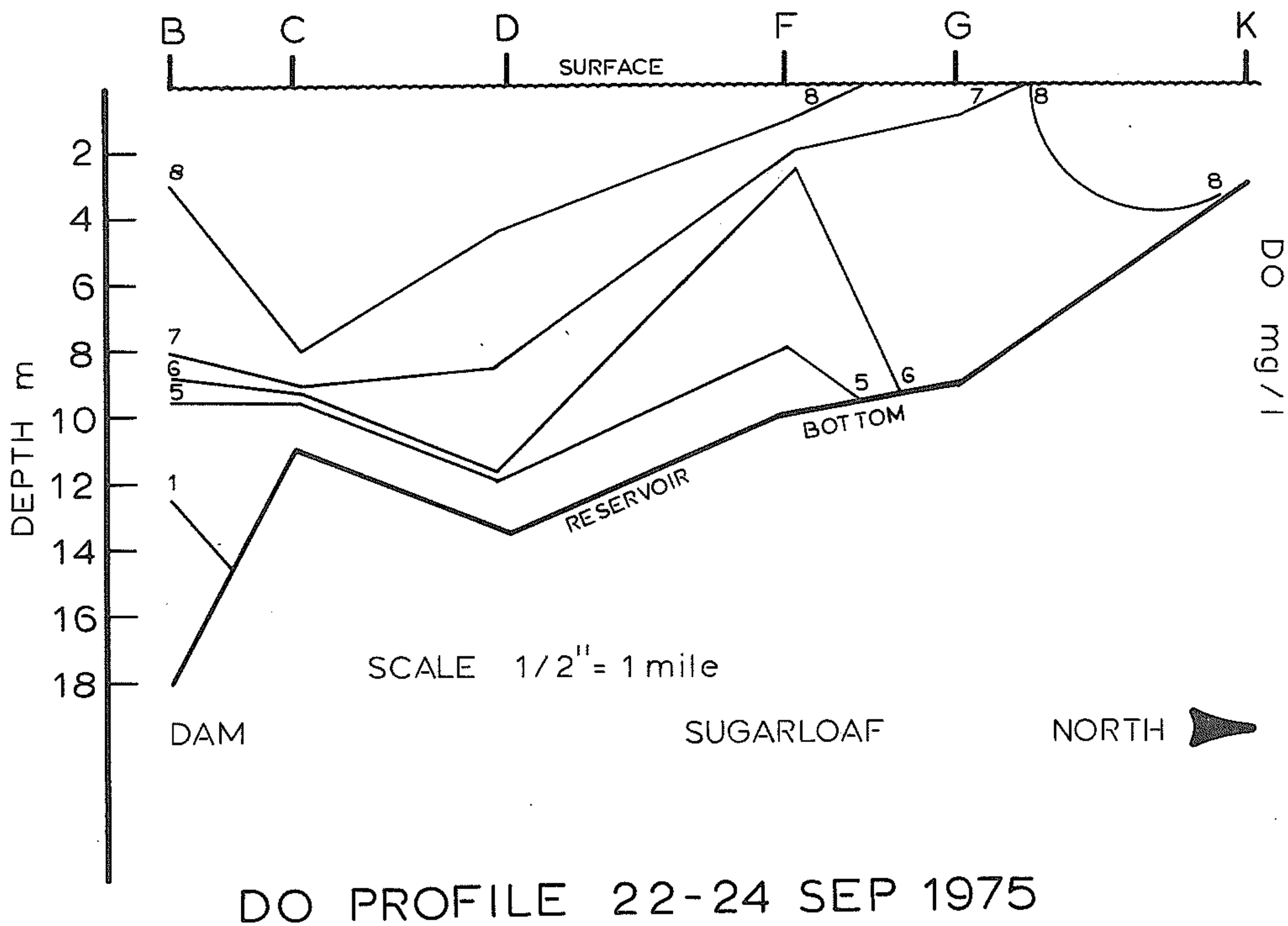


Figure 12b: Dissolved Oxygen profile, Cascade Reservoir, September 22-24, 1975.

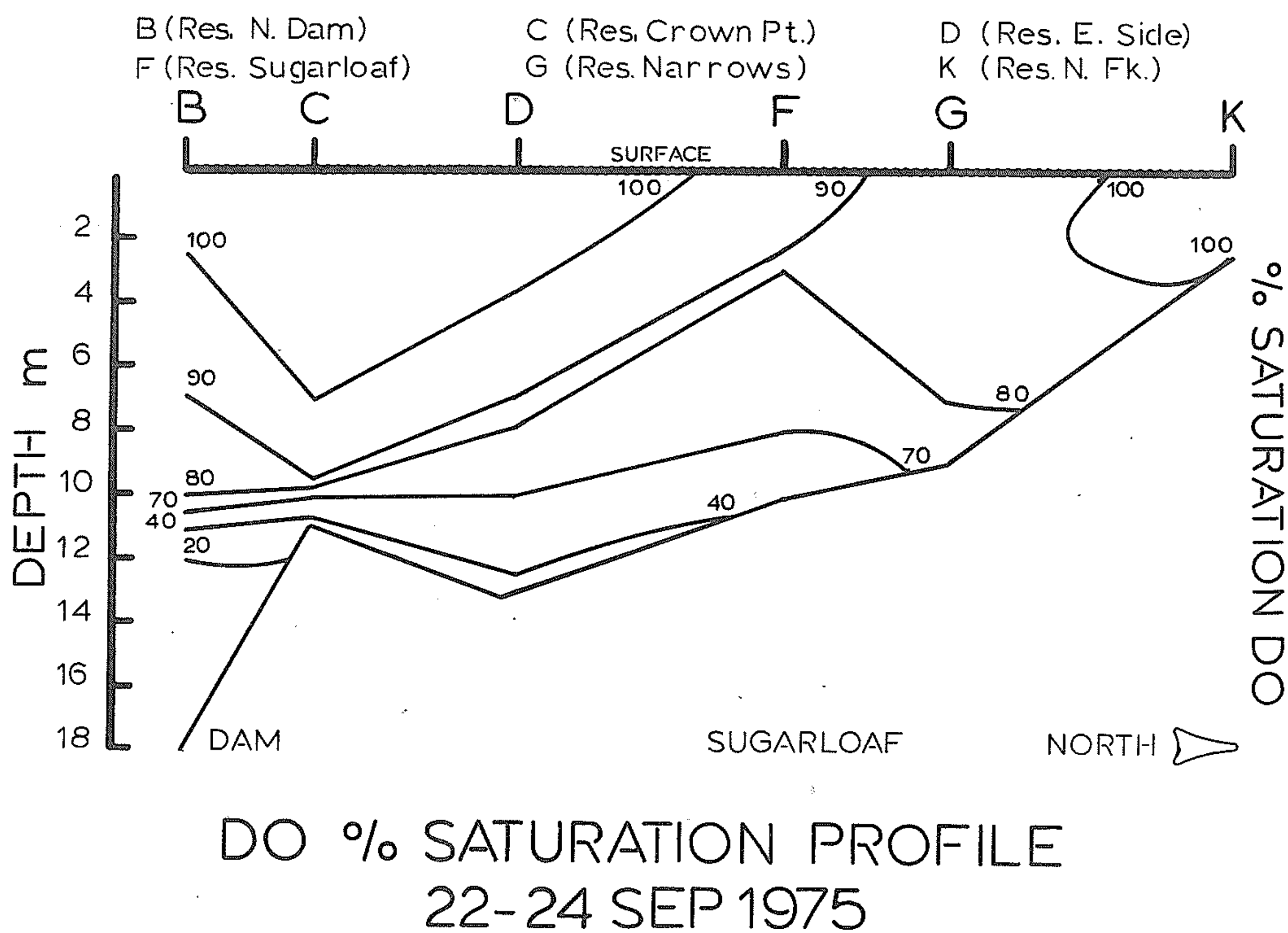


Figure 12c: Dissolved Oxygen profile (% saturation) Cascade Reservoir, September 22-24, 1975.

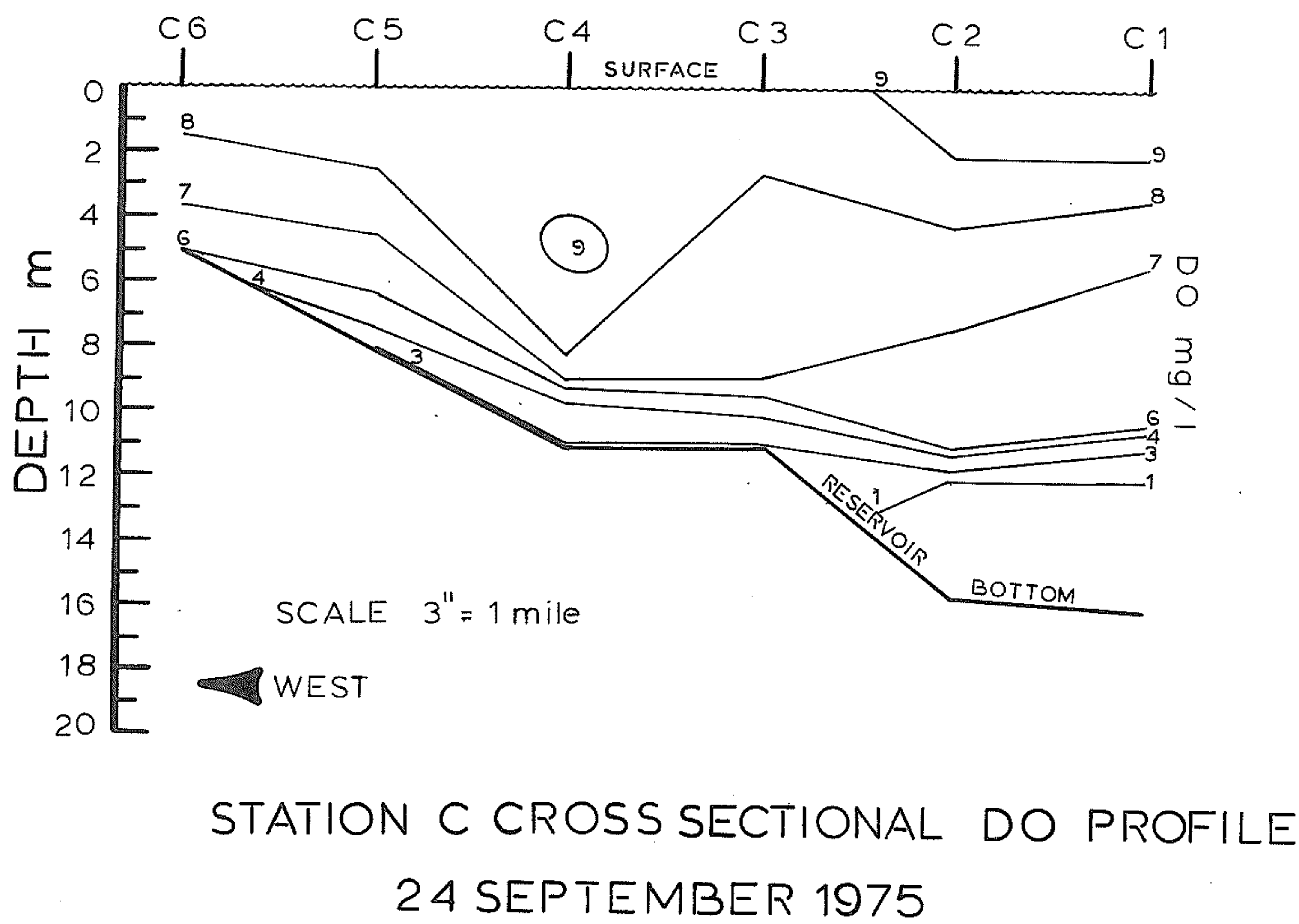
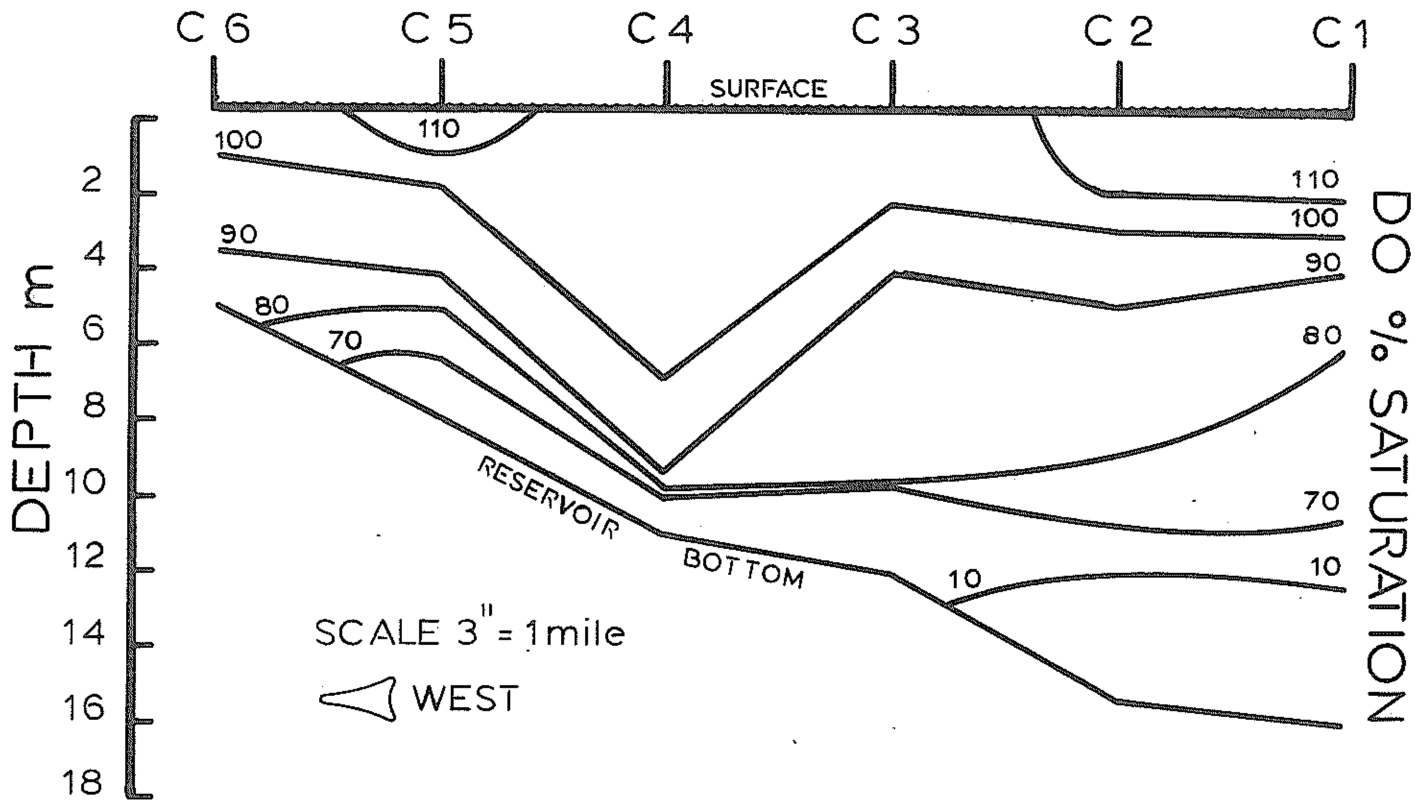


Figure 12d: Dissolved Oxygen profile, transect C, Cascade Reservoir, Sept. 24, 1975.



STATION C (Res. Crown Point)
DO % SATURATION CROSS SECTION
PROFILE

Figure 12e: Dissolved Oxygen (% saturation) profile, Transect C, Cascade Reservoir, September 22-24, 1975.

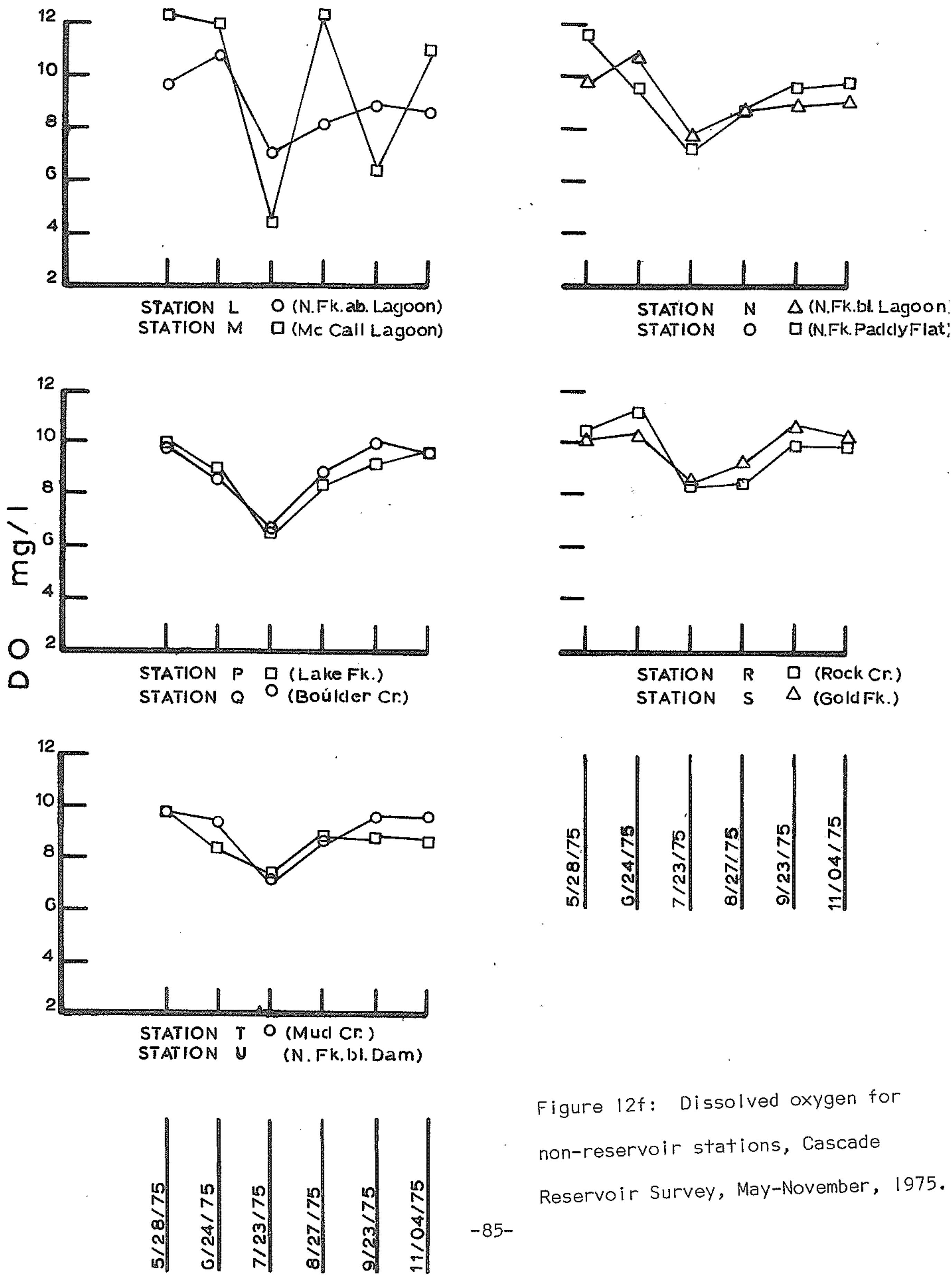


Figure 12f: Dissolved oxygen for non-reservoir stations, Cascade Reservoir Survey, May-November, 1975.

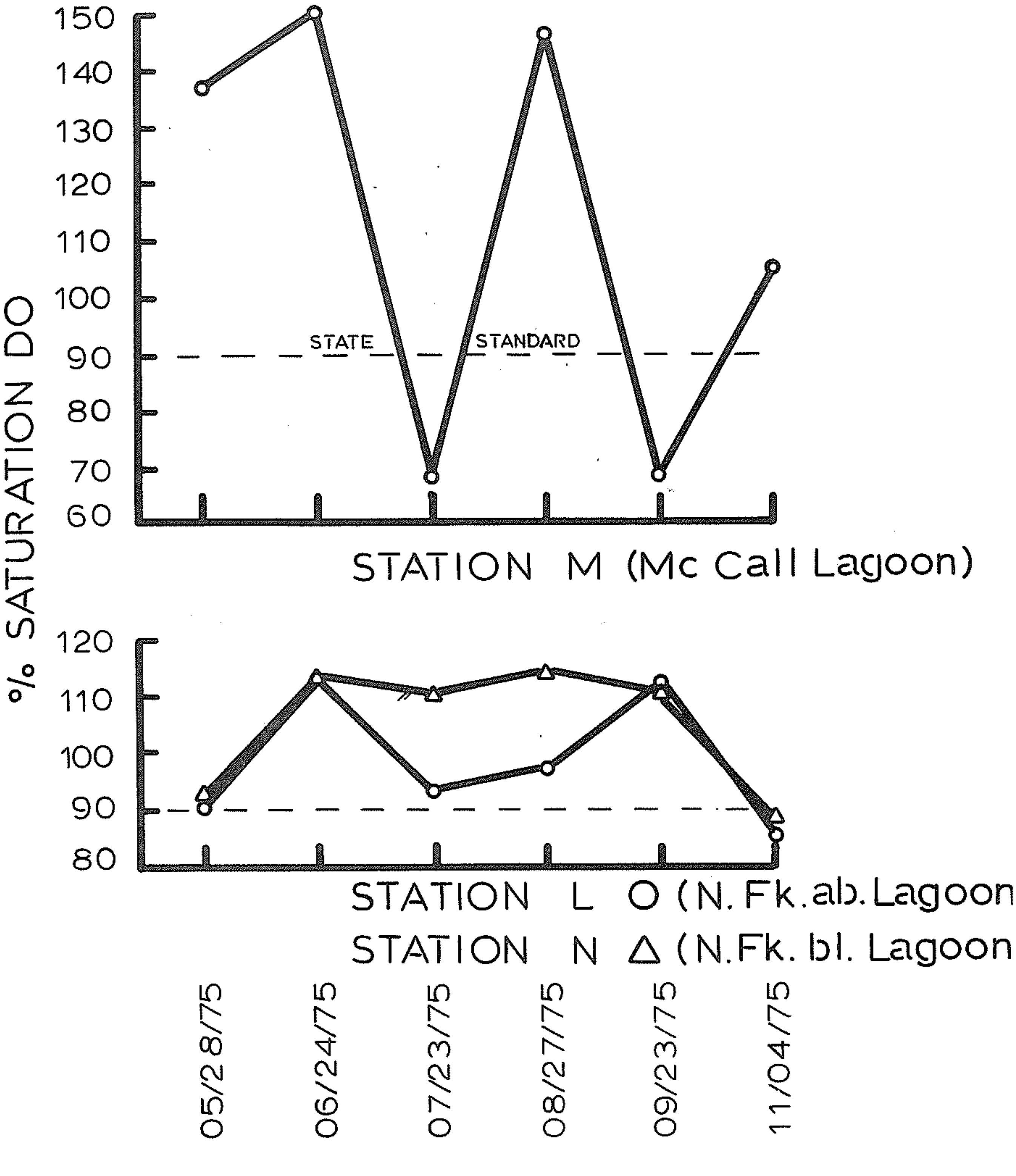


Figure 12g: Dissolved Oxygen (% saturation), stations M, L and N, Cascade Reservoir Survey, May-November, 1975.

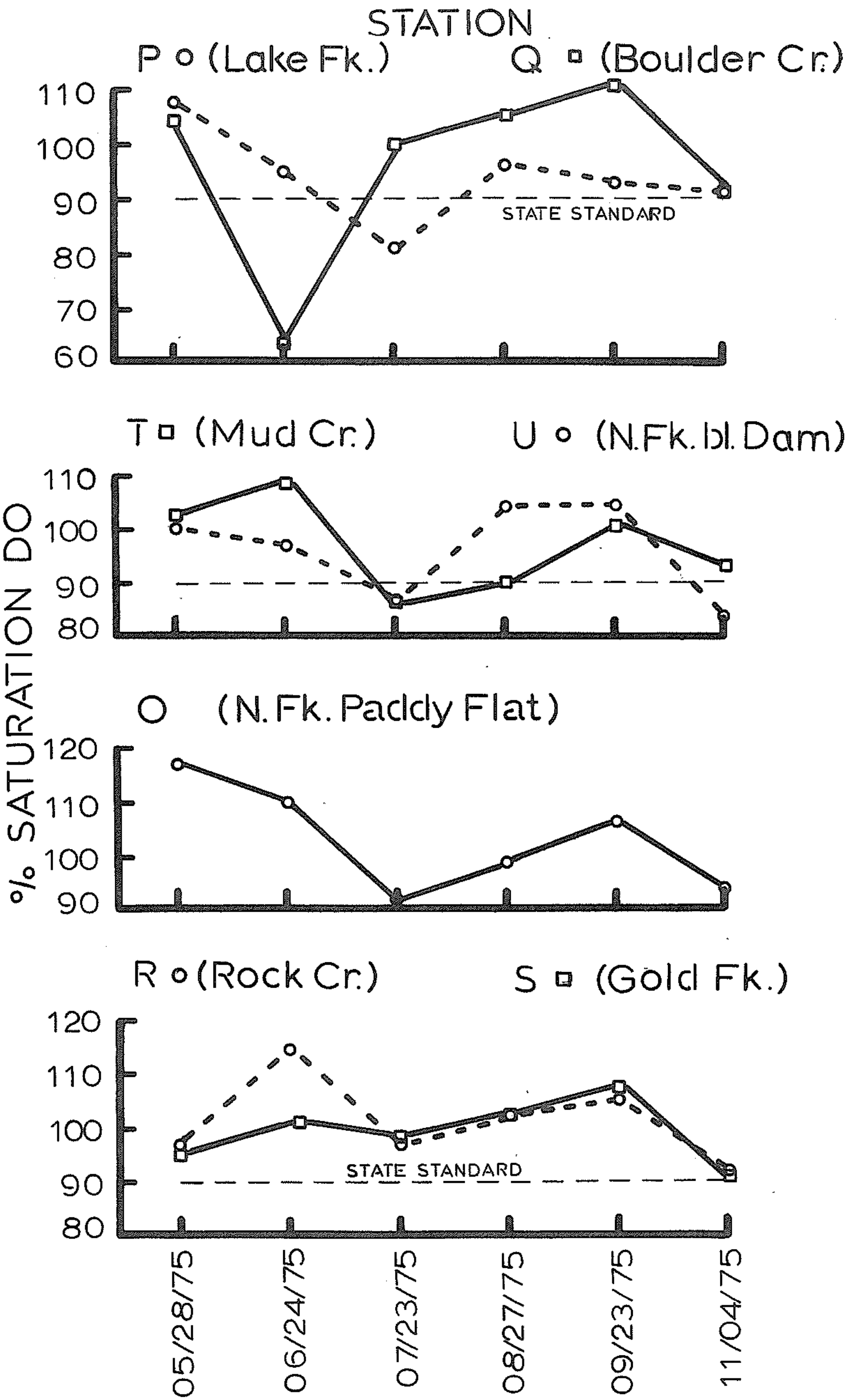


Figure 12h: Dissolved Oxygen (% saturation), stations P, Q, T, U, O, R and S, Cascade Reservoir Survey, May-November, 1975.

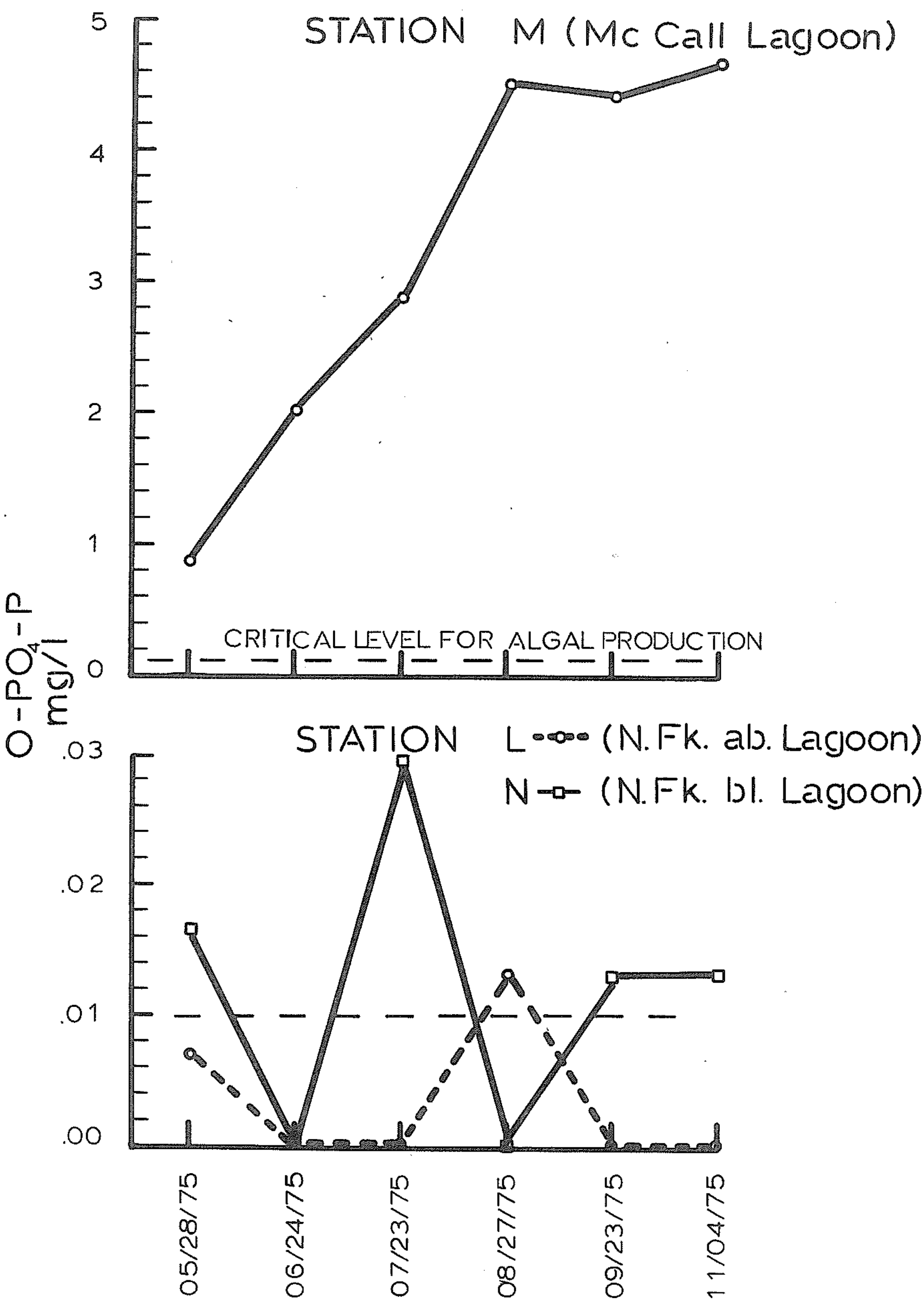


Figure 13a: Orthophosphate (as P) concentrations, stations M, L and N, Cascade Reservoir Survey, May-November, 1975.

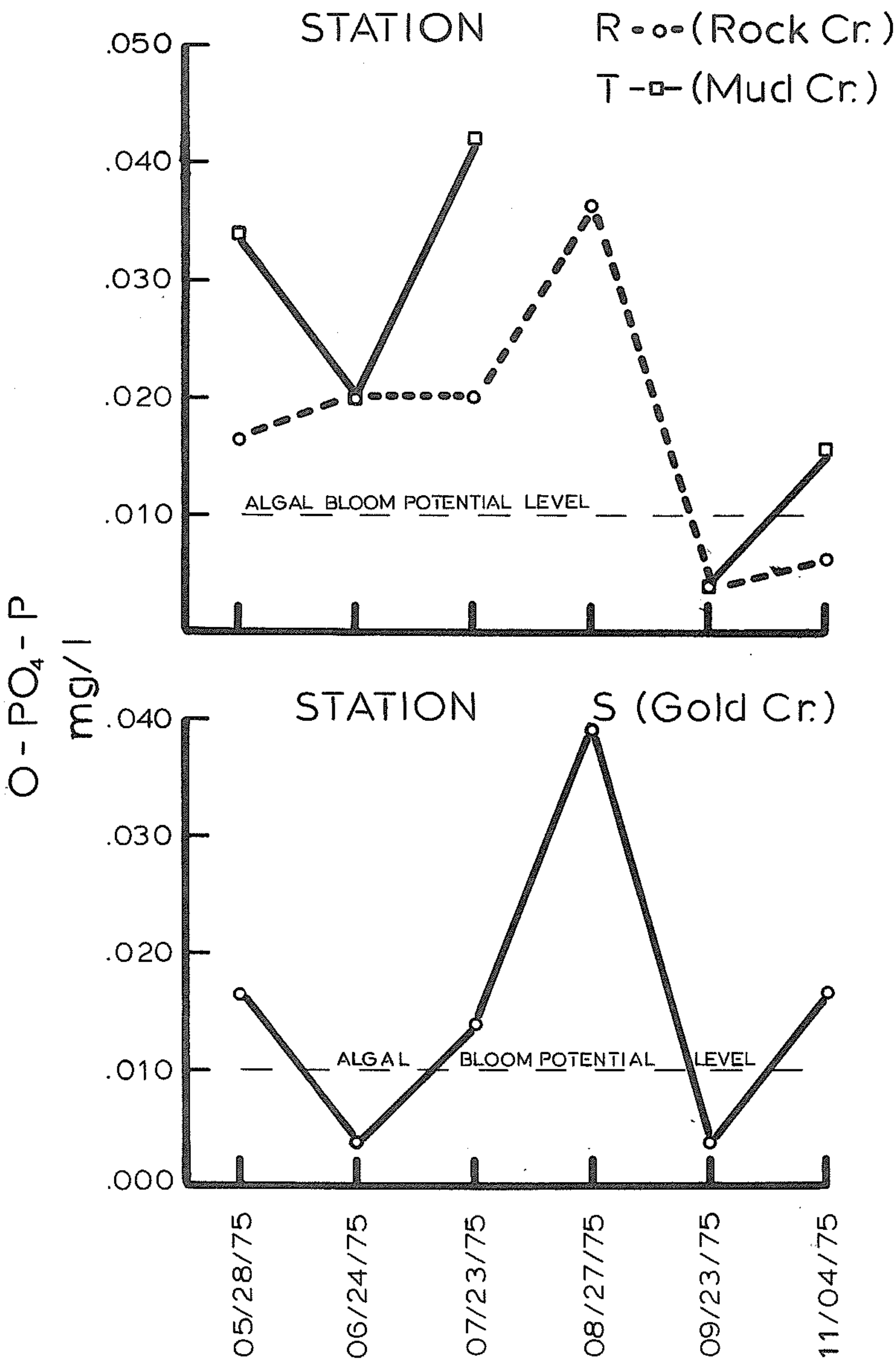


Figure 13b: Orthosphosphate (as P) concentrations, stations R, T and S, Cascade Reservoir Survey, May-November, 1975.

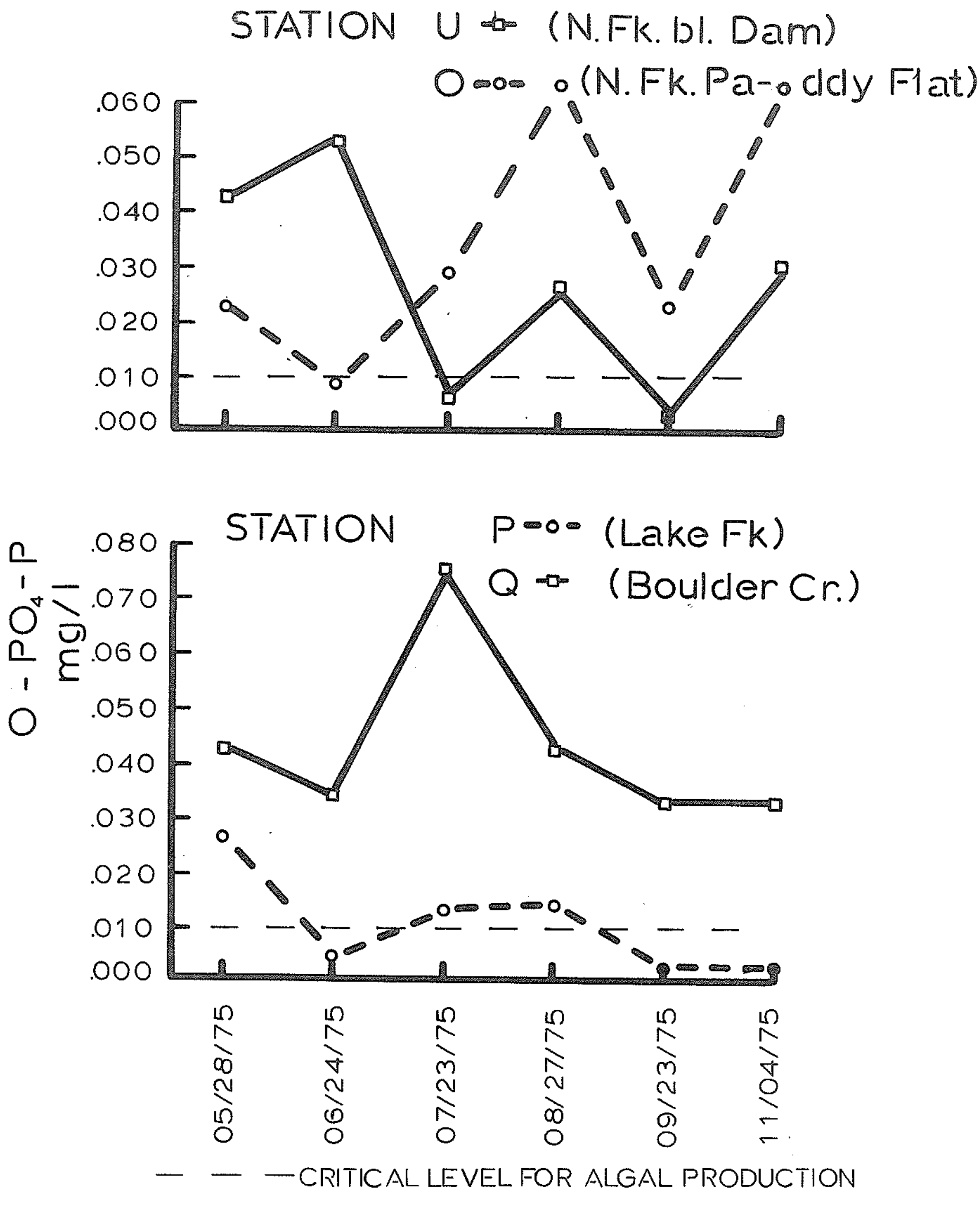


Figure 13c: Orthophosphate (as P) concentrations, stations O, U and P and Q, Cascade Reservoir Survey, May-November, 1975.

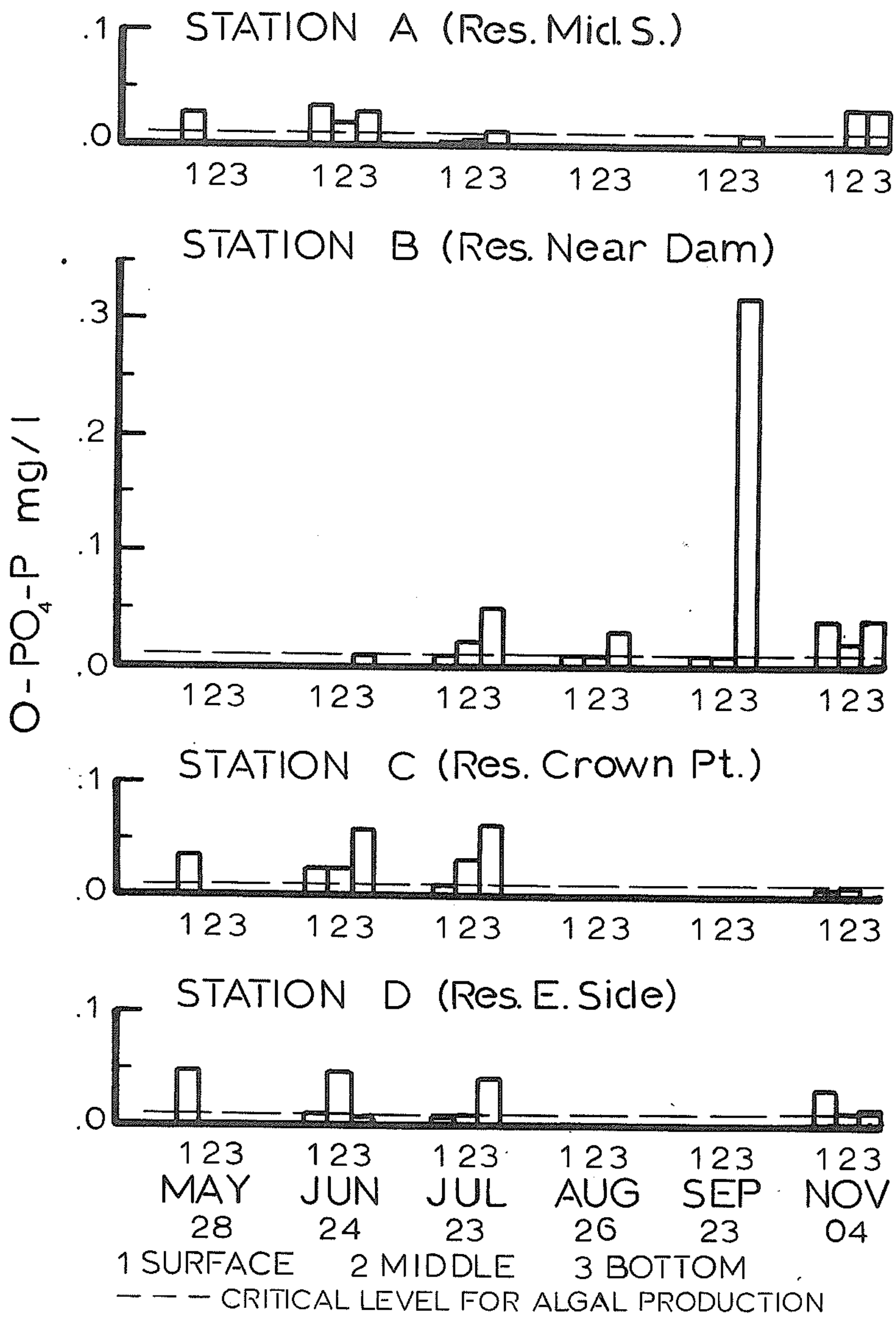


Figure 13d: Orthophosphate (as P) concentrations, stations A-D, Cascade Reservoir Survey, May-November, 1975.

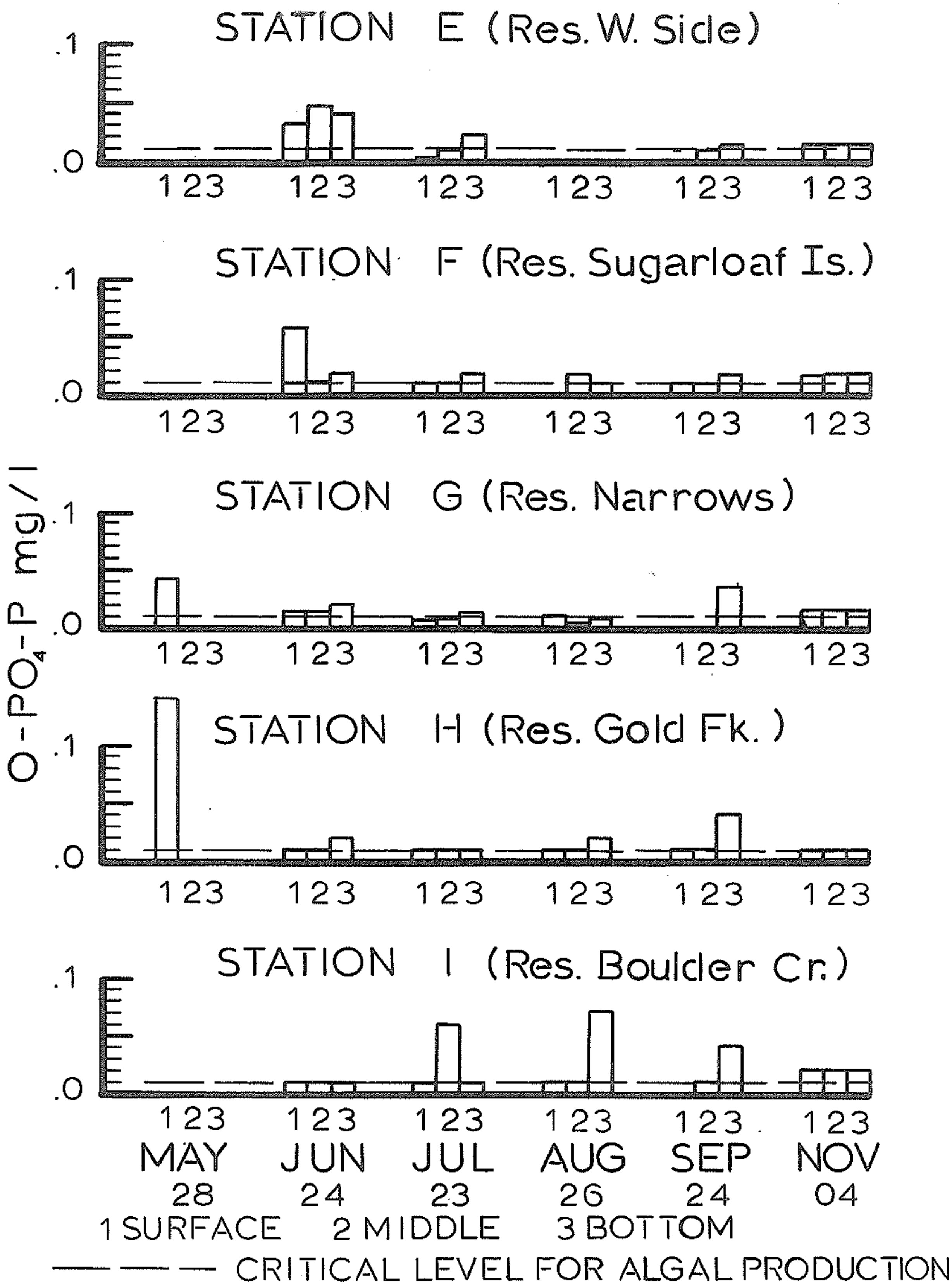


Figure 13e: Orthophosphate (as P) concentrations, stations E-I, Cascade Reservoir Survey, May-November, 1975.

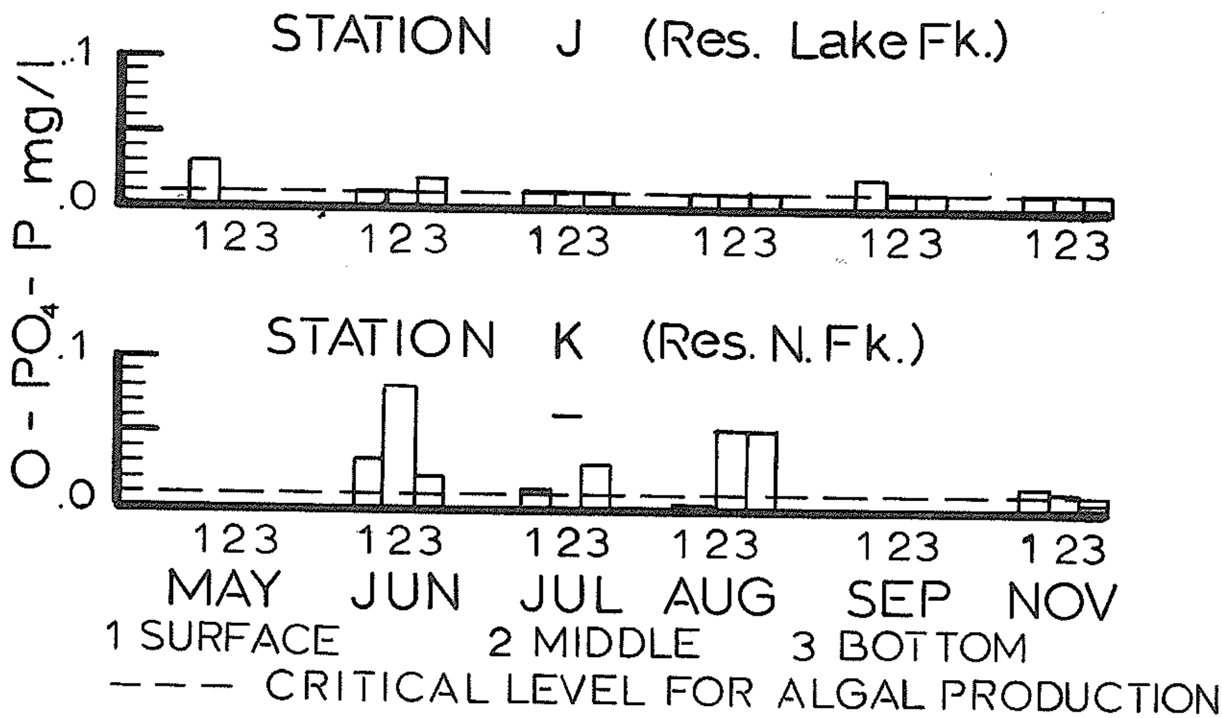


Figure 13f: Orthophosphate (as P) concentrations, stations J-K, Cascade Reservoir Survey, May-November, 1975.

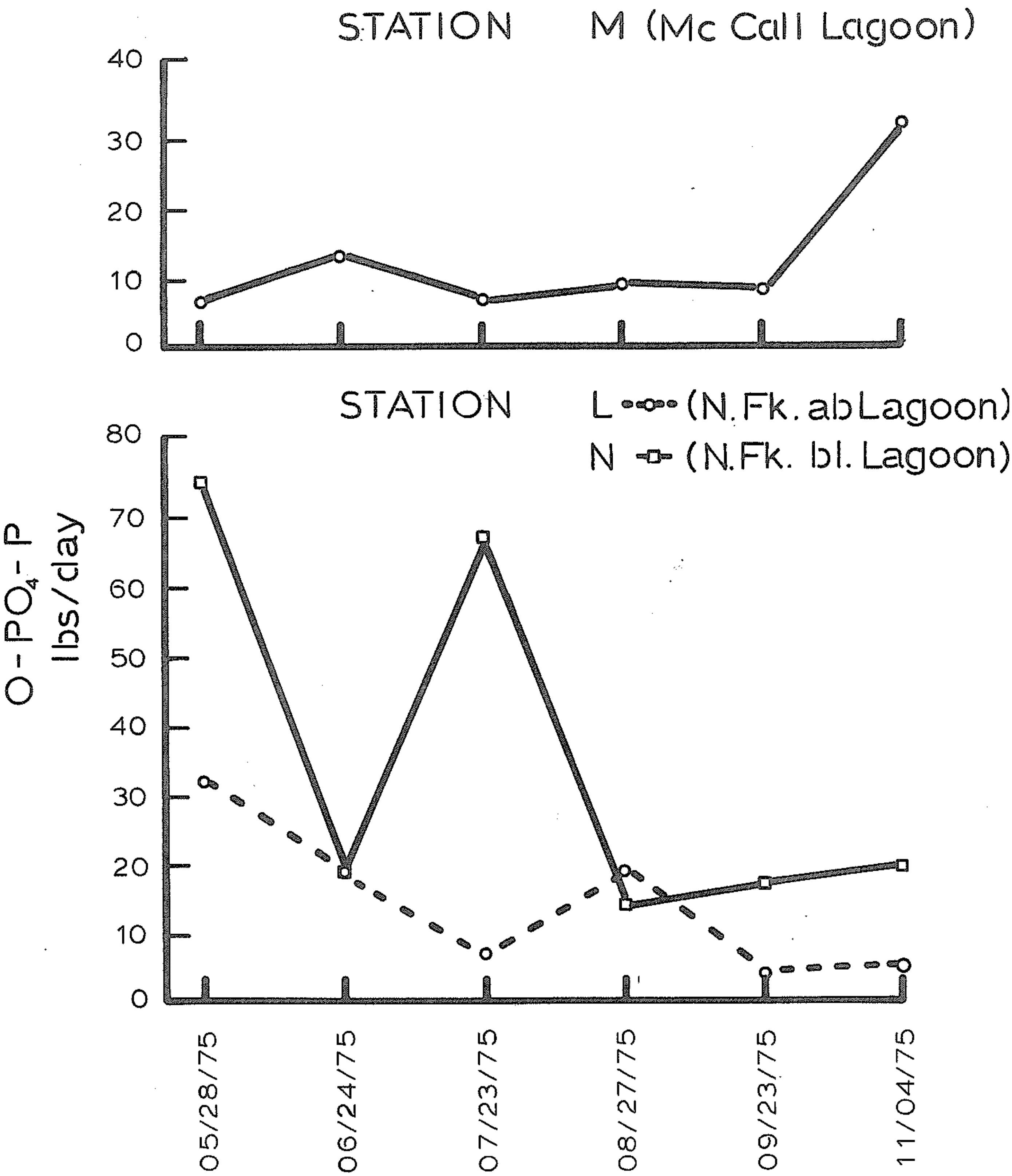


Figure 13g: Orthophosphate (as P) loadings, stations M, L and N, Cascade Reservoir Survey, May-November, 1975.

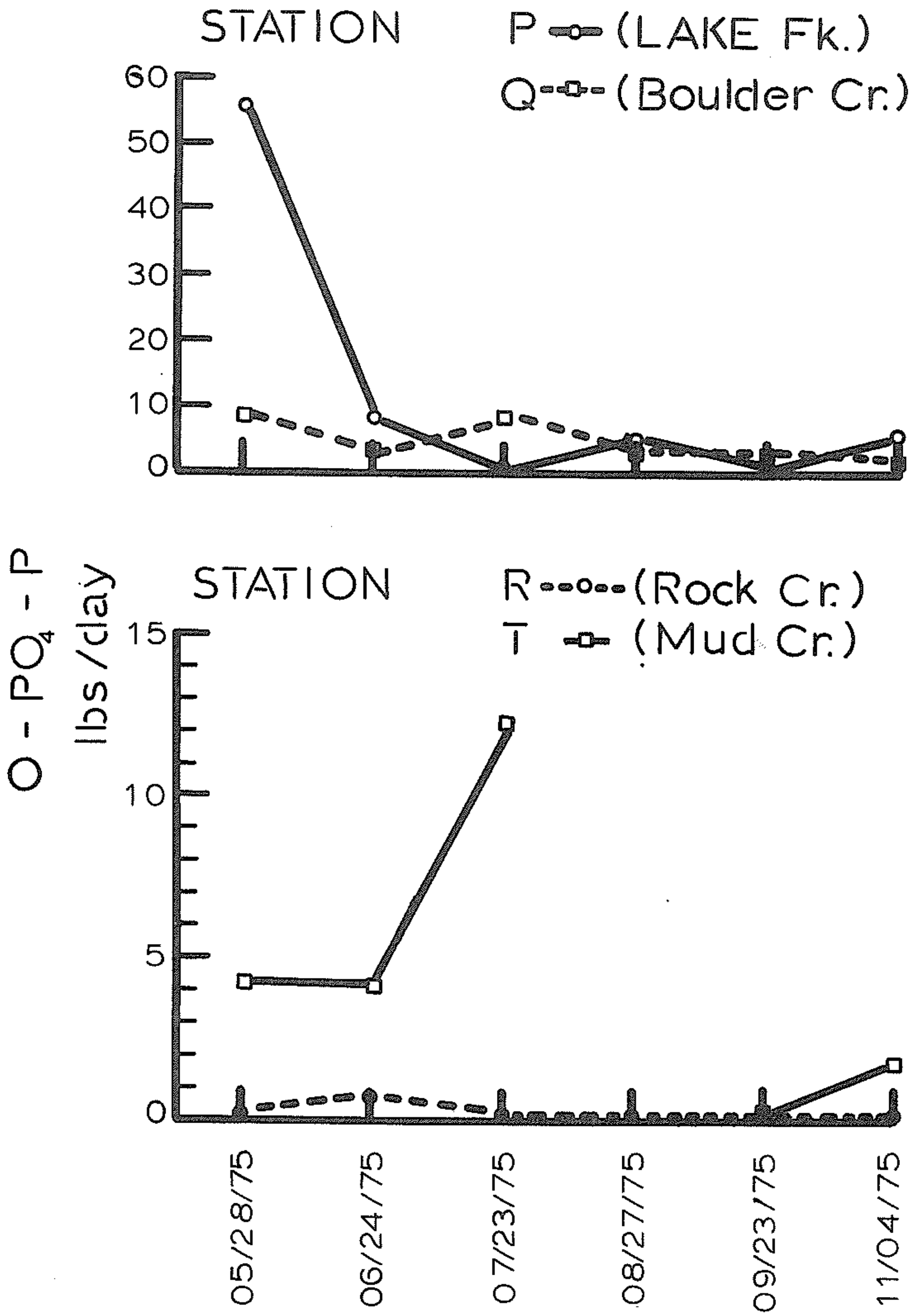


Figure 13h: Orthophosphate (as P) loadings, stations P, Q, R and T, Cascade Reservoir Survey, May-November, 1975.

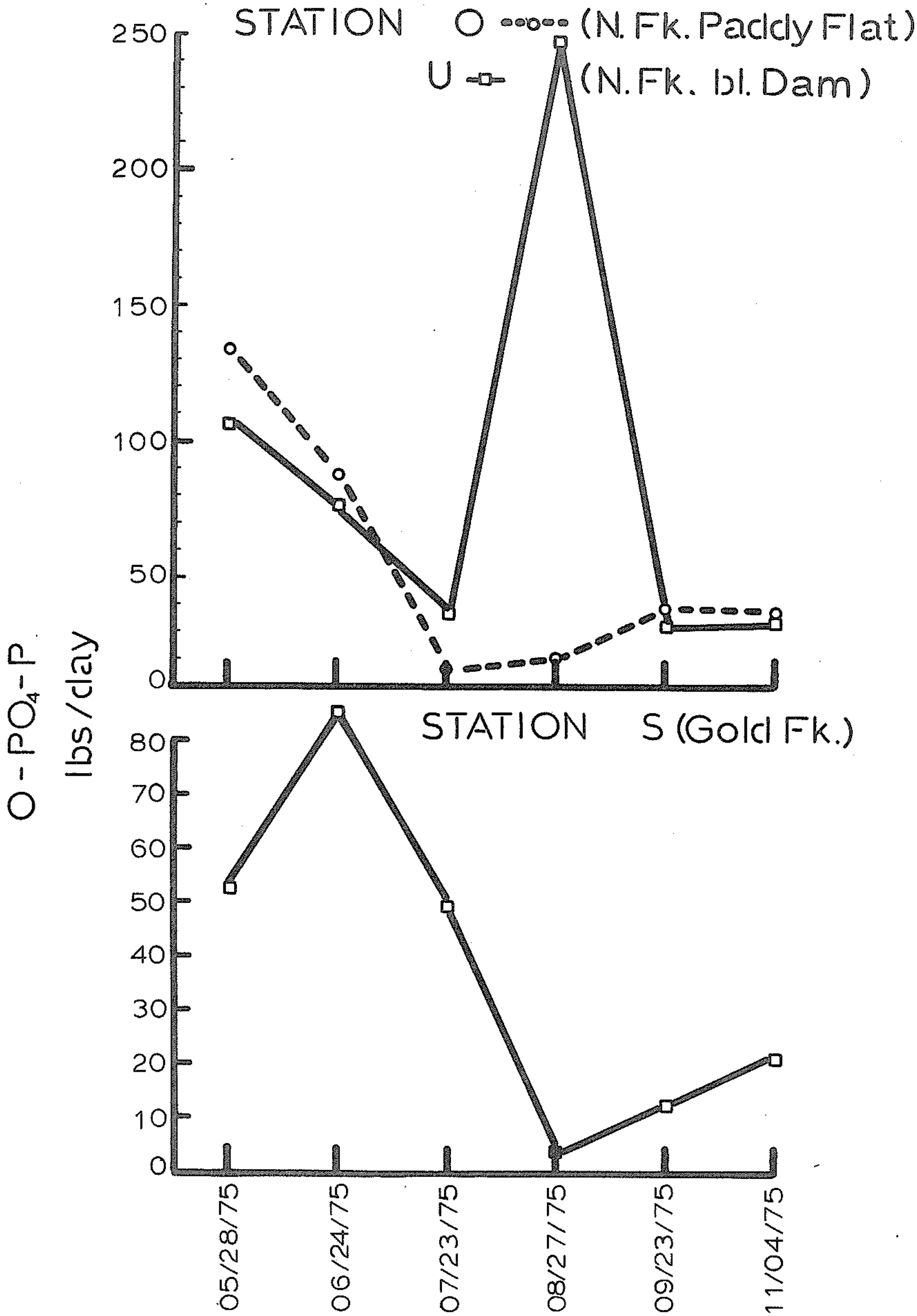


Figure 13i: Orthophosphate (as P) loadings, stations O, U and S, Cascade Reservoir Survey, May-November, 1975.

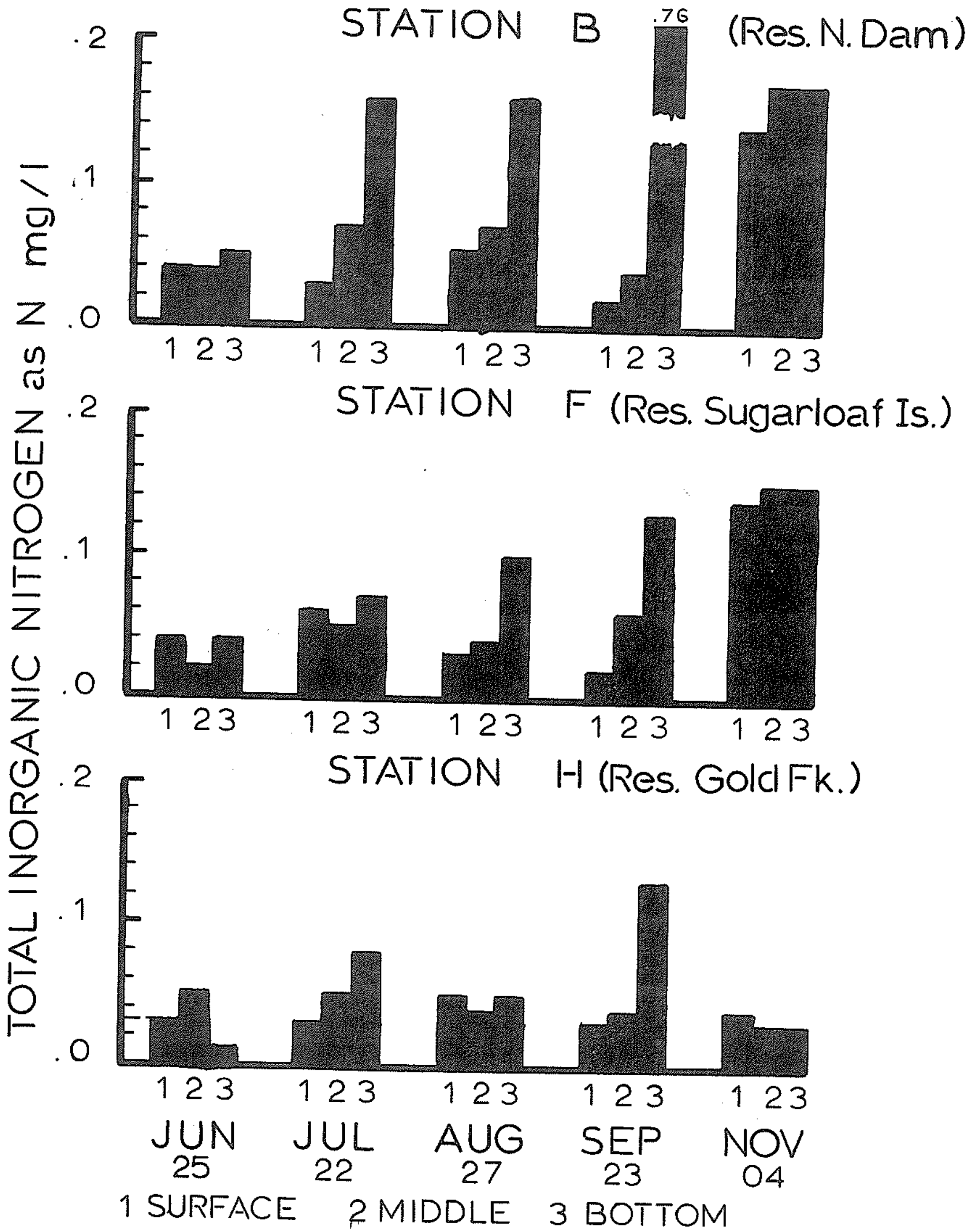


Figure 14a: Total inorganic nitrogen (as N) concentrations, stations B, F and H at three levels, Cascade Reservoir, June-November, 1!

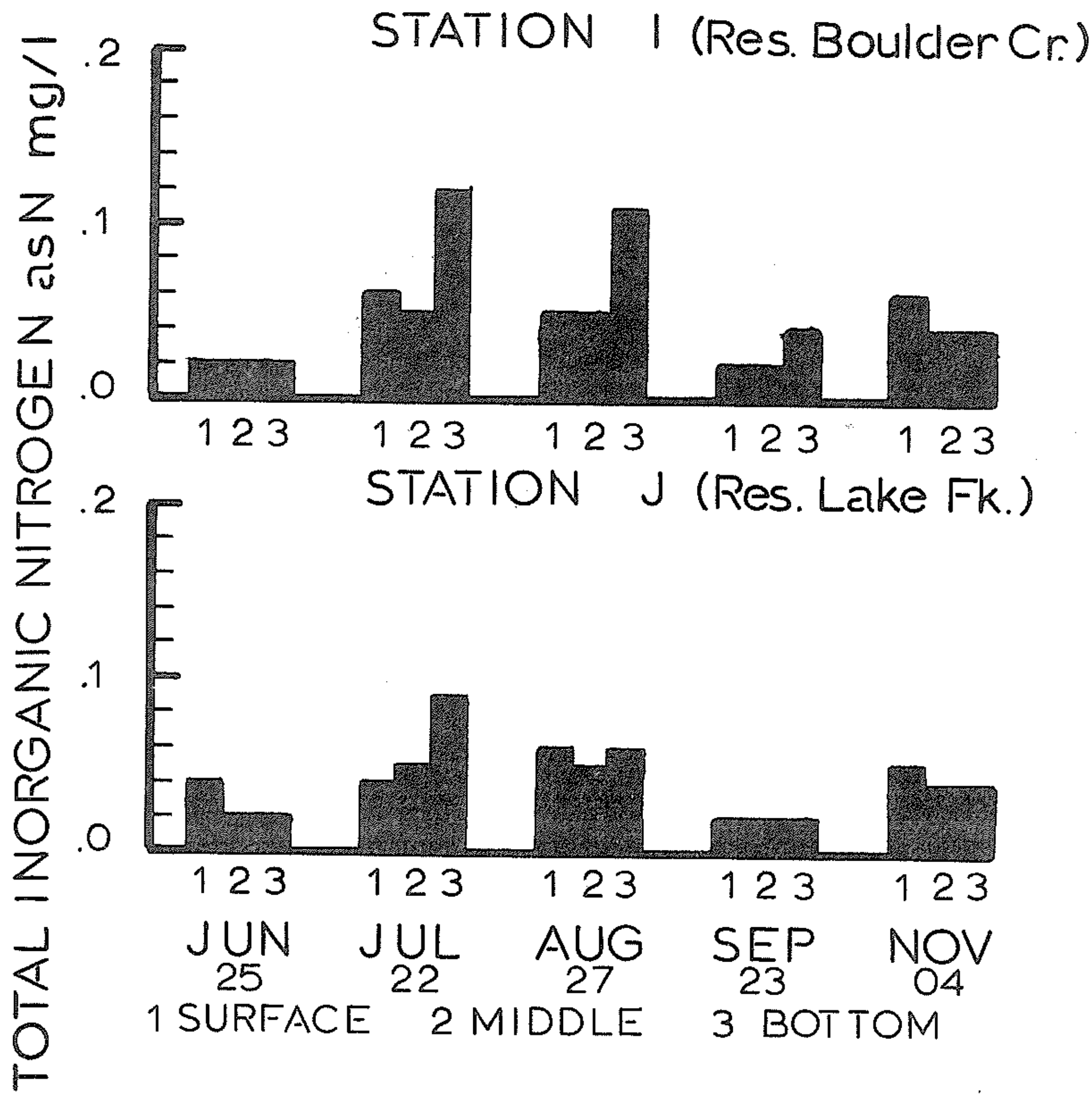


Figure 14b: Total inorganic nitrogen (as N) concentrations, stations I and J at three levels, Cascade Reservoir, June-November, 1975.

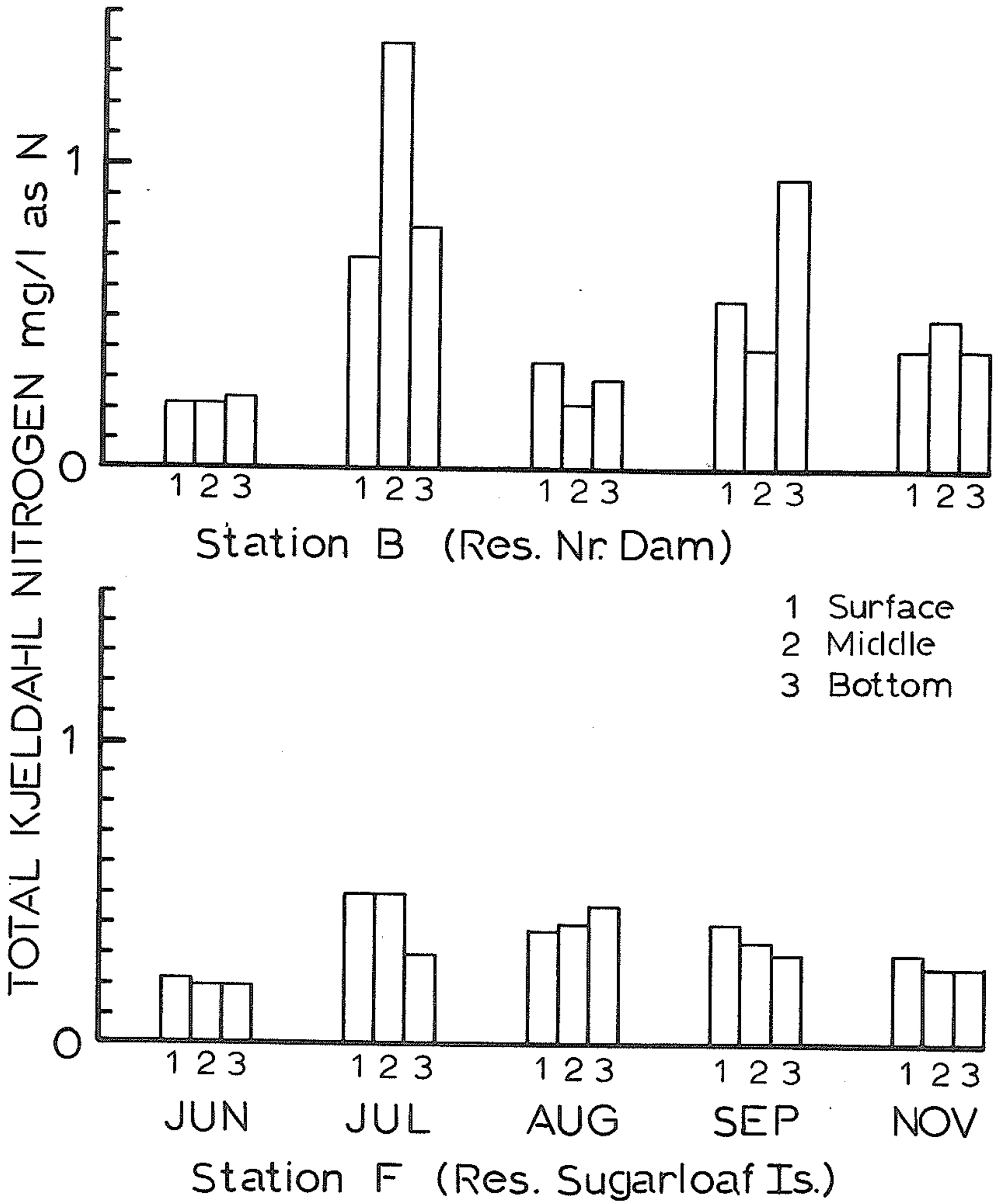


Figure 15a: Total Kjeldahl nitrogen (as N) concentrations for stations B and F, Cascade Reservoir, 1975.

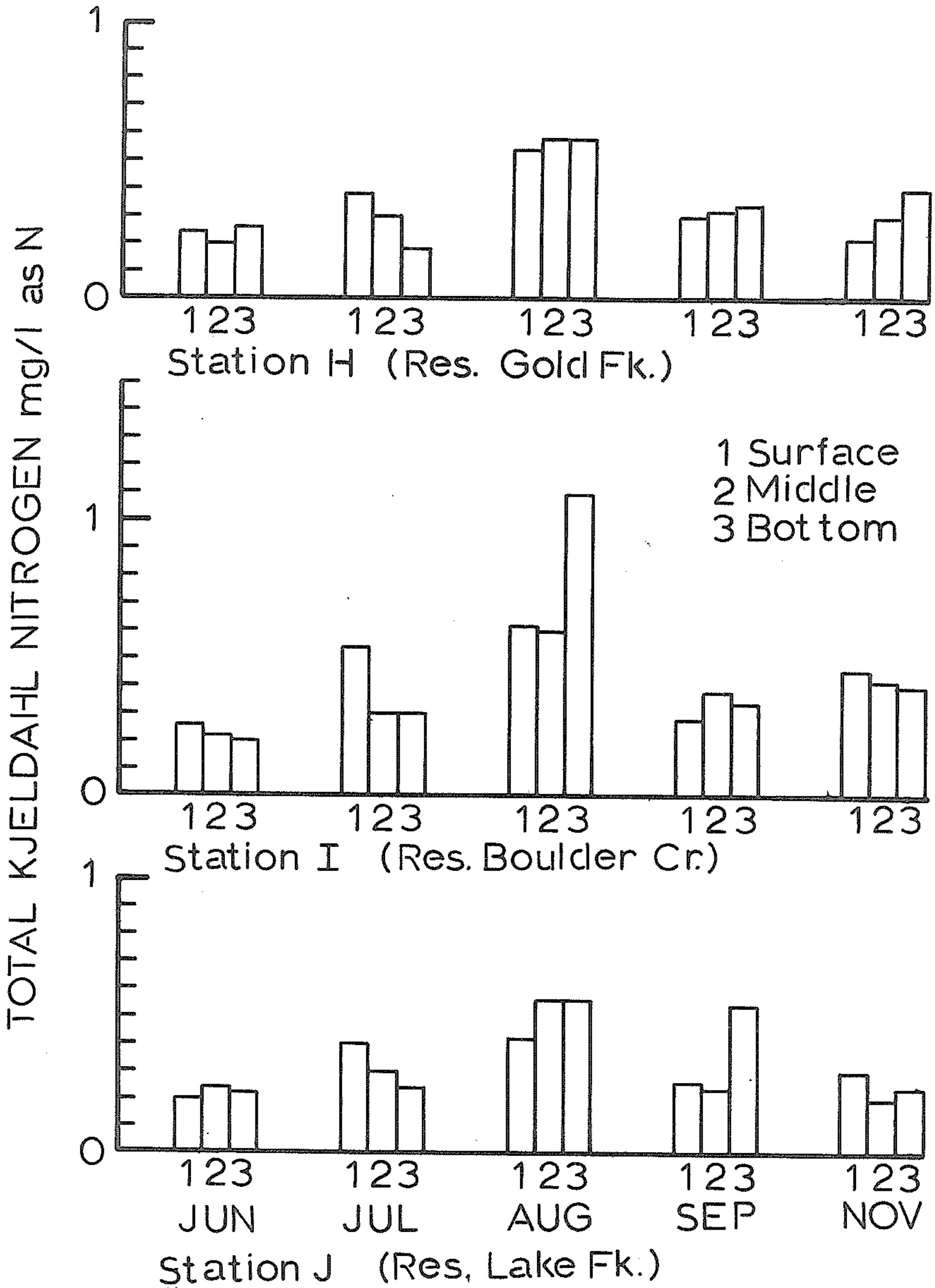


Figure 15b: Total kjeldahl nitrogen (as N) concentrations for station H, I and J, Cascade Reservoir, 1975.

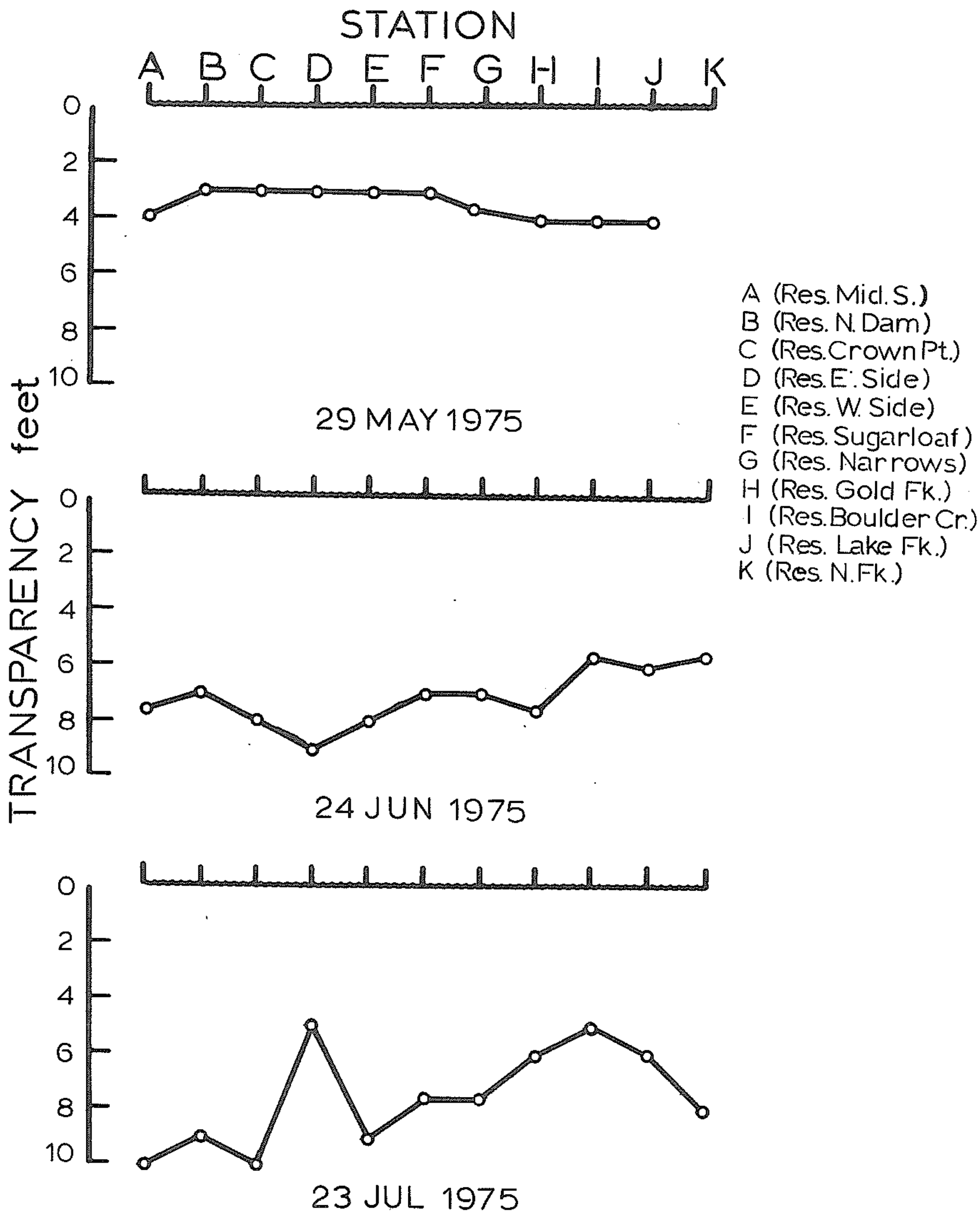


Figure 16a: Transparency for Cascade Reservoir, May-July, 1975.

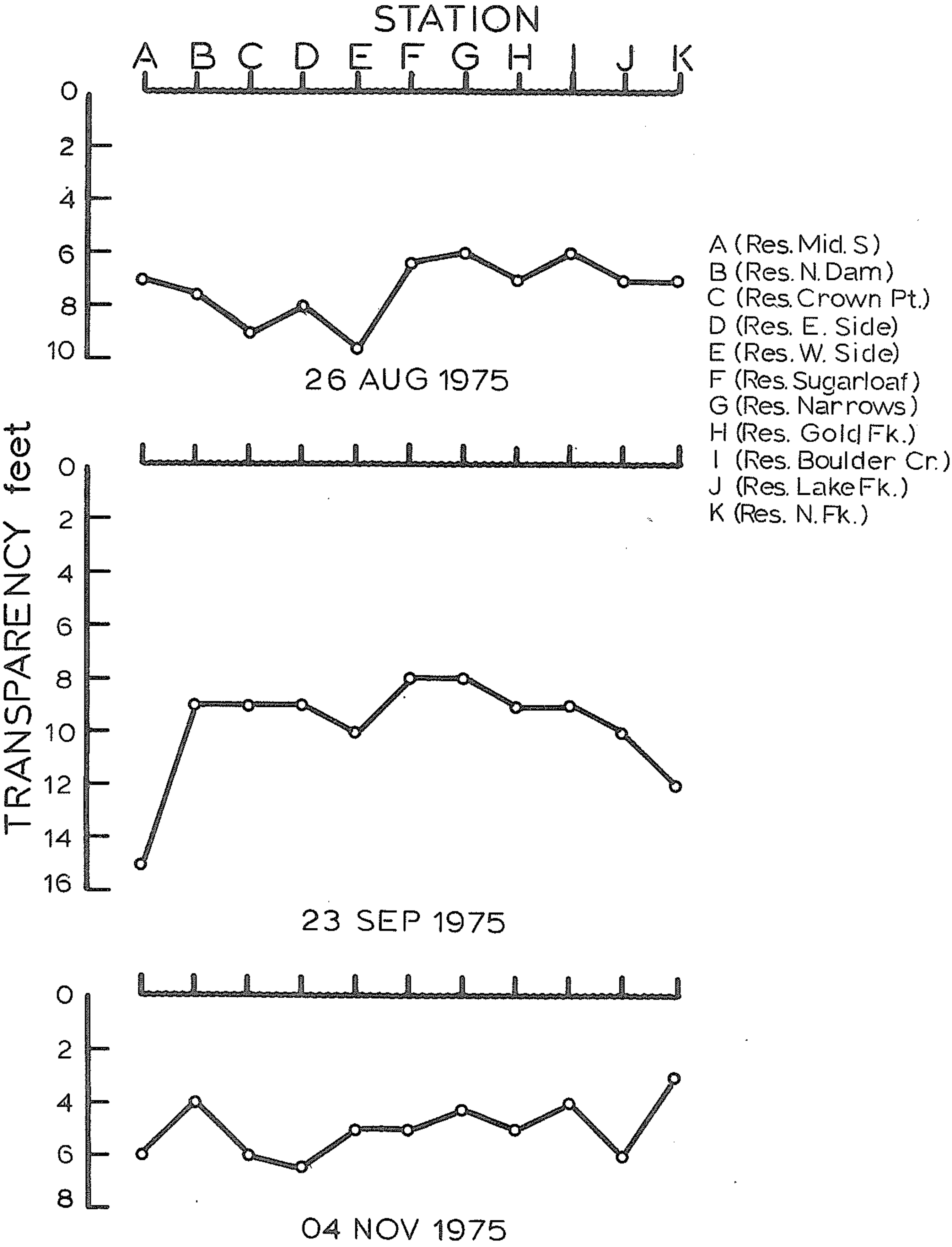


Figure 16b: Transparency for Cascade Reservoir, August-November, 1975.

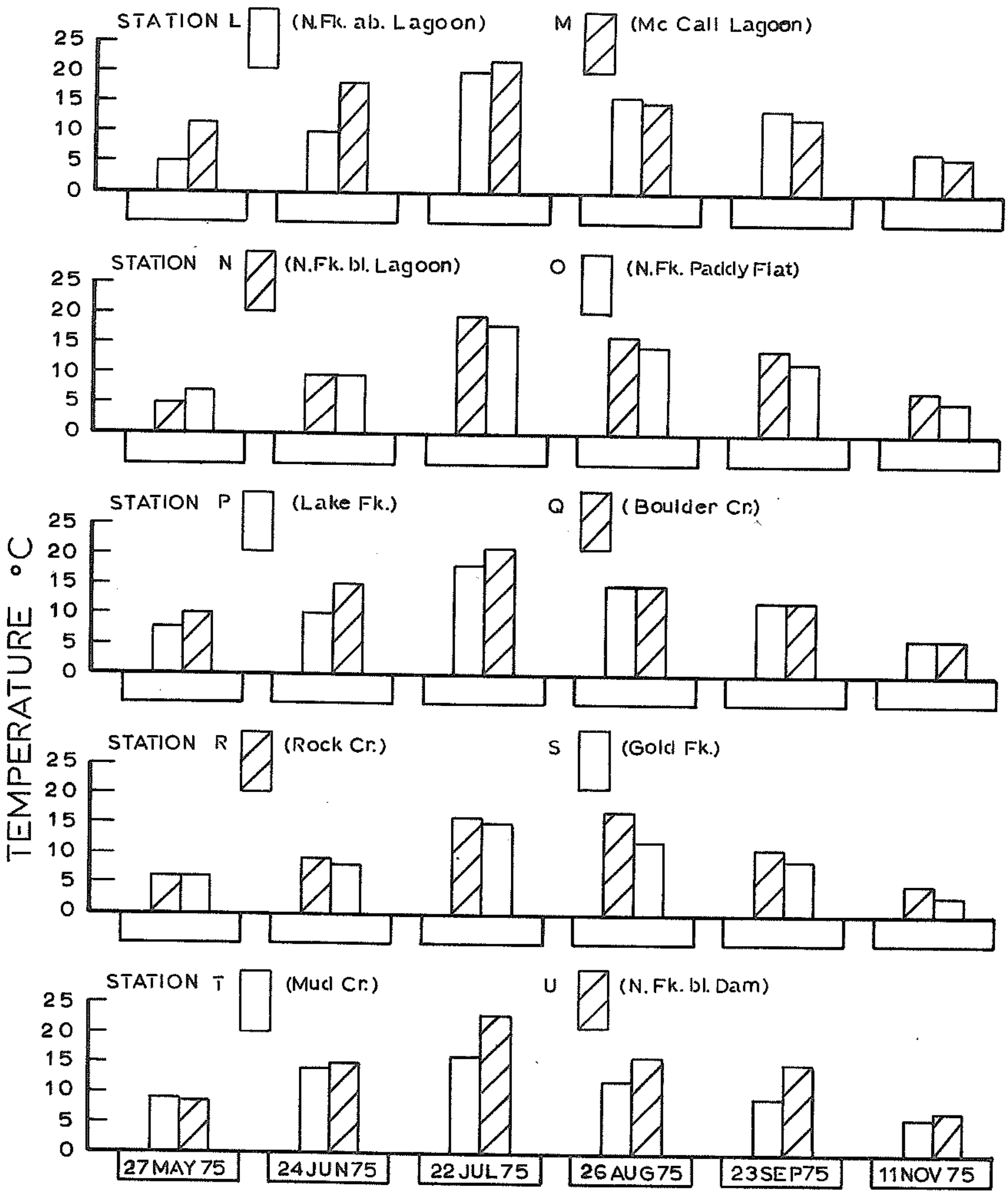


Figure 17: Temperatures for stream stations for Cascade Reservoir Survey, May - November, 1975.

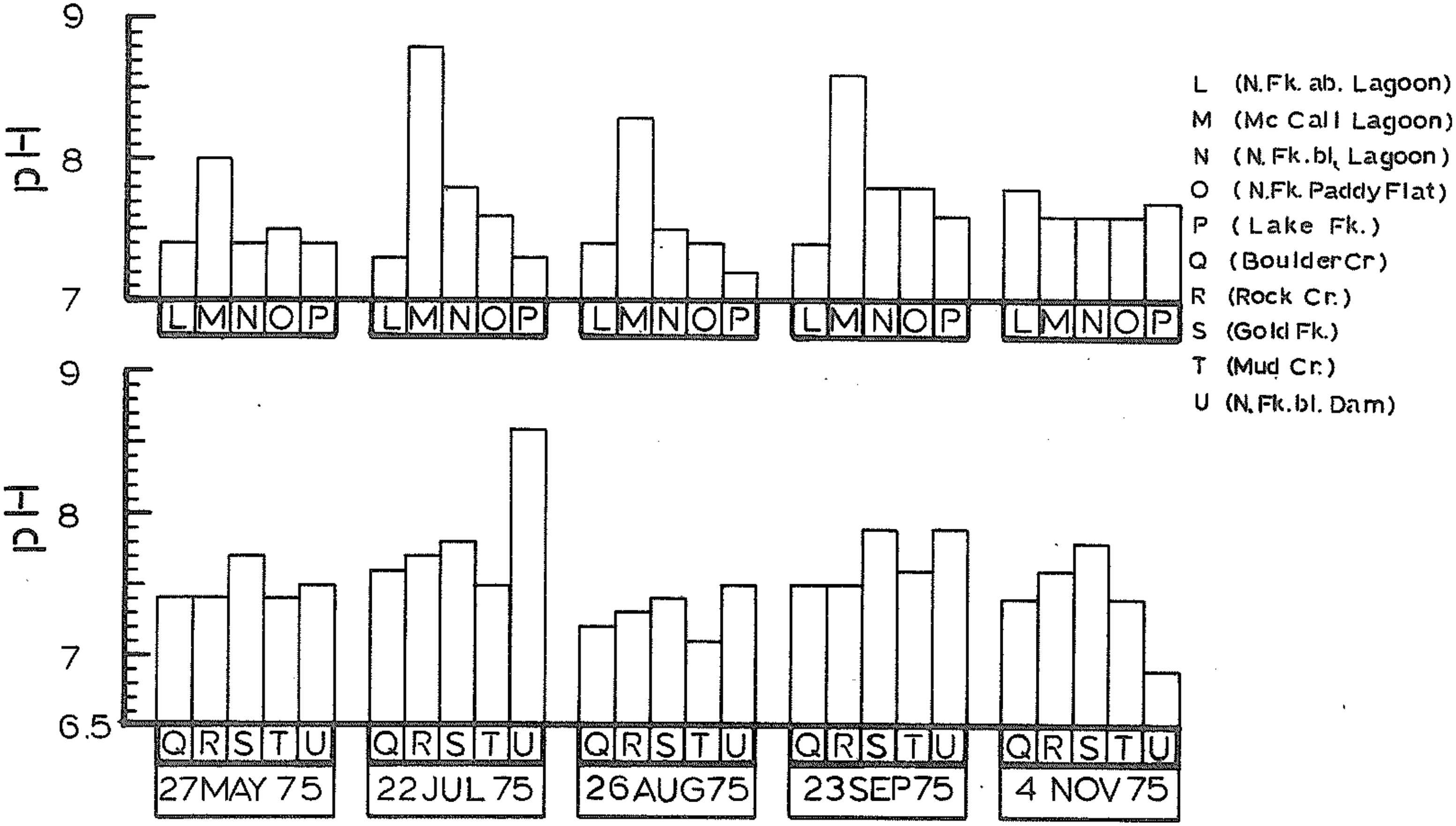


Figure 18: pH values for stream stations for Cascade Reservoir Survey, May - November, 1975.

Figure 19: Cascade Reservoir at approximately Station G, facing east, showing some of the near shore development.
Photo May 30, 1975

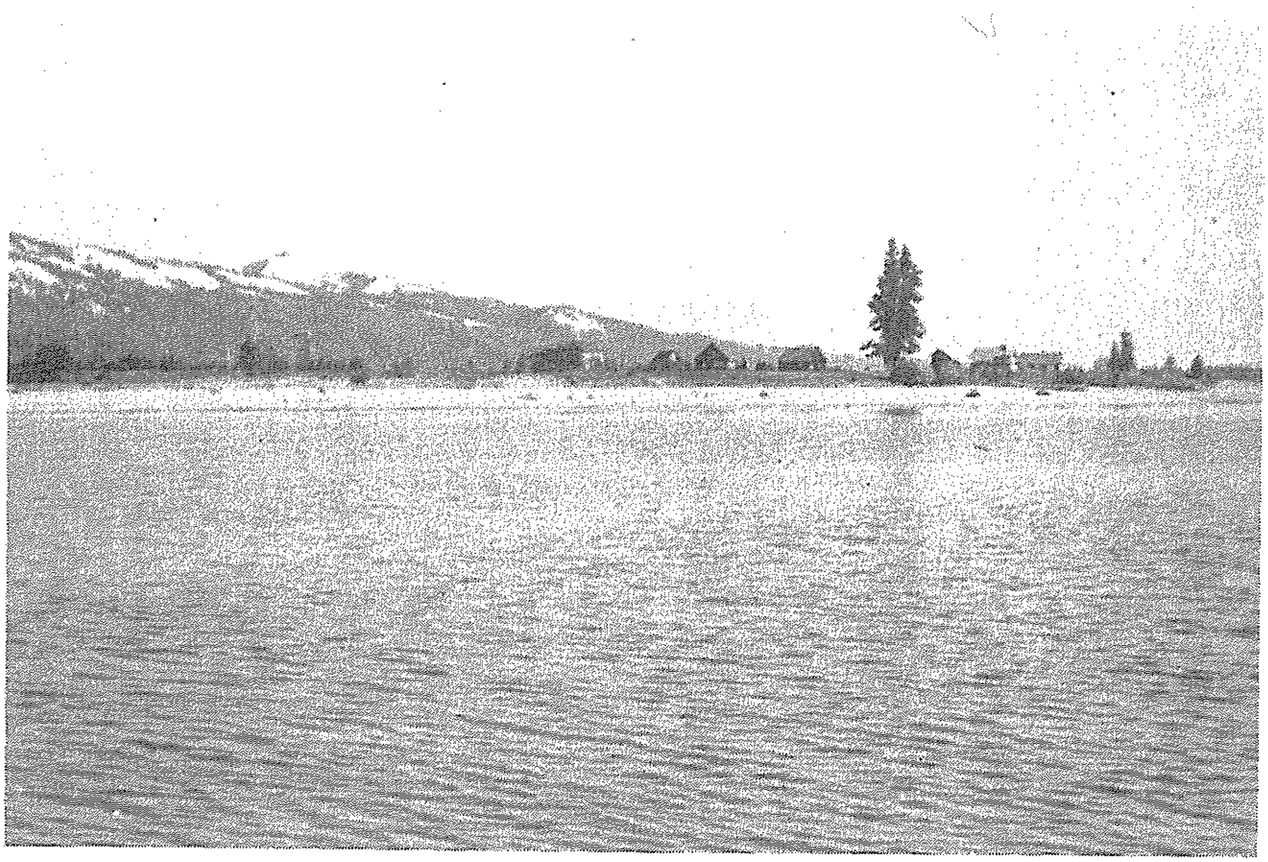


Figure 20: Confined livestock area along Boulder Creek, a possible nonpoint source input. Photo May 6, 1975.

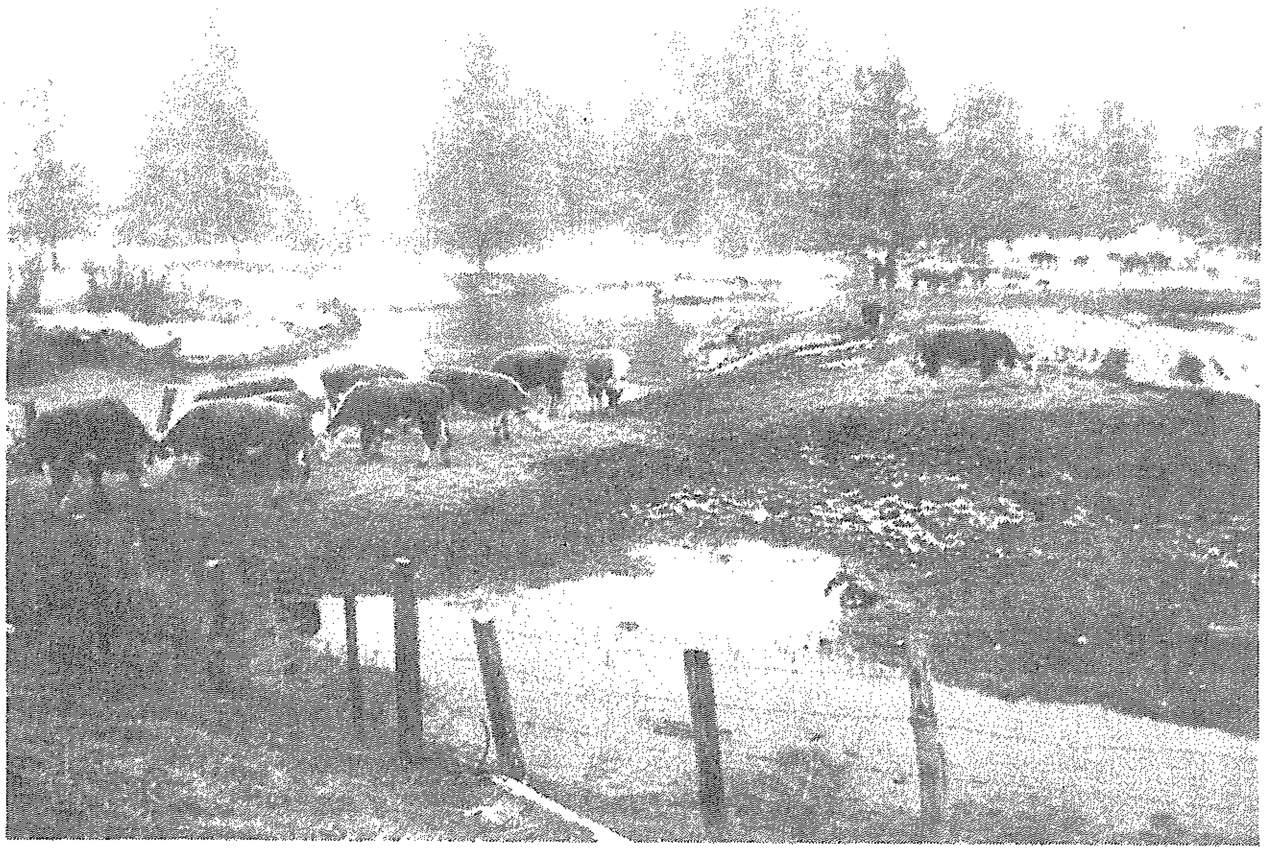


Figure 21a: Colony of *Pectinatella magnifica*, Lake Fork Arm, near Station J. Photo September 23, 1975. Scale is 15 cm.

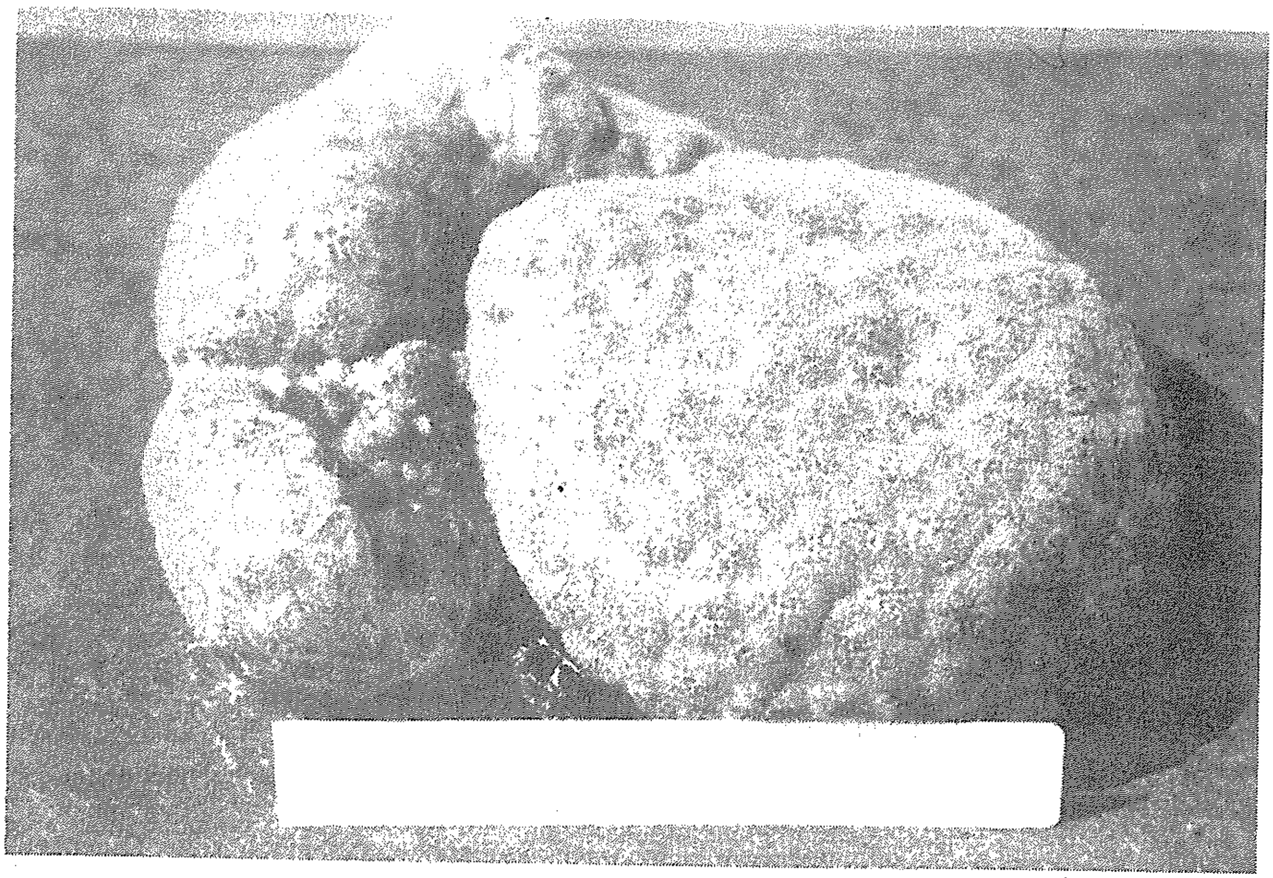


Figure 21b: Gelatinous center of _Pectinatella magnifica_ colony, Lake Fork Arm, near Station J. Photo September 23, 1975. Scale is 15 cm.

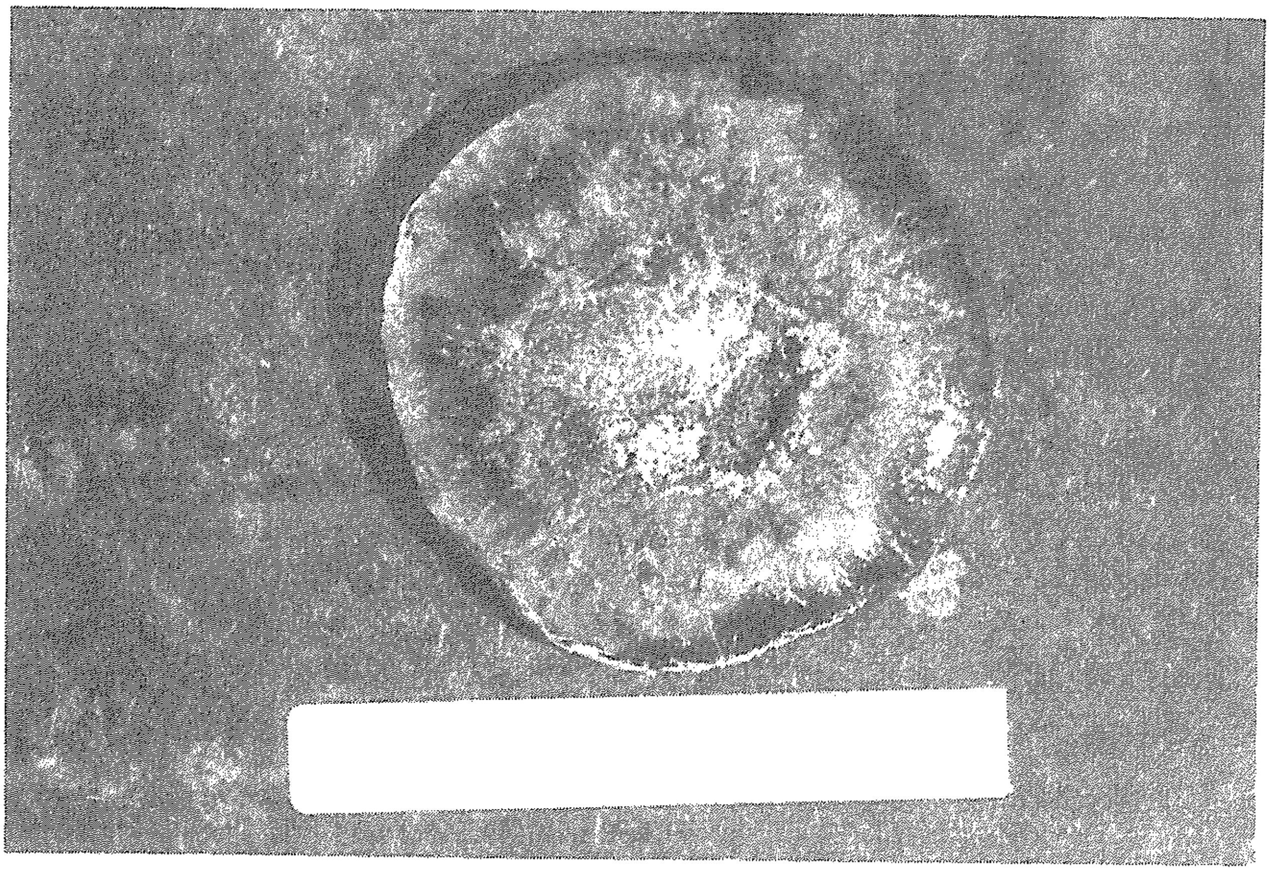


Figure 22: Photograph of Cascade Reservoir surface at Station B from a distance of 2 m. Clumped phytoplankton dominated by *Aphanizomenon* are readily visible. Photo September 24, 1975 from color infared.

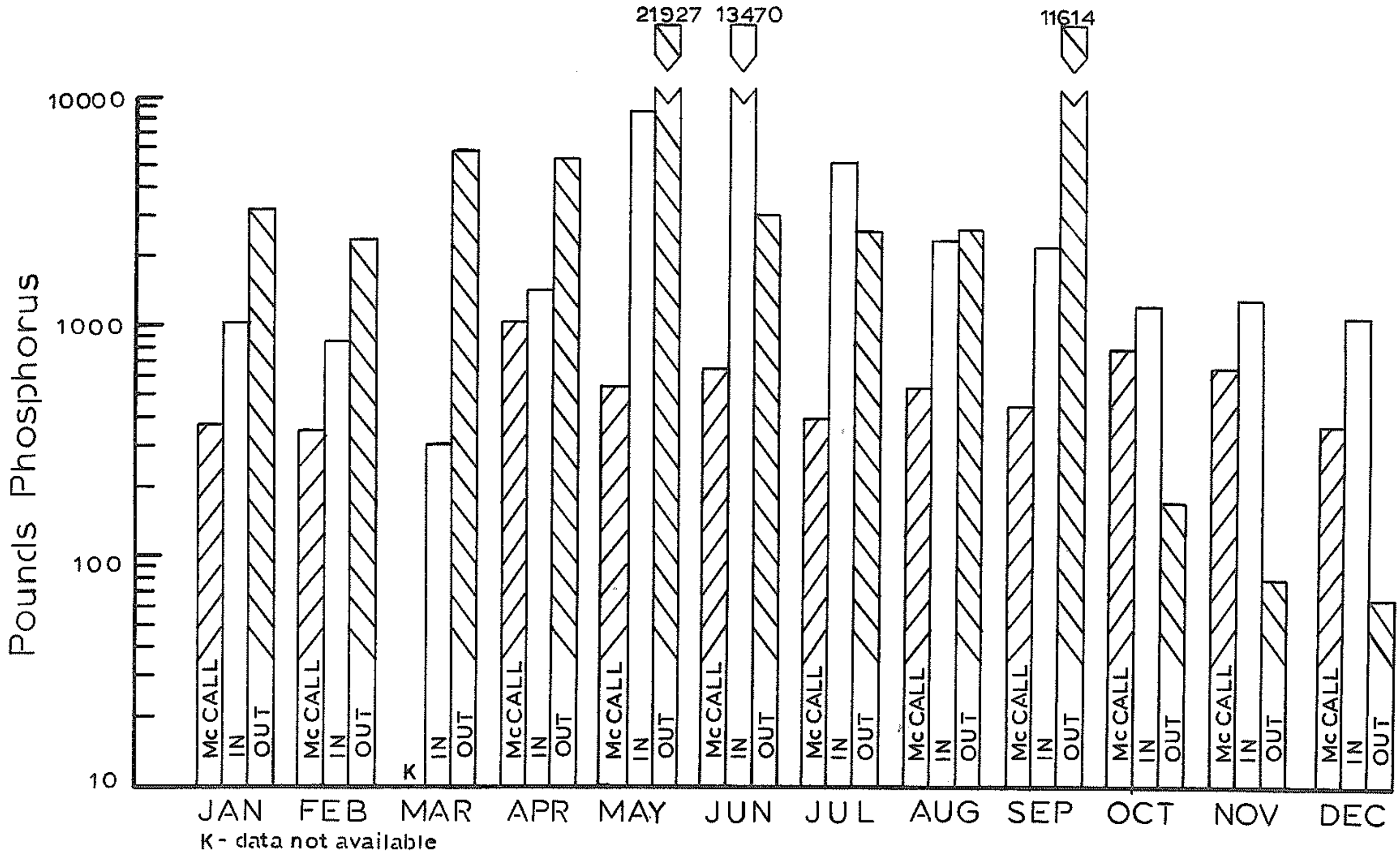


Figure 23. Monthly total Phosphorus loading in pounds at Cascade Reservoir compared with city of McCall laoding, 1975. McCall's percent contribution of total inflow is given.

APPENDIX C TABLES

TABLE I

Sample Stations - Cascade Reservoir Survey

Station Designation	Description of Sampling Location	Storet Number	Latitude (North)	Longitude (West)
A	Cascade Reservoir, Middle, S. end	2040000	44° 30' 25"	116° 04' 16"
B	Cascade Reservoir, Log boom, near dam	2040001	44° 31' 23"	116° 03' 42"
C	Cascade Reservoir, Middle, West of Crown Point	2040002	44° 32' 04"	116° 05' 21"
D	Cascade Reservoir, West of Grandma's Creek	2040003	44° 33' 44"	116° 04' 40"
E	Cascade Reservoir, West of Station D	2040004	44° 33' 44"	116° 07' 23"
F	Cascade Reservoir, Northwest of Sugarloaf Island	2040005	44° 36' 54"	116° 05' 32"
G	Cascade Reservoir, Mouth of Narrows, North end	2040006	44° 38' 46"	116° 05' 50"
H	Cascade Reservoir, Mouth of Gold Fork Arm	2040007	44° 40' 33"	116° 05' 06"
I	Cascade Reservoir, Mouth of Boulder Creek Arm	2040008	44° 41' 15"	116° 06' 07"
J	Cascade Reservoir, Mouth of Lake Form Arm	2040009	44° 42' 00"	116° 06' 31"
K	Cascade Reservoir, Mouth, North Fork, Payette River	2040055	44° 42' 21"	116° 07' 35"
L	North Fork, Payette River, McCall	2040010	44° 59' 30"	116° 07' 10"
M	McCall Lagoon Effluent	2040011	44° 54' 37"	116° 07' 05"
N	North Fork, Payette River, Bridge below McCall	2040012	44° 54' 54"	116° 07' 05"
O	North Fork, Payette River, Paddy Flat Bridge	2040013	44° 47' 24"	116° 08' 42"
P	Lake Fork, County road bridge	2040014	44° 45' 45"	116° 05' 40"
Q	Boulder Creek, Railroad Bridge	2040015	44° 43' 08"	116° 04' 35"
R	Rock Creek, Near mouth, at County Road	2040017	44° 39' 50"	116° 03" 35"
S	Gold Fork, Old U.S.G.S. station	2040016	44° 41' 19"	116° 00' 04"
T	Mud Creek, County Road Bridge	2040018	44° 43' 40"	116° 06' 30"
U	North Fork, Payette River, below Cascade Dam	2040019	44° 30' 44"	116° 01' 52"

TABLE 2a

CASCADE RESERVOIR - PLANKTON
May 30, 1975

	Organisms/ml		
	Station G	Station D	Station B
PHYTOPLANKTON			
Cyanophyta			
Microcystis aeruginosa[2]	-0-	0.4	0.4
Sub Total	-0-	0.4	0.4
Chlorophyta			
Scenedesmus sp.	0.1	-0-	-0-
Sphaerocystis sp.[2]	0.1	0.1	-0-
Staurastrum paradoxum	0.3	0.1	0.4
Sub Total	0.5	0.2	0.4
Chrysophyta			
Asterionella sp.[1]	20.9	83.0	112.0
Cymbella sp.	0.2	-0-	-0-
Diatoma spp.	1.0	-0-	-0-
Fragilaria arcus	0.1	-0-	-0-
Fragilaria crotonensis[1]	0.15	0.15	0.17
Gomphonema sp.	0.8	-0-	-0-
Melosira sp.[1]	0.8	96.0	98.0
Navicula sp.	0.11	-0-	-0-
Nitzchia sp.	P	-0-	-0-
Pleurosigma sp.	0.3	-0-	-0-
Synedra spp.	0.7	-0-	-0-
Unidentified spp.	-0-	-0-	0.2
Sub Total	25.06	179.25	210.47
Pyrrophyta			
Ceratium hirundinetta	0.1	0.2	-0-
TOTAL	25.66	180.05	211.27
ZOOPLANKTON			
Rotatoria	-0-	0.2	0.3
Cladocera			
Unidentified spp.	-0-	0.3	0.1
Copepoda	-0-	-0-	-0-
TOTAL	-0-	0.5	0.4

[1]number of filaments
[2]number of colonies other than filaments
P species present in sample but not counted

TABLE 2b

CASCADE RESERVOIR - PLANKTON
June 24-25, 1975

	Organisms/ml		
	Station G	Station D	Station B
PHYTOPLANKTON			
Cyanophyta			
Anabaena spiroides[1]	1.0	-0-	1.4
Mirocystis aeruginosa[2]	0.12	0.03	0.04
Sub Total	1.12	0.03	1.44
Chlorophyta			
Scenedesmus sp.	0.25	0.09	-0-
Sphaerocystis sp.[2]	0.04	0.03	-0-
Staurastrum paradoxum	0.08	0.16	0.2
Sub Total	0.37	0.28	0.2
Chrysophyta			
Asterionella sp.[1]	34.0	31.7	16.0
Cyclotella sp.	P	0.03	-0-
Cymbella sp.	0.04	-0-	-0-
Diatoma spp.	0.08	-0-	-0-
Fragilaria crotonensis[1]	0.7	0.12	0.16
Melosira sp.[1]	23.0	6.8	6.3
Synedra spp.	1.0	-0-	-0-
Tabellaria fenestrata[1]	0.29	0.03	-0-
Sub Total	59.11	38.68	22.46
Pyrrophyta			
Ceratium hirundinetta	0.12	0.06	0.12
Sub Total	0.12	0.06	0.12
TOTAL	60.72	39.05	24.22
ZOOPLANKTON	P		
Rotatoria	0.04	0.12	0.08
Keratella sp.[1]	0.04	0.06	0.08
Keratella sp.[2]	-0-	0.03	-0-
Unidentified spp.	-0-	0.03	0.12
Sub Total	0.08	0.24	0.28
Cladocera	0.08	-0-	-0-
Daphnia sp.	0.08	-0-	-0-
Sub Total	0.16	-0-	-0-
Copepoda			
Cyclops spp.	-0-	0.06	0.12
TOTAL	0.24	0.30	0.40

[1]number of filaments
[2]number of colonies other than filaments
P species present in sample but not counted

TABLE 2c

CASCADE RESERVOIR - PLANKTON
July 22-23, 1975

	Organisms/ml		
	Station G	Station D	Station B
PHYTOPLANKTON			
Cyanophyta			
* Anabaena spiroides[1]	13.7	22.5	29.6
* Aphanizomenon flos-aquae[1]	71.0	92.5	75.0
* Microcystis aeruginosa[2]	0.35	0.08	0.64
* Nostoc[1] sp.	1.7	1.4	
Sub Total	86.75	116.48	105.24
Chlorophyta			
Pediastrum duplex[2]	0.06	-0-	0.64
Scenedesmus sp.	0.35	0.08	
* Sphaerocystis sp.[2]	1.4	0.8	4.5
Tetraedron sp.	0.23	0.48	-0-
Sub Total	2.04	1.36	5.14
Chrysophyta			
* Asterionella sp.[1]	50.0	52.8	75.3
* Dinobryon sp.[2]	0.06		
* Fragilaria crotonensis[1]	44.5	45.0	54.7
* Melosira sp.[1]	1.4	3.4	1.9
* Tabellaria fenestrata[1]	0.35	0.32	-0-
Sub Total	96.31	101.52	131.9
Pyrrophyta			
* Ceratium hirundinetta	0.4	0.72	0.13
Sub Total	0.4	0.72	0.13
TOTAL	185.50	220.08	242.41
ZOOPLANKTON			
Rotatoria			
Keratella sp.[1]		0.08	
Keratella sp.[2]	0.06	-0-	0.64
Unidentified spp.	0.12		
TOTAL	0.18	0.08	0.64

[1]number of filaments
[2]number of colonies other than filaments
P species present in sample but not counted

* Reported by United States Bureau of Reclamation (1975) for 6 August 1974.

TABLE 2d

CASCADE RESERVOIR - PLANKTON
August 26, 1975

	Organisms/ml		
	Station G	Station D	Station B
PHYTOPLANKTON			
Cyanophyta			
Anabaena spiroides[1]	4.3	4.9	1.0
Aphanizomenon flos-aquae[1]	352.6	153.7	363.0
Microcystis aeruginosa[2]	1.4	0.5	1.5
Nostoc[1] *sp.*	21.0	2.1	0.5
Sub Total	379.3	161.2	366.0
Chlorophyta			
Pediastrum duplex[2]		0.5	
Sphaerocystis sp.[2]	0.7	0.5	1.5
Staurastrum paradoxum	0.7	1.0	3.6
Sub Total	1.4	2.0	5.1
Chrysophyta			
Asterionella sp.[1]	79.6	44.5	16.7
Dinobryon sp.[2]	0.7		
Fragilaria crotonensis[1]	24.6	14.7	10.9
Melosira sp.[1]	23.9	13.0	23.0
Tabellaria fenestrata[1]	0.7		
Sub Total	129.5	72.2	50.6
Pyrrophyta			
Ceratium hirundinetta	0.7	0.5	0.5
Sub Total	0.7	0.5	0.5
TOTAL	510.90	235.90	422.20
ZOOPLANKTON			
Rotatoria			
Keratella sp.[1]	-0-	-0-	0.5
Keratella sp.[2]	0.7	0.5	0.5
Sub Total	0.7	0.5	1.0
TOTAL	0.7	0.5	1.0

[1]number of filaments
[2]number of colonies other than filaments
P species present in sample but not counted

TABLE 2e

CASCADE RESERVOIR - PLANKTON
November 4, 1975

	Organisms/ml		
	Station G	Station D	Station B
PHYTOPLANKTON			
Cyanophyta			
Aphanizomenon flos-aquae[1]	9.3	4333.8	66.5
Microcystis aeruginosa[2]	2.7	4.7	3.6
Sub Total	12.0	4338.5	70.1
Chlorophyta			
Scenedesmus sp.	-0-	-0-	0.7
Sphaerocystis sp.[2]	-0-	0.67	-0-
Staurastrum paradoxum	1.3	P	1.4
Sub Total	1.3	0.67	2.1
Chrysophyta			
Asterionella sp.[1]	50.0	0.67	-0-
Fragilaria crotonensis[1]	7.3	2.0	2.8
Melosira sp.[1]	10.0	3.3	2.1
Sub Total	67.3	5.97	4.9
Pyrrophyta	-0-	-0-	-0-
TOTAL	80.6	4345.14	77.10
ZOOPLANKTON			
Rotatoria			
Keratella sp.[1]	0.67	-0-	p
TOTAL	0.67	-0-	P

[1]number of filaments
[2]number of colonies other than filaments
P species present in sample but not counted

TABLE 2f

CASCADE RESERVOIR - PLANKTON
September 24, 1975

	Organisms/ml		
	Station G	Station D	Station B
PHYTOPLANKTON			
Cyanophyta			
Anabaena spiroides[1]	-0-	-0-	0.64
Aphanizomenon flos-aquae[1]	64.0	331.6	308.3
Microcystis aeruginosa[2]	2.1	0.25	2.2
Sub Total	66.1	331.85	311.14
Chlorophyta			
Sphaerocystis sp.[2]	-0-	0.36	-0-
Staurastrum paradoxum	1.0	0.72	0.64
Tetraedron sp.	-0-	0.36	0.32
Sub Total	1.0	1.44	0.96
Chrysophyta			
Asterionella sp.[1]	-0-	-0-	0.96
Fragilaria crotonensis[1]	1.0	0.36	3.5
Melosira sp.[1]	60.8	10.9	0.64
Tabellaria fenestrata[1]	1.8	-0-	0.32
Sub Total	63.6	11.26	5.42
Pyrrophyta			
Ceratium hirundinetta	1.0	0.36	0.96
Sub Total	1.0	0.36	0.96
TOTAL	131.70	344.91	318.48
ZOOPLANKTON			
Rotatoria	-0-	0.36	-0-
Keratella sp.[1]	0.36	-0-	-0-
Keratella sp.[2]	-0-	-0-	0.32
Cladocera	-0-	0.36	-0-
TOTAL	0.36	0.72	0.32

[1]number of filaments
[2]number of colonies other than filaments
P species present in sample but not counted

TABLE 3

INFLOWS TO CASCADE RESERVOIR*

DATE	CFS	M3/S
May 28, 1975	2312.0	65.5
June 24, 1975	3443.0	97.5
July 23, 1975	339.3	9.6
August 27, 1975	474.4	13.4
September 23, 1975	452.7	10.3
November 4, 1975	747.2	21.1

*Data obtained from U. S. Bureau of Reclamation

TABLE 4

INORGANIC NITROGEN & ORTHOPHOSPHATE VALUES FOR CASCADE RESERVOIR

STATION	DATE	INORGANIC NITROGEN*	ORTHOPHOSPHATE*	N:P RATIO
B	6/25/75	.036	.01	3.6:1
F	6/25/75	.033	.03	1.1:1
H	6/25/75	.030	.013	2.3:1
I	6/25/75	.020	.010	2:1
J	6/25/75	.030	.014	2.1:1
B	7/22/75	.086	.315	0.27:1
F	7/22/75	.060	.015	4:1
H	7/22/75	.053	.010	5.3:1
I	7/22/75	.076	.026	2.9:1
J	7/22/75	.060	.010	6:1
B	8/27/75	.053	.016	3.3:1
F	8/27/75	.056	.015	3.7:1
H	8/27/75	.046	.013	3.5:1
I	8/27/75	.070	.030	2.3:1
J	8/27/75	.056	.013	4.3:1
B	9/23/75	.273	.113	2.4:1
F	9/23/75	.070	.013	5.4:1
H	9/23/75	.066	.020	3.3:1
I	9/23/75	.026	.025	1:1
J	9/23/75	.023	.013	1.7:1
B	11/04/75	.160	.022	4.8:1
F	11/04/75	.140	.020	7:1
H	11/04/75	.033	.010	3.3:1
I	11/04/75	.046	.020	2.3:1
J	11/04/75	.043	.010	4.3:1

*Values are expressed as mg/l

TABLE 5

ORTHOPHOSPHATE BALANCE CASCADE RESERVOIR SURVEY

Pounds per day (Kilograms/day)

Date	Inflow		Reservoir		Outflow	
May 28, 1975	L 258.8	(L 117.3)	43,453.6	(19710.2)	113.1	(51.3)
June 24, 1975	188.9	(85.7)	57,316.9	(25998.5)	82.3	(37.3)
July 23, 1975	77.7	(35.2)	43,521.6	(19741)	35.1	(15.9)
August 27, 1975	23.3	(10.6)	31,930.8	(14483.6)	245.5	(111.3)
September 23, 1975	52.2	(23.7)	44,739.8	(20293.6)	K 29.6	(K 13.4)
November 4, 1975	69.0	(31.3)	20,938.0	(9497.3)	33.4	(15.1)

L - greater than
K - less than