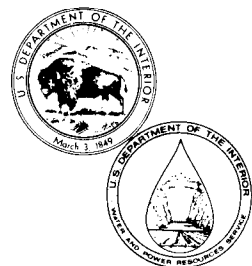


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RESULTS OF A LIMNOLOGICAL STUDY OF LAKE POCASSE, SOUTH DAKOTA

**Engineering and Research Center
Water and Power Resources Service**

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16. ABSTRACT In 1977-78, a limnological study was done on Lake Pocasse, South Dakota, to evaluate the present condition of the lake and to assist in the feasibility decision of using the lake as a regulating reservoir. The shallow depth (3 to 4 m) allows for water temperatures during the summer to reach 25 °C with very little stratification. The dissolved oxygen in the water is usually maintained at levels adequate for the survival of aquatic organisms during the ice-free period, but may frequently approach anaerobic conditions during winters with heavy snow and ice cover. Potentially toxic levels of the heavy metals—copper, lead, zinc, manganese, and iron have been measured, but these elements are usually in the less harmful particulate form. Anaerobic conditions may contribute to the release of the ionic forms of heavy metals which are highly toxic to aquatic life. The levels of nitrogen and phosphorus compounds measured accounted for the high primary production during the late summer and fall. A bloom of the blue-green alga <i>Aphanizomenon flos-aquae</i> (L.) Ralfs occurred during this period. Zooplankton populations generally were greatest during midsummer and the population of benthic organisms continued to increase throughout the season. Lake Pocasse appears to act as a trap for sediments, nutrients, and heavy metals because of limited and irregular flushing.					
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**RESULTS OF A
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by

Richard A. Roline

James F. LaBounty

June 1980

**Applied Sciences Branch
Division of Research
Engineering and Research Center
Denver, Colorado**



As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

On November 6, 1979, the Bureau of Reclamation was renamed the Water and Power Resources Service in the U.S. Department of the Interior. The new name more closely identifies the agency with its principal functions—supplying water and power.

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ABBREVIATIONS AND SYMBOLS

APHA	American Public Health Association
°C	degrees celsius
Eh	oxidation-reduction (redox) potential
g	grams
g/m ²	grams per square meter
kg/ha	kilograms per hectare
L	liter
mg/L	milligrams per liter
mL	milliliter
m	meter
mm	millimeter
mg/m ³	milligrams per cubic meter
mV	millivolt
μS/cm	microsiemens per centimeter
No./m ²	number per square meter
pH	hydrogen-ion concentration
TDS	total dissolved solids
Ca	calcium
Cl	chlorine
CO ₃	carbonate
Cu	copper
DDE	dichloro-diphenyl-dichloro-ethylene
DDT	dichloro-diphenyl-trichloro-ethane
2,4-D	dichloro-phenoxyacetic acid
Fe	iron
HCO ₃	bicarbonate
K	potassium
Mg	magnesium
MgCO ₃	magnesium carbonate
Mn	manganese
N	nitrogen
Na	sodium
NH ₃	ammonia
NO ₂	nitrite
NO ₃	nitrate
P	phosphorus
Pb	lead
PCB	polychlorinated biphenol
SO ₄	sulphate
TDE	tetrachloro-diphenyl-ethane
TKN	total Kjeldahl nitrogen
Zn	zinc

INTRODUCTION

Using Lake Pocasse (fig. 1) as a regulating reservoir for the Pollock-Herreid Unit (fig. 2) was proposed in the Water and Power Resources Service 1968 feasibility study. Cold water would be pumped from Lake Oahe into Lake Pocasse during the growing season. The feasibility study proposes pumping 38 237 942 m³ of water through the 11 101 338-m³ capacity of Lake Pocasse. This action will result in a greater flushing rate for Lake Pocasse. Spring Creek, the natural drainage system into Lake Pocasse, is also proposed as the drainage for this irrigation system. This, along with the placement of intake and outflow pumps will change the quantity and quality of water entering Lake Pocasse. The result will be a change in the water quality of Lake Pocasse. This study characterizes the limnology of the lake during 1977-78 before any alterations to the present system are made.

Lake Pocasse is located in Campbell County, South Dakota. It is an impoundment of Spring Creek which flows west into Lake Oahe. The U.S. Corps of Engineers constructed the Spring Creek Dam during the late 1950's and early 1960's. Lake Pocasse, a mitigation feature for the construction of Oahe Dam and Reservoir, is managed by the U.S. Fish and Wildlife Service as a national wildlife refuge.

APPLICATION

The results of this study will be of use and interest to those involved in studying the aquatic ecology of shallow lakes and reservoirs, particularly those of the northern prairie region. Study data will provide base information on the aquatic environment of Lake Pocasse and will aid in determining the lake's suitability as a regulating reservoir.

SUMMARY

This report documents the results of a limnological study of Lake Pocasse, South Dakota, during 1977-78. Quantitative and qualitative data characterize the aquatic ecology of the lake and provide a basis for recommendations on the use, if any, of Lake Pocasse as a regulating reservoir. Sampling was

done approximately twice monthly for physical and chemical water parameters, chlorophyll content, plankton identification and population estimates, and benthic fauna identification and density. Water samples were collected on one date for the analyses to determine the presence of insecticides, herbicides, and PCB's.

DESCRIPTION OF THE STUDY AREA

Lake Pocasse is located in Campbell County, South Dakota, immediately east of Lake Oahe and south of the North Dakota border. It is an impoundment of the lower reaches of Spring Creek near the confluence with Lake Oahe and covers approximately 570 ha at maximum pool.

METHODS AND MATERIALS

Field work for this project was performed from October 1977 to October 1978. Most of the sampling was done twice a month starting in the spring of 1978 after ice-off. Field monitoring and sample collections were performed by U.S. Fish and Wildlife Service personnel from the area office in Pierre, South Dakota. Six stations were sampled. Brief descriptions of each station are in figure 3.

Physical-Chemical Factors

Temperature and dissolved oxygen were measured onsite with a Hydrolab Corporation TDO, a dissolved oxygen-temperature meter. The pH in the field was measured using the Hach Chemical Company colormetric method. On one occasion (June 29, 1978), a Hydrolab Corporation Model 6D Surveyor multiparameter probe was used to measure temperature dissolved oxygen, conductivity, pH, and oxidation-reduction potential profiles. Water samples were collected from the surface and bottom with a standard Van Dorn water sampler. Water samples for heavy metal analyses were preserved immediately after collection with 1 mL of nitric acid per 0.473 L. Samples for nutrient analyses were frozen immediately after collection. All water samples were analyzed according to APHA [1]* procedures by the Service's Chemistry, Petrography, and Chemical

* Numbers in brackets refer to entries in the bibliography.

Engineering section at the E&R Center in Denver.

Chlorophyll

Samples for chlorophyll analysis were collected near the surface at stations 1, 2, 3, and 4 with a standard Van Dorn water sampler. Following collection, from 200 to 350 mL of the water was filtered through 0.45-micron glass filter pads preserved with 1 mL of 0.01 percent $MgCO_3$. The filters were frozen and shipped by airfreight to the Service's Denver laboratories for analysis. Chlorophyll levels were determined using a cold-acetone extraction method and a Beckman Corporation dual-beam spectrophotometer [2, 3].

Insecticides, Herbicides, and PCB's

Levels of suspected chemical compounds in the water were measured in July by Station Biochemistry of the Chemistry Department at South Dakota State University, Brookings, S. Dak.

Zooplankton

Zooplankton were collected by towing a metered Miller plankton sampler having a No. 10 (mesh opening = 0.158 mm) silk net and bucket. Oblique tows were made at each station from the surface to near the bottom. Samples were put in 0.236-L bottles and preserved with a 5-percent formalin solution for laboratory analysis by Service personnel in Denver. Triplicate subsamples from each collection were identified and counted using a Sedgwick-Rafter counting cell.

Phytoplankton

Phytoplankton samples were collected near the surface using a Van Dorn water sampler. The samples were placed in 0.236-L polyethylene bottles and preserved with a 5-percent formalin solution for laboratory identification and counting.

Benthic Fauna

Three samples of benthic muds were collected from each station using a 229-mm-square Ekman dredge. These samples were each filtered through a 600-micron sieve (U.S. standard series

No. 30) and preserved in a 10-percent formalin solution for analysis in the Service's Denver laboratory. All specimens were identified, counted, and weighed to determine both wet and dry weights. Dry weight was obtained by drying the organisms in preweighed aluminum cups in an oven at 60 °C for 24 hours.

RESULTS

Physical-Chemical Factors

Table 11 and figures 4 through 7 present the field measurements for the study. Water temperatures in Lake Pocasse reached 25 °C during midsummer with little stratification. This is probably due to the shallow depths and mixing by winds. Some weak temperature stratification may have occurred during warm periods of calm winds but was never measured. Anaerobic conditions seemed to have been reached during the winter of 1977-78. This probably resulted in a serious die-off in the lake and accounted for the low biological production during the spring. In addition, local residents reported a fishkill in the lake. However, dissolved oxygen levels usually remained high throughout the summer because of wind mixing and algal productivity. The diurnal dissolved oxygen fluctuations were not measured. Summer kills during periods of stagnation (due to no mixing by winds) might occur. The pH ranged from 7.8 to 9.5 throughout the summer. This could have been due to high algal productivity and dissolved solids in the water. The secchi disk measurements were low (< 0.9 m) throughout the summer, indicating high turbidity and algal production.

Water Chemistry

Results of chemical analyses of water samples are in tables 1 through 5. There is little distinct difference between the stations in major cation and anion concentrations. The concentration of total dissolved solids increases throughout the summer to a high in the fall. Figure 8 shows average total dissolved solids concentrations during the 1978 season at all sampling stations. Concentrations were highest at station 4 (see map) building from a low at station 1 and dropping to a low at station 5 which is the Spring Creek inflow. Station 4 is probably highest in total dissolved solids due to the shallow mud

flats in combination with high evaporation. This level probably remains quite high until spring runoff when dilution occurs.

Calcium and sodium are the dominant cations while bicarbonate and sulfate are the major anions. During August, carbonate levels rise and bicarbonate levels drop. This is expected since pH during that time rose significantly above 8.3, which is the point at which the bicarbonate-carbonate system equilibrium favors carbonate. These high pH levels, and especially this switch from bicarbonate to carbonate, are significant in that they are an indication of the lake's productivity. The primary production was very high during August and the lake was in a highly productive or eutrophic category. Further evidence for this conclusion is found in the chlorophyll and autotrophic plant nutrient data that are discussed later in this report.

Heavy Metals

Heavy metals (some refer to these as trace elements) are defined here as any element heavier than manganese. Tables 6 through 10 present the levels found for copper, iron, lead, manganese, and zinc. The presence of these metals under certain circumstances could be toxic or detrimental to aquatic life. The levels of all of these heavy metal elements were at various times during the 1978 season excessive for the survival of most aquatic life if they occurred in an ionic form. Since no die-off was found during the 1978 summer, it is concluded that all of these elements were in biologically unimportant particulate forms. If, however, dissolved oxygen levels reached 0, pH values dropped below 7.0, and Eh readings approached 200 mV, the bonds between the element and this buffer which forms the silt would be broken and the trace metals would occur in ionic forms. This is, of course, what occurs by adding nitric acid to a sample. In the ionic forms these elements are both acutely and chronically toxic to aquatic life. For example, ionic copper at levels above 0.10 mg/L will kill many freshwater organisms; ionic lead above 0.10 mg/L is deleterious to fish life; ionic zinc at levels of 0.01 mg/L begin to be toxic to aquatic life; ionic manganese would have to reach at least 1.0 mg/L to be harmful to aquatic life; and ionic iron at concentrations of 0.2 mg/L has been found harmful to aquatic life [4]. According to Davies and Goettl [5] the biologically acceptable levels of selected heavy

metals for the hardness of 100 to 200 mg/L (as CaCO_3), which occurs in Lake Pocasse, should not exceed the following: 0.01 mg/L of copper, 0.025 mg/L of lead, 0.05 mg/L of zinc, 1.0 mg/L of manganese, and 0.5 mg/L of iron.

Figures 9 to 12 are plots of copper and manganese concentrations during the 1978 season. Even though lead, iron, and zinc concentrations were not plotted, their relative concentrations are represented in some degree by these plots.

Figure 9 shows copper concentration at each station on each of the dates sampled. Between the June 28 and July 12 sampling dates, copper concentrations rose dramatically at all stations. From that time until the end of the sampling period, which occurred on October 18, values dropped. Figure 10 shows plots of copper concentrations on four related dates for each of the five stations sampled. Station 5, which is the Spring Creek inflow, seems the most likely source of the "slug" of copper. However, the data are not sufficient to conclude that this is the source of copper, especially when these values are compared with other heavy metals' concentrations.

Figure 11 is a graph of manganese concentrations during 1978 for each of the stations sampled. These data indicate several "slugs" of manganese entering the lake but especially on or near July 12 and August 7. Data in figure 11 indicate that the largest increase in manganese concentration entered Lake Pocasse just before or on August 7 at station 3. Figure 12 shows plots of manganese concentrations on four selected dates for each of the five stations sampled. Data in this figure again indicate a significant increase of manganese from station 3 on or just before August 7. In addition, increases of manganese of lower magnitudes were found at station 3 on July 12 and again at station 5 on July 25.

The reason or reasons for these increased concentrations of heavy metal elements entering Lake Pocasse can only be hypothesized. Since "slugs" of trace heavy metal elements seem to appear at various stations at different times throughout the late summer, it can be speculated that they must enter after heavy rains or possibly through some other type of runoff. During the early part of the year, runoff from Spring Creek

may keep the lake freshened, while after July, runoff from nearby areas may add excessive amounts of trace elements from the surrounding soils. Another possible source of these increases in heavy metals concentrations could be the lake sediments themselves. When water depths at some of the shallower stations become less than a meter, winds cause the water at that station to become turbid. This sediment-laden water then would contain large amounts of trace elements.

The presence of excessive amounts of trace heavy metal elements is not of concern in this instance provided that they remain in a nonionic form.

Nitrogen and Phosphorus Autotrophic Plant Nutrients

Table 12 presents the values for the amounts of orthophosphate and total phosphorus as phosphorus and nitrate, nitrite, ammonia, and total Kjeldahl nitrogen as nitrogen. Average levels for the study period are presented at the bottom of the table. The levels of phosphorus and nitrogen in Lake Pocasse are well into the range considered to be highly productive or eutrophic. There seems to be an abundant supply of organic and inorganic forms of both nitrogen and phosphorus. Lake Pocasse probably acts as a nutrient trap with inflow from the drainage of agricultural lands and less of an outflow into Oahe Reservoir. Flushing of Lake Pocasse would not seem to be uniform or complete from year to year. In most instances, the nitrogen-phosphorus levels in Spring Creek are lower than those found in Lake Pocasse (fig. 13, 14, and 15). This would indicate that Lake Pocasse is indeed acting as a nutrient trap.

Most of the phosphorus present in this system occurs as orthophosphate. This being the soluble form, it is readily available for use by algae. In many natural aquatic systems, phosphorus is an element that can limit primary production. In Lake Pocasse the high levels of phosphorus measured suggests that this is not the situation.

The critical concentration of nitrogen, below which nuisance algal "blooms" are usually not apparent, is 0.30 mg/L provided that available phosphorus is below 0.015 mg/L and that there are no nitrogen-fixing species occurring in the habitat [6]. Nitrates are one of the most important forms of nitrogen necessary for algal

production. These were found in much lower concentrations during the peak of the *Aphanizomenon flos-aquae* (L.) Ralfs "bloom." The lowest nitrate levels (table 12) correspond with the highest abundance of *Aphanizomenon* which is shown in figure 22. This suggests utilization of nitrate by this species of algae. This species is a known nitrogen fixer [7], but the reduction of nitrate levels in the water during this period would indicate that the water contains a major source of nitrogen for algal production. Nitrites are a very transient form which can be oxidized to nitrates, particularly by the nitrification-denitrification process. Another source of nitrogen: ammonia, depending on pH, has been found to be toxic to fish in concentrations as low as 0.3 mg/L [8]. Ammonia decreases the ability of the hemoglobin in fish to combine with oxygen, and they may suffocate. Gusseva [9] reported that *Aphanizomenon* completely disappeared when ammonia concentrations reached 0.4 to 0.5 mg/L. Values this high were not found in Lake Pocasse.

Small lakes, such as Lake Pocasse, are very subject to intense nutrient cycling. Summer storms mix nutrients from bottom zones, thus making them available for use by phytoplankton. The limited volume of small lakes also makes them very sensitive to nutrient inflows [10].

Chlorophyll Concentration

Table 13 presents the results of chlorophyll *a*, *b*, and *c* analyses for July through the October sampling. The major portion of the *Aphanizomenon flos-aquae* (L.) Ralfs "bloom" took place during this period and can be recognized by the relatively high chlorophyll *a* concentrations. These levels would classify Lake Pocasse as eutrophic according to Leith and Wittaker [11]. Chlorophylls *b* and *c* were detected very little during this study. This indicates only a slight presence of green algae and diatoms [12]. The blue-green alga *Aphanizomenon* was the dominant species as indicated by observation, phytoplankton counts, and chlorophyll measurements. According to Barica [13], lakes with a chlorophyll *a* concentration of less than 100 µg/L are not strong candidates for summer kill due to the collapse of the algae. Area residents have reported some fish kills during the summer, but these do not appear to be regular or severe.

Insecticides, Herbicides, and PCB's

Table 14 lists the results of the waters analyzed for the presence of some toxic chemical compounds used primarily in agricultural operations. No such compounds were detected in any of the samples except for the Spring Creek sample which contained 0.001 mg/L PCB's at the Herreid sampling station.

Benthic Fauna

Figures 16 and 17 present the values for the benthic fauna sampled during the study period. Two main types of benthic animals were found. They were chironomids and oligochaetes. Chironomids, or the nonbiting midges (family, Chironomidae) are representatives of the order of flies, Diptera, and are best known as the predominant insect in lake sediments [14]. They are sometimes present in large numbers and may feed on detritus, animals, or plants. The chironomids collected during this study range from 3 to 12 mm in length. Oligochaetes (class, Oligochaeta) are aquatic earthworms. They, like chironomids, take part in the exchange of substances within the sediments and between them and the interstitial water layers. Both of these types of benthic organisms are a large part of the diet of bottom-feeding fish and of the food chain in lakes. A number of clam shrimp (order, Conchostraca) were collected at stations 1 through 4 at some time during the study. These organisms were apparently on or near the bottom and were collected by the dredge upon sampling. The numbers and dry mass of the benthic fauna generally increased through the summer with the highest values recorded in September and October. Tables 15 and 16 compare the numbers and dry weight values for benthic organisms with other lakes from throughout the world randomly selected from literature. It is difficult to categorize lakes according to the types of abundance of benthic fauna because these organisms are not always indicative of water quality. The increase in benthic biomass through the summer is apparently due to a recovery from the previous winter "die-off." The recovery was very significant. Whether this is an annual occurrence or not is unknown, but it could be expected following any severe winter.

Zooplankton and Phytoplankton

The results of the zooplankton and phytoplankton sampling are seen in figures 18 through 22. Three major groups of zooplankton found were the copepods, *Diaptomus* spp. and *Cyclops* spp., cladocerans, and rotifers. All these forms would be expected in lakes within this geographical area and provide a food base for the small and young fish in the lake. Their abundance is quite significant and increased toward midseason as might be expected.

The blue-green alga *Aphanizomenon flos-aquae*, (L.) Ralfs was by far the dominant phytoplankton species found. It is an indication of a highly productive body of water and being a blue-green algae, it is not entirely desirable for zooplankton, fish, or human consideration. It tends to dominate because it is considered an allelopathic species; that is, one which produces toxins that exclude other species from coexisting with it. Its presence in the area is considered, however, entirely normal. The highest production period for this blue-green alga was from middle to late summer. Other phytoplankton present were the diatoms *Cyclotella* spp., *Nitzschia* spp., *Synedra* spp., *Biddulphia* spp., and a green alga, *Spirogyra* spp. Most of the peak zooplankton populations occurred during the same period as the *Aphanizomenon* "bloom," from midsummer to late summer. The decline in phytoplankton concentrations in late September seems to be closely related to decreasing water temperatures during that period. However, the fact that *Aphanizomenon* is allelopathic should be considered. This decline can also be seen in zooplankton abundance.

This relationship may exist because of the loss of a phytoplankton food source, the production of toxins by blue-green algae, or because of bacterial action during the decay of the large amounts of algae.

CONCLUSIONS

1. Lake Pocasse is a shallow lake (3 to 4 m) of eutrophic status. That is, it is quite productive

when compared to other lakes in the world. High levels of inorganic nitrogen and phosphorus are available for primary and secondary production. In addition, high levels of certain trace heavy metal elements are found. These heavy metal elements are of minor biological importance in their present form.

2. Winds in the area seem to mix the lake completely during the ice-off period, and usually no significant thermoclines are allowed to develop.

3. The Spring Creek inflow combined with a limited surface outflow makes Lake Pocasse a trap for sediments, nutrients, heavy metals, and possibly organic chemical compounds used in agriculture. These nutrients and elements seem to circulate readily within the system, both

attached to soil particles and incorporated into the biota.

4. The shallow depth of the lake combined with the high production potential of the water, high organic content of the bottom muds, and limited flushing rate make it a candidate for extremes in productivity. Anaerobic conditions and the probable release of toxic forms of heavy metals during severe winters result in a die-off of aquatic organisms followed by high production and the repopulation of plankton and benthic fauna in the summer. This phenomenon will probably continue to limit the fishery in Lake Pocasse as well as primary and secondary productivity in the spring. Any program that would increase the flushing of Lake Pocasse, particularly during the ice-on period of the winter, would help maintain adequate levels of dissolved oxygen for the survival of aquatic life.

BIBLIOGRAPHY

- [1] *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association, Inc., 874 pp., New York, 1971.
- [2] Parsons, T. R., and J.D.H. Strickland, "Discussion of Spectrophotometric Determination of Marine-Plant Pigments, With Revised Equations for Ascertaining Chlorophylls and Carotenoids," *Journal of Marine Research*, vol. 21, No. 3, pp. 155-163, 1963.
- [3] Stein, J. R., *Handbook of Phycological Methods*, 448 pp., Cambridge University Press, London, 1973.
- [4] McKee, J. E., and H. W. Wolf, *Water Quality Criteria*, 2nd ed. Publication No. 3-A, California State Water Resources Control Board, 548 pp., Sacramento, reprinted June 1, 1976.
- [5] Davies, P. H., and J. P. Goettl, *Aquatic Life-Water Quality Recommendations for Heavy Metal and Other Inorganic Toxicants in Fresh Water*, Colorado Division of Wildlife, July 1976.
- [6] Sawyer, C. N., "Fertilization of Lakes by Agricultural and Urban Drainage," *New England Water Works Association Journal*, vol. 61, p. 109, 1947.
- [7] Carr, N. G., and B. A. Whitton (editors), "The Biology of Blue-green Algae," *Botanical Monographs*, vol. 9, 676 pp., University of California Press, Los Angeles, California, 1973.
- [8] Brockway, D. R., "Metabolic Products and Their Effects," *Progressive Fish Culturist*, vol. 12, 126 pp., 1950.
- [9] Gusseva, K. A., "Hydrobiology and Microbiology of the Vchinskii Reservoir (Moscow-Volga Canal), II. Observations of the Department of *Anabena Lemmermannii*, *Aphanizomenon flos-aquae*, and *Asterionella Formosa*," *Water Pollution Abstracts*, vol. 20, February 1947.
- [10] Thomas, E. A., "The Process of Eutrophication in Central European Lakes," *Eutrophication Causes, Consequences, Correctives*, Proceedings of a Symposium, NAS, Washington, D.C., 1967.
- [11] Leith, H. and R. H. Wittaker (editors), "Primary Productivity of the Biosphere," *Ecological Studies No. 14*, 339 pp., Springer-Verlag, New York, 1975.
- [12] Morris, I., *An Introduction to the Algae*, Hutchinson and Company, Ltd., London, 1967.
- [13] Barica, J., "Collapses of *Aphanizomenon flos-aquae*, Blooms Resulting in Massive Fish Kills in Eutrophic Lakes: Effect of Weather," *Proceedings: 20th Congress, International Vereinigung fur theoretische und Angewandte Limnologie*, Copenhagen, Denmark, August 8, 1977.
- [14] Mundie, J. H., "The Ecology of Chironomidae in Storage Reservoirs," *Transactions Royal Entomological Society*, London, vol. 109, No. 5, pp. 149-232, 1957.
- [15] LaBounty, J. F., *Studies of the Benthic Environment of Twin Lakes, Colorado*, Bureau of Reclamation Report No. REC-ERC-76-12, 47 pp., Denver, Colorado, 1976.
- [16] Ricker, W. E., "The Benthos of Cultus Lake," *Journal Fisheries Research Board Canada*, vol. 9, No. 4, pp. 204-212, 1952.
- [17] Rinne, J. N., *A Limnological Study of Central Arizona Reservoirs with Reference to Horizontal Fish Distribution*, Ph. D. Dissertation, 350 pp., Arizona State University, Tempe, Arizona, 1973.
- [18] Rawson, D. S., "A Comparison of Some Large Alpine Lakes in Western Canada," *Ecological Monographs*, vol. 23, No. 2, pp. 143-161, 1942.
- [19] Craven, R. E., *Benthic Macroinvertebrates and Physiochemical Conditions of Boomer Lake, Payne County, Oklahoma*, M.S. Thesis, 62 pp., Oklahoma State University, Stillwater, 1968.

- [20] Cole, G. A., and J. C. Underhill, "The Summer Standing Crop of Sublittoral and Profundal Benthos in Lake Itasca, Minn.," *Limnology and Oceanography*, vol. 10, No. 4, pp., 591-597.
- [21] Rawson, D. S., "The Bottom Fauna of Great Slave Lake," *Journal Fisheries Research Board Canada*, vol. 10, No. 8, pp. 486-520, 1953.
- [22] Deevey, E. S., "Limnological Studies in Connecticut VI. The Quality and Composition of the Bottom Fauna of Thirty-six Connecticut and New York Lakes," *Ecological Monographs*, vol. 11, No. 4, pp. 414-455, 1941.
- [23] Maitland, P. S., C. W. Nigel, N. C. Morgan, K. East, and M. C. Gray, "Preliminary Research on the Production of Chironomidae in Loch Levan, Scotland," *Productivity Problems of Freshwater*, Warszawa-Krakow, pp. 795-812, 1970.
- [24] Benson, N. G., and P. L. Hudson, "Effects of a Reduced Fall Drawdown on Benthos Abundance in Lake Francis Case," *Transactions American Fisheries Society*, vol. 104, No. 3, pp. 526-528, 1975.
- [25] Carlson, C. A., "Summer Bottom Fauna of the Mississippi River above Dam 19, Keokuk, Iowa," *Ecology*, vol. 49, No. 1, pp. 162-169, 1968.
- [26] Rowe, G. T., P. T. Polloni, and R. L. Haedrich, "Quantitative Biological Assessment of the Benthic Fauna in Deep Basins of the Gulf of Maine," *Journal Fisheries Research Board Canada*, vol. 32, pp. 1805-1812, 1975.
- [27] Henson, E. B., *The Profundal Bottom Fauna of Cayuga Lakes*, Ph. D. Dissertation, Cornell University, Ithaca, New York, 1954.
- [28] Eggleton, F. E., "A Limnological Study of the Profundal Bottom Fauna of Certain Freshwater Lakes," *Ecological Monographs*, vol. 1, No. 3, pp. 232-331, 1931.
- [29] Adamstone, F. B., "Distribution and Economic Importance of Bottom Fauna of Lake Nipigon: with an Appendix on the Bottom Fauna of Lake Ontario," *Study in Biology, Public Fishery Research, Laboratory No. 24*, pp. 33-100, 1924.
- [30] Alley, W. P., and C. F. Power, "Dry Weight of the Macrobenthos as an Indicator of Eutrophication of the Great Lakes," *Proceedings 13th Conference, Great Lakes Research*, pp. 595-600, 1970.
- [31] Juday, C., "Quantitative Studies of the Bottom Fauna in the Deeper Water of Lake Mendota," *Transactions Wisconsin Academic Science, Arts, and Letters*, vol. 20, pp. 461-493, 1921.



Figure 1.—Spring Creek Dam and Lake Pocasse, S. Dak.

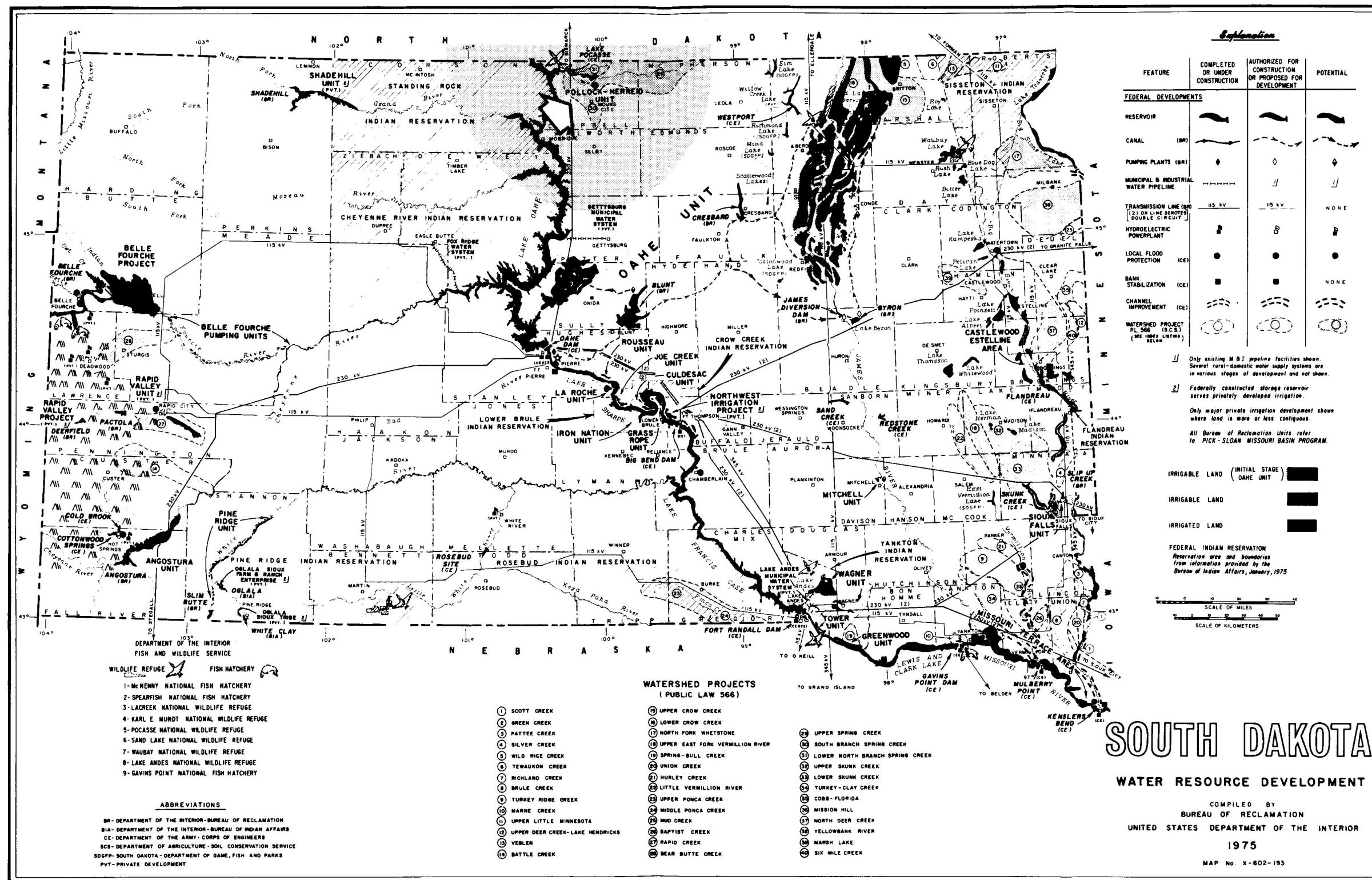


Figure 2.-Location of Pollock-Herleid Unit.

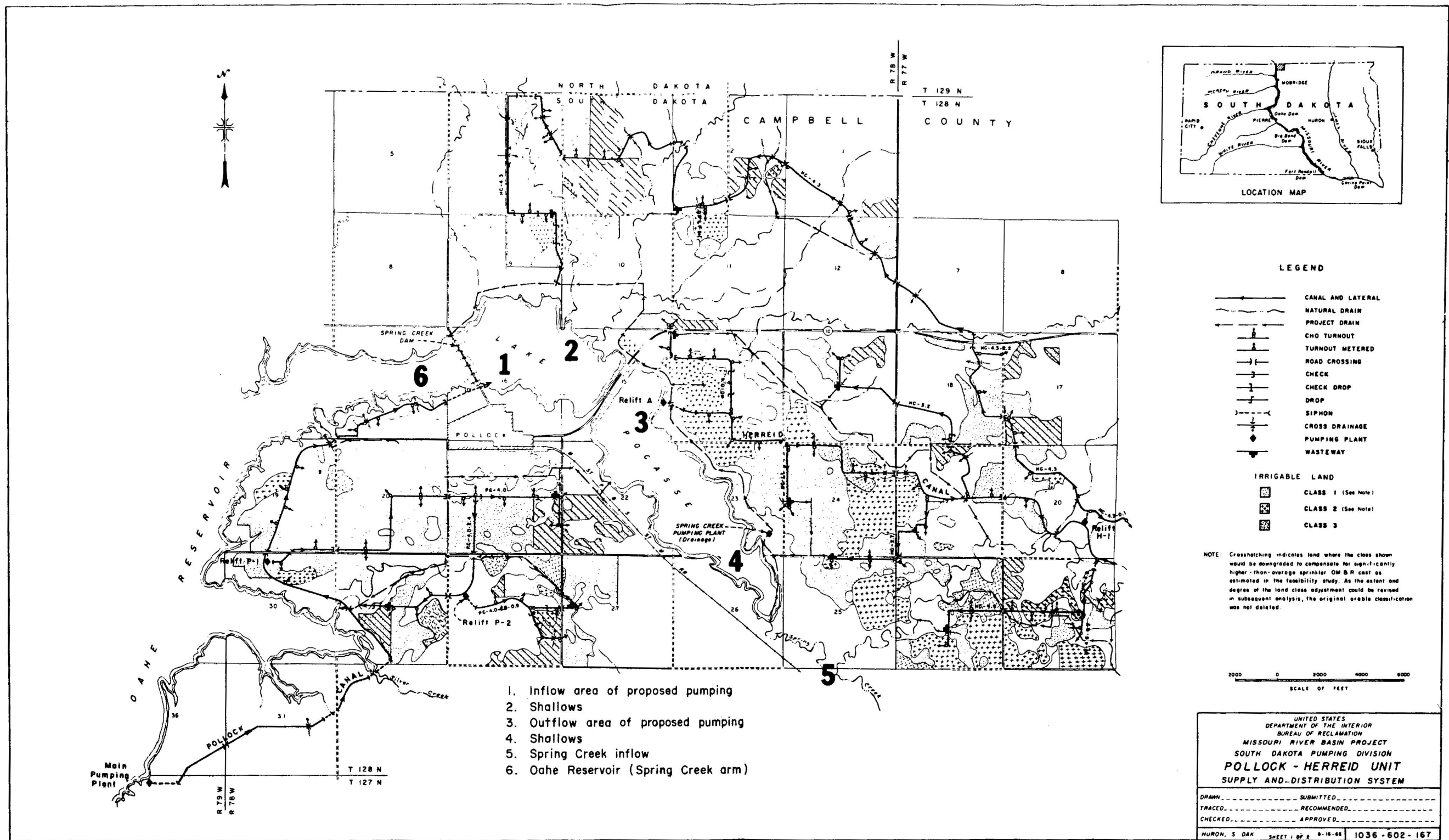


Figure 3.-Location of Lake Pocasse sampling stations.

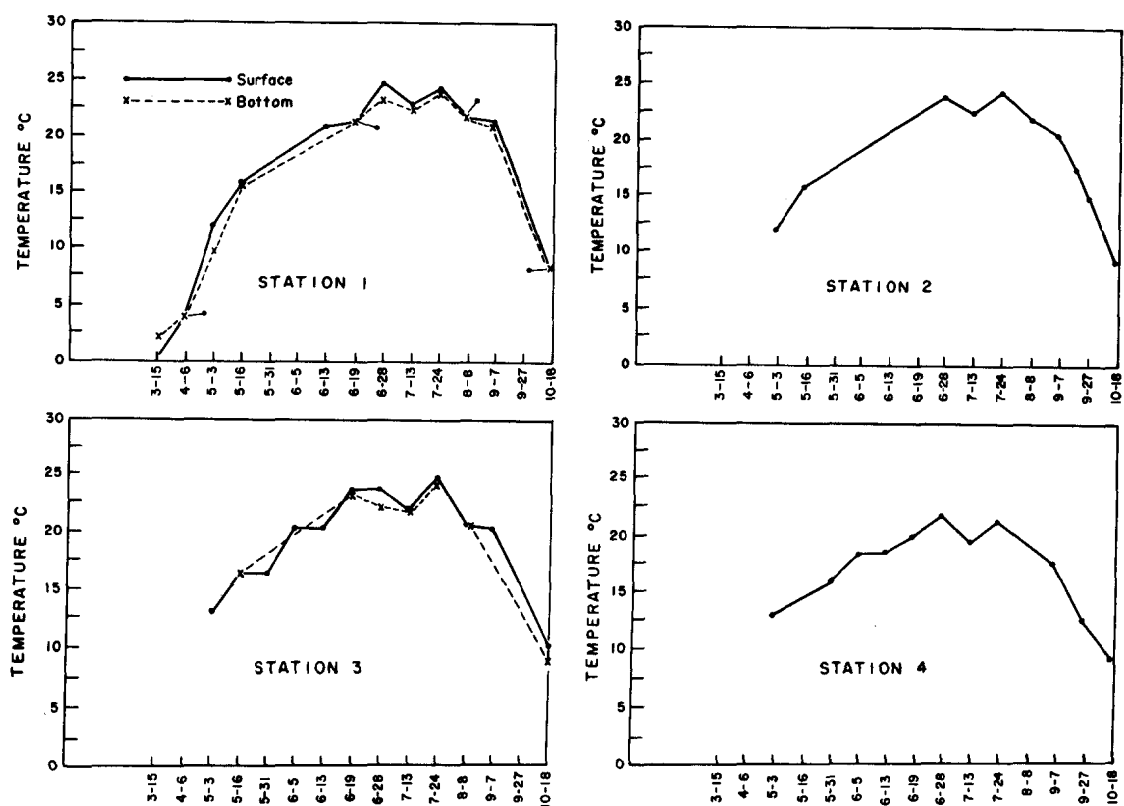


Figure 4.—Temperatures in Lake Pocasse during 1978.

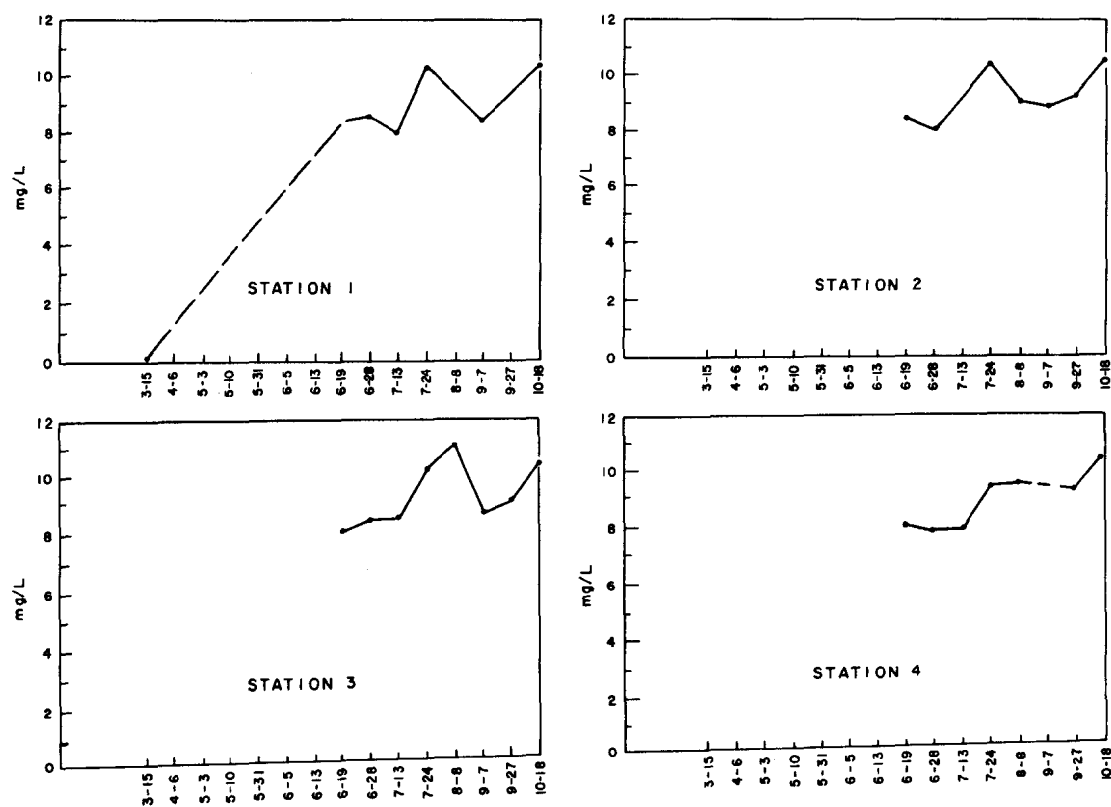


Figure 5.—Concentration of dissolved oxygen in Lake Pocasse during 1978.

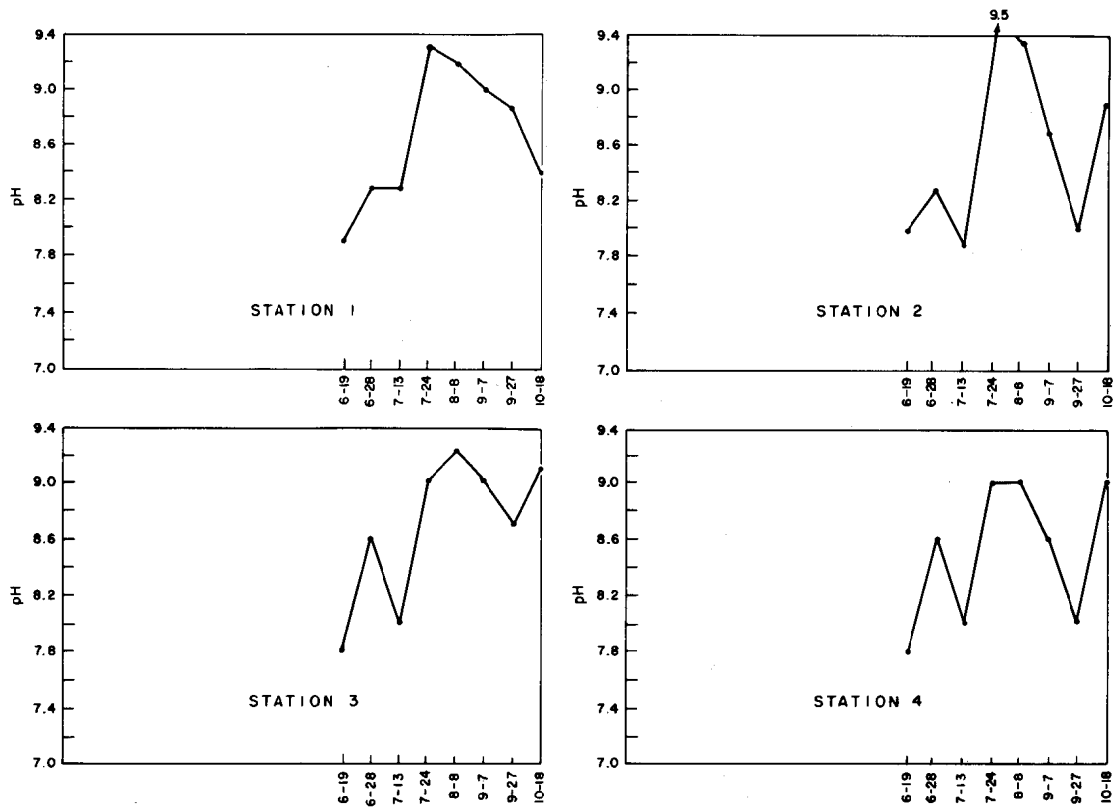


Figure 6.-pH in Lake Pocasse during 1978.

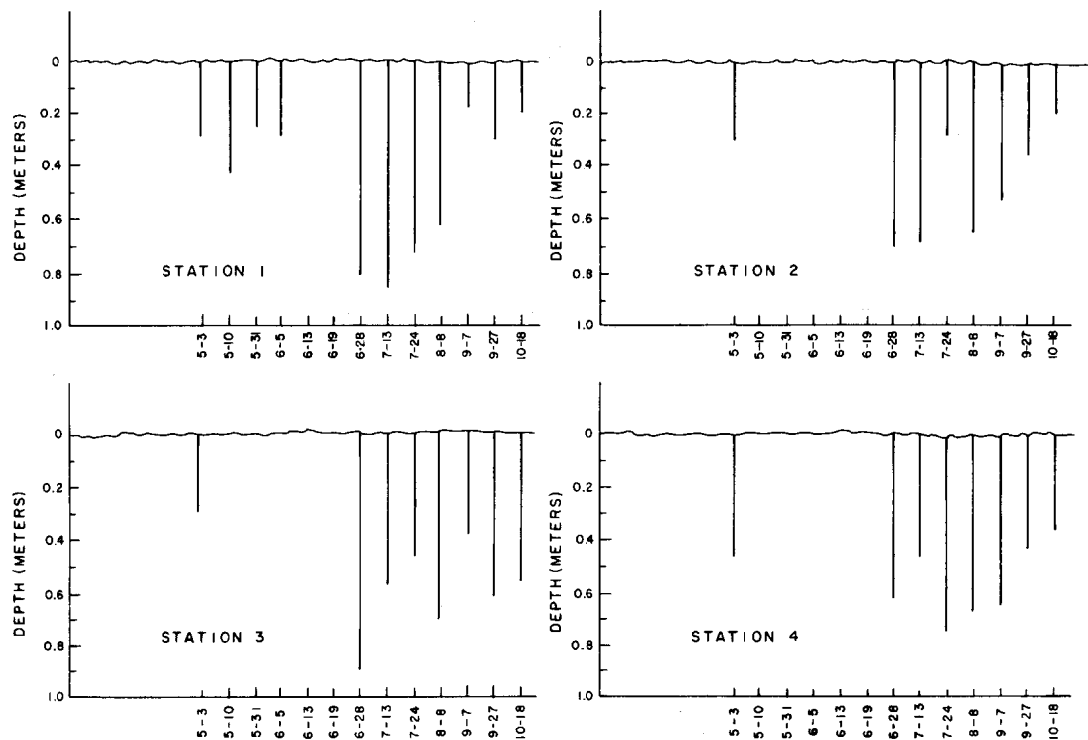


Figure 7.-Transparency measurements using a secchi disk in Lake Pocasse during 1978.

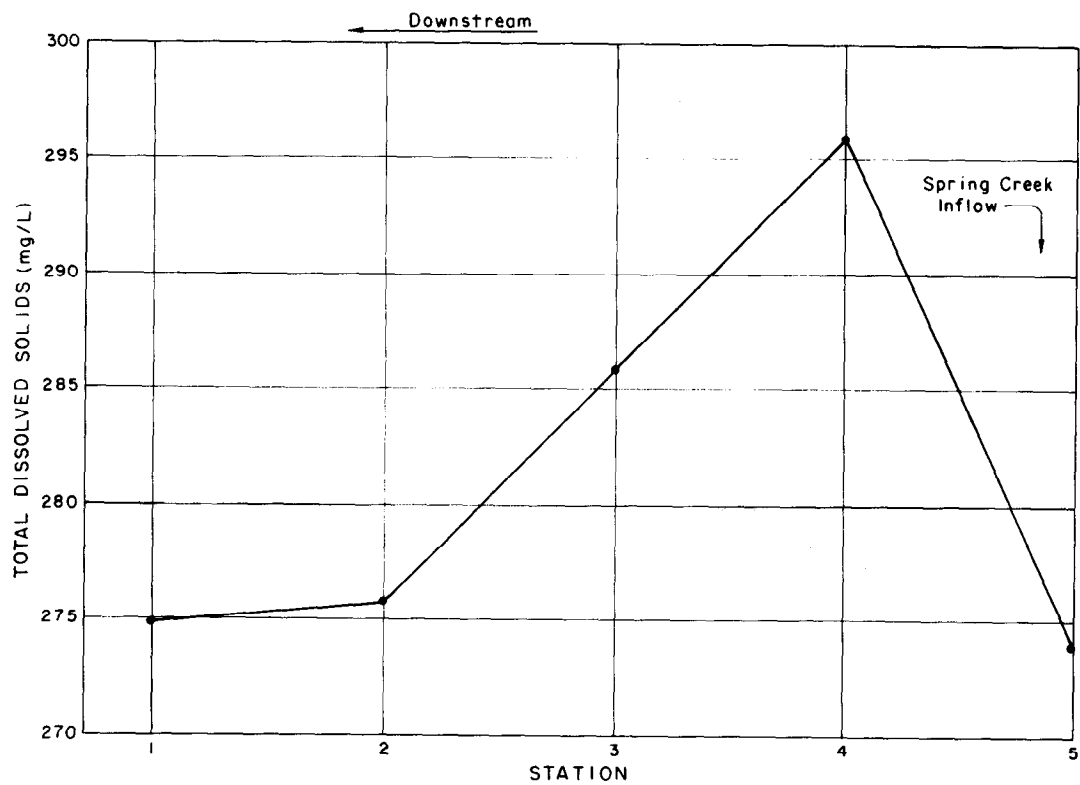


Figure 8.—Average total dissolved solids in Lake Pocasse during 1978.

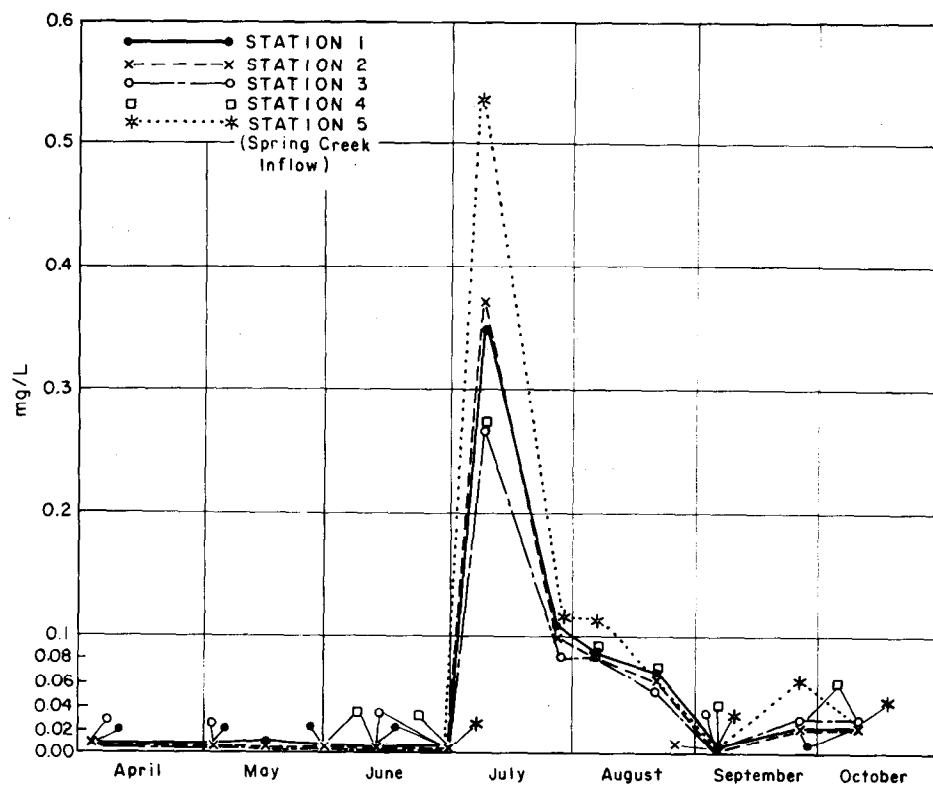


Figure 9.—Concentration of copper in Lake Pocasse during 1978.

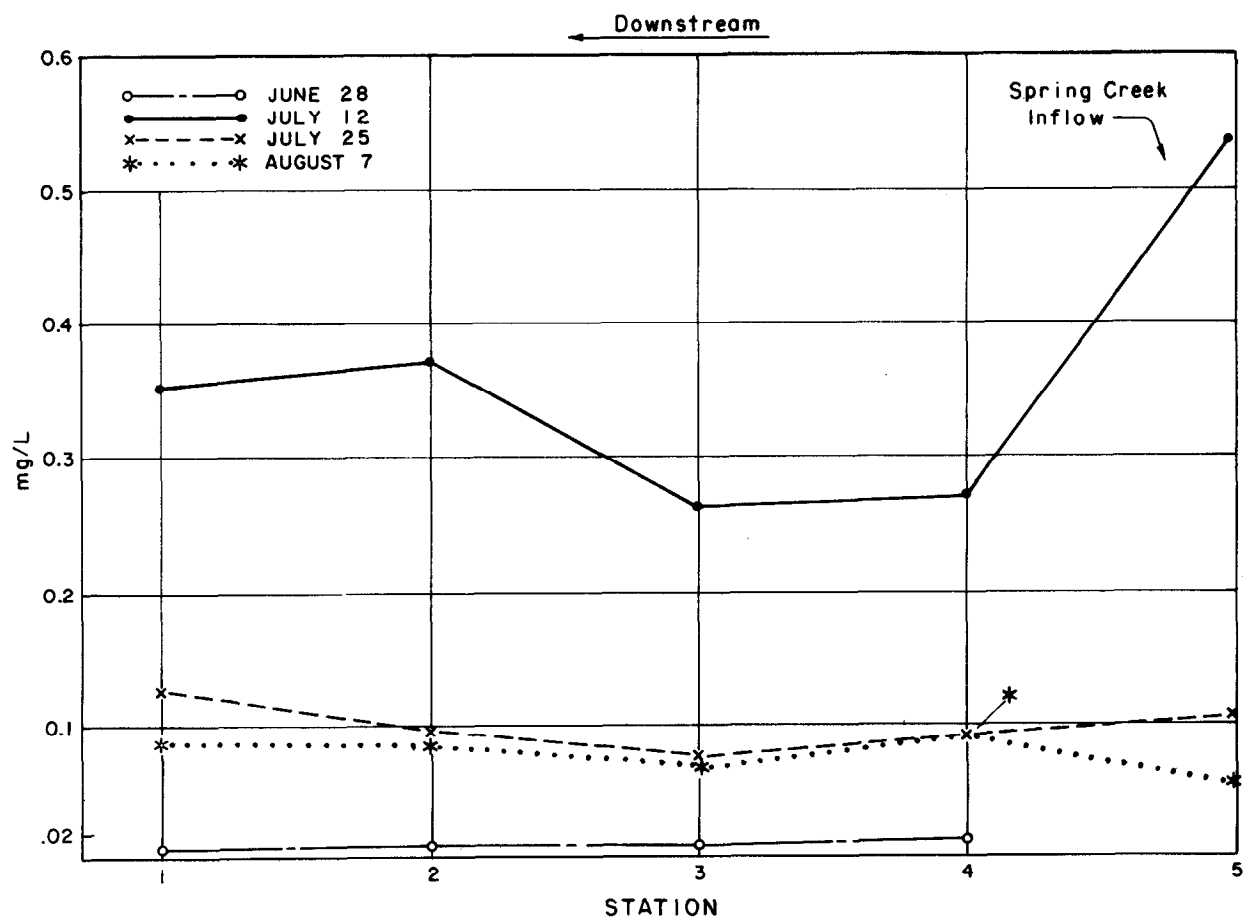


Figure 10.—Concentration of copper in Lake Pocasse during the summer of 1978.

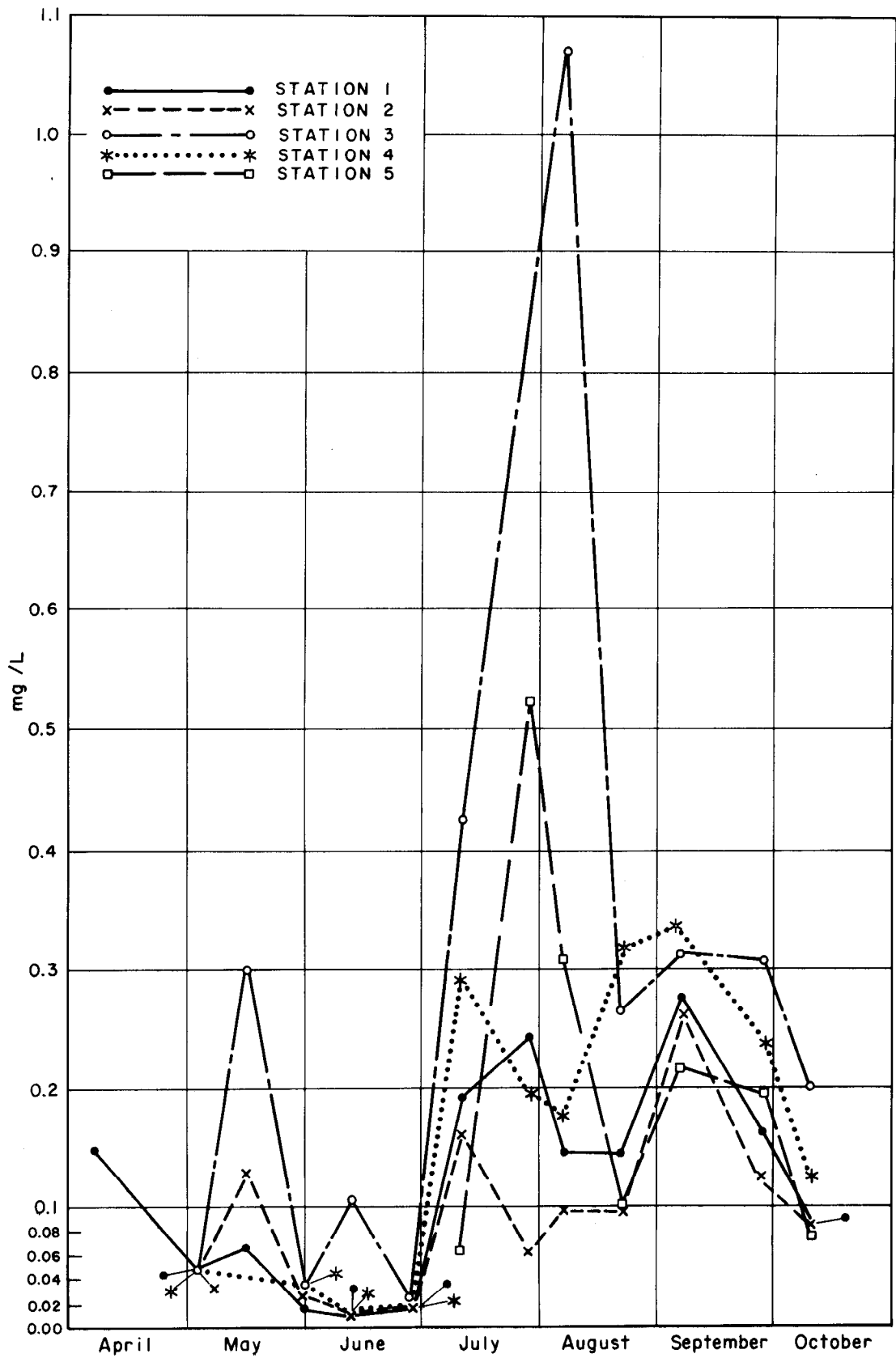


Figure 11.—Concentration of manganese in Lake Pocasse during 1978.

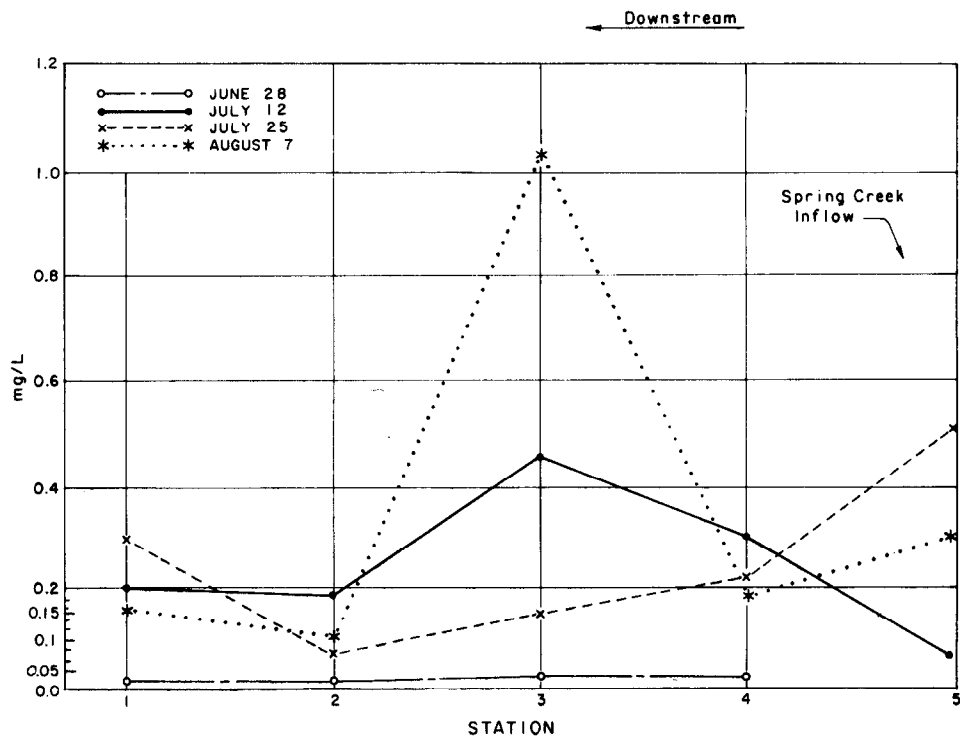


Figure 12.—Concentration of manganese in Lake Pocasse during the summer of 1978.

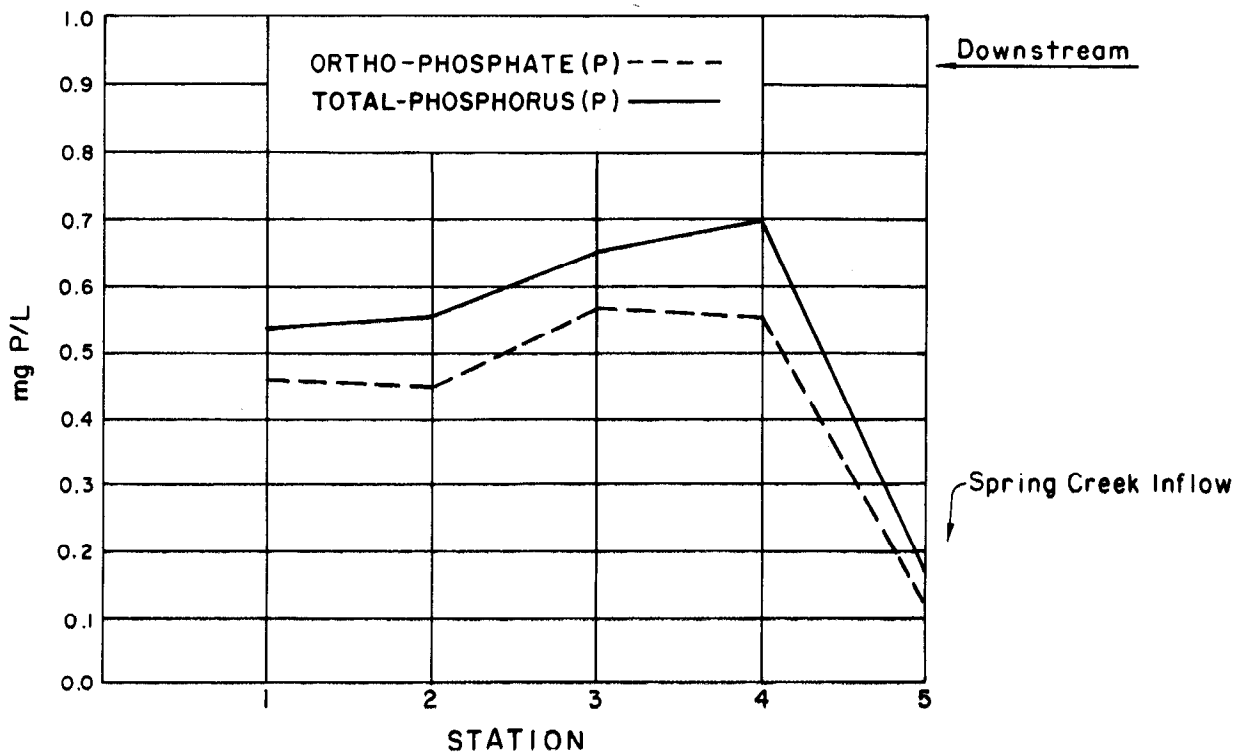


Figure 13.—Mean levels of phosphorus in Lake Pocasse during 1978.

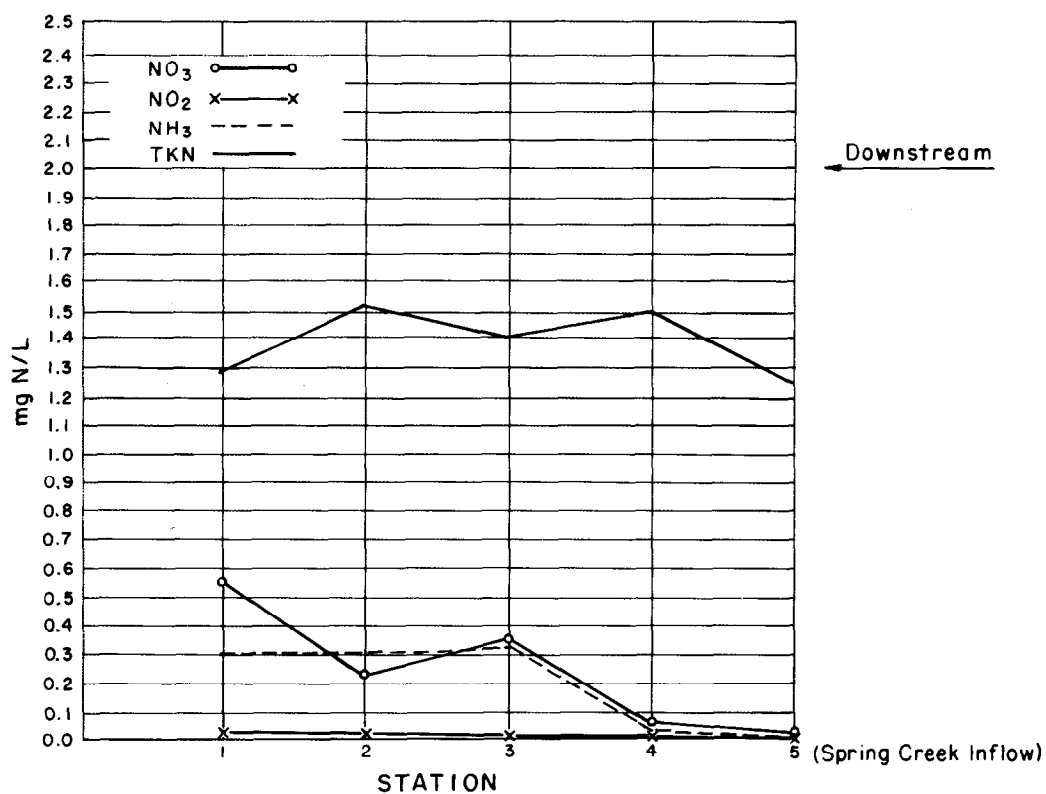


Figure 14.—Mean levels of nitrogen in Lake Pocasse during 1978.

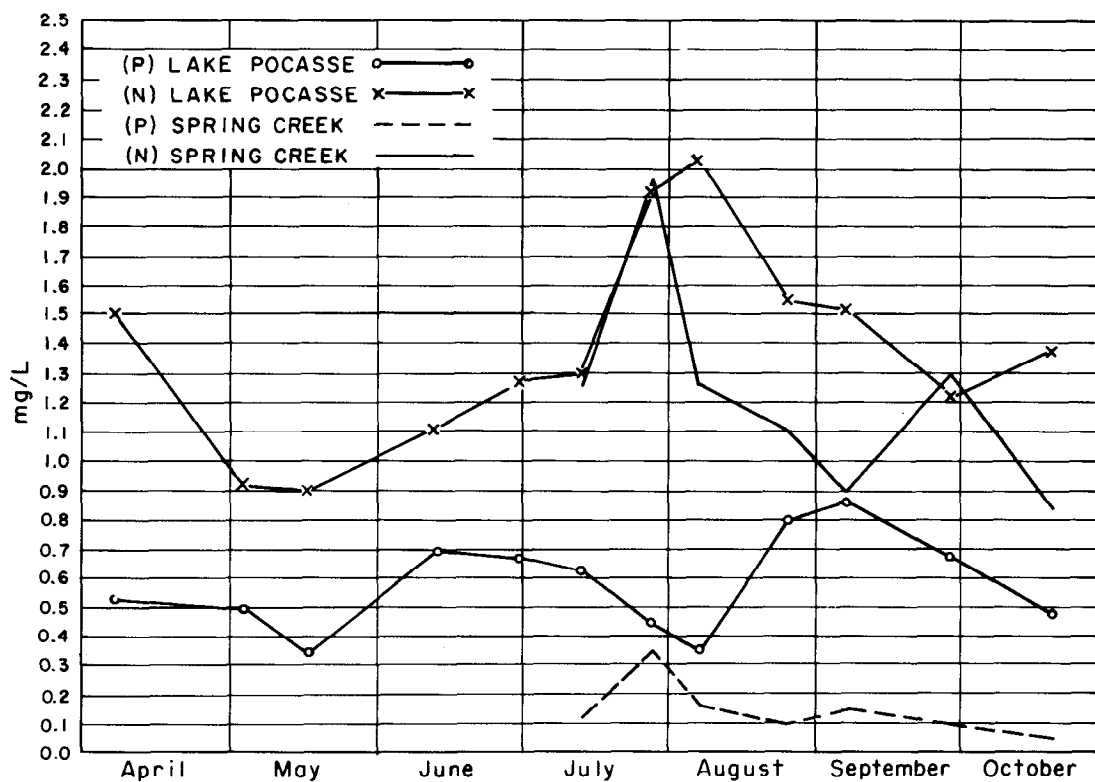


Figure 15.—Mean levels of total phosphorus and total Kjeldahl nitrogen in Lake Pocasse and Spring Creek during 1978.

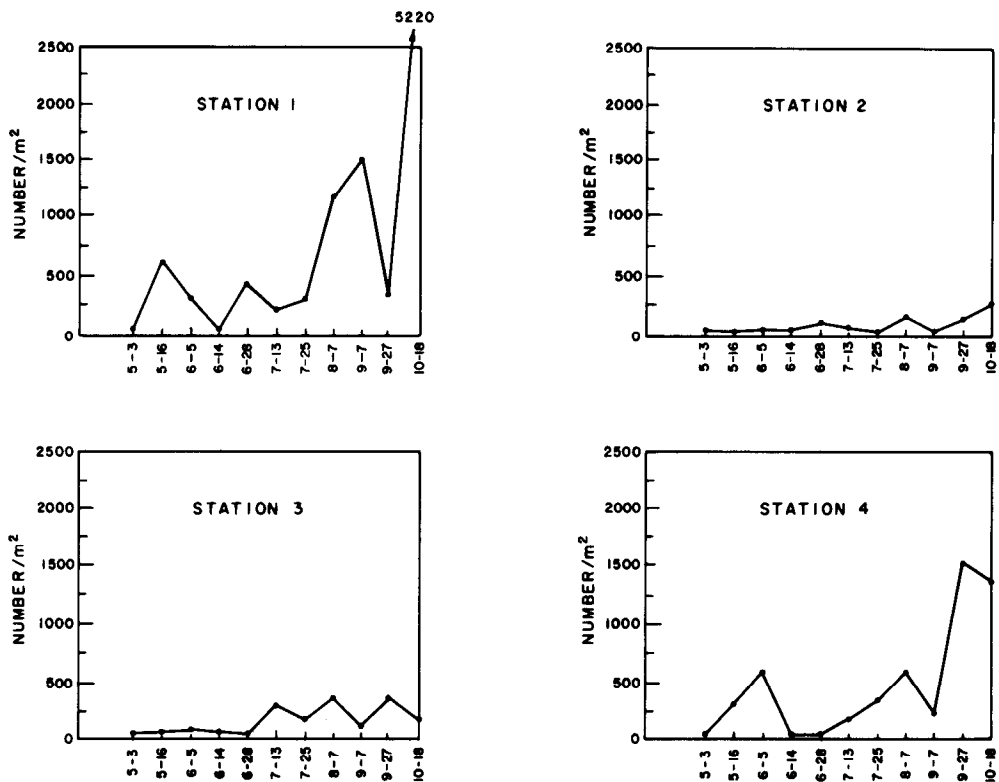


Figure 16.—Abundance of benthic organisms in Lake Pocasse during 1978.

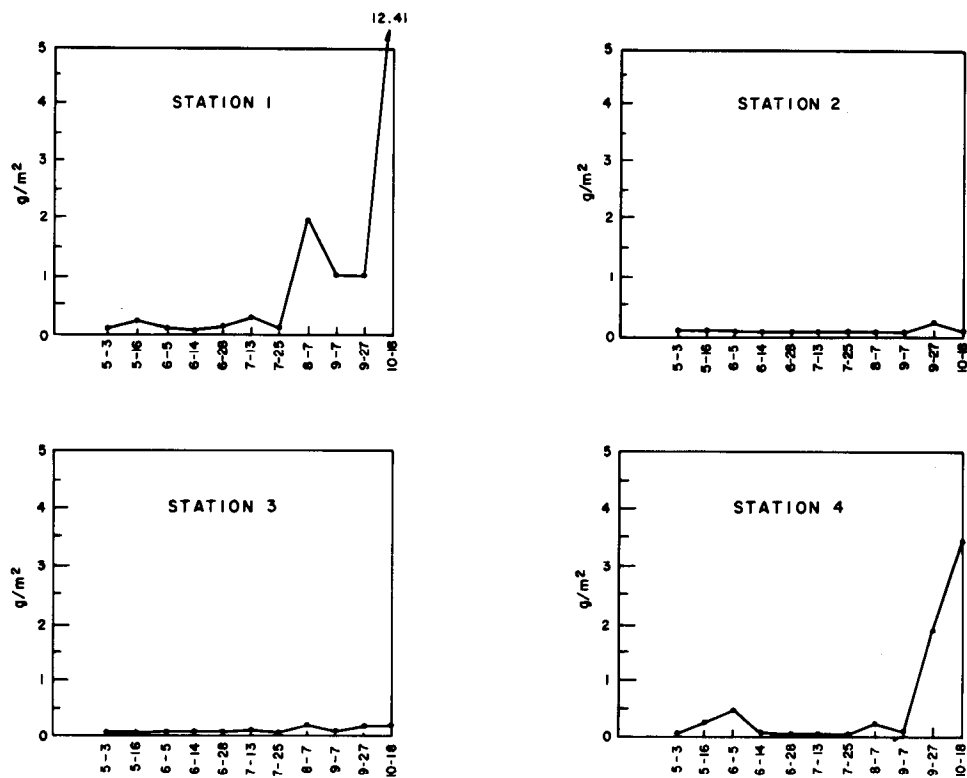


Figure 17.—Dry mass of benthic organisms in Lake Pocasse during 1978.

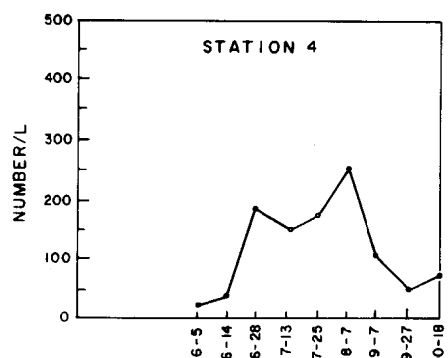
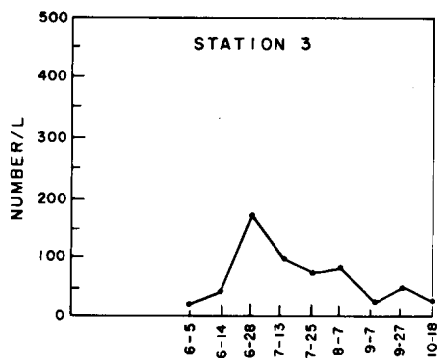
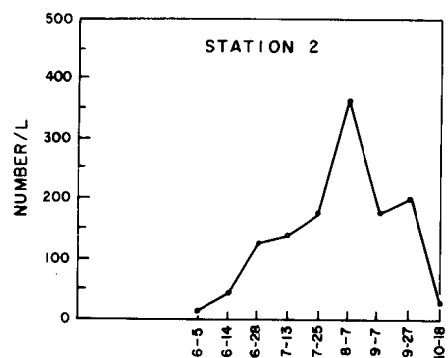
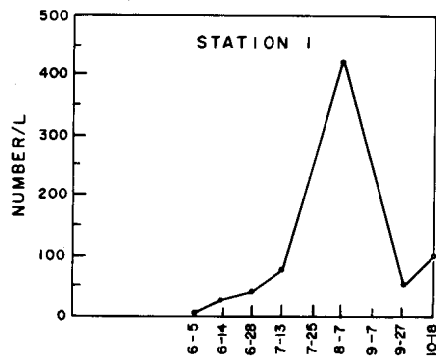


Figure 18.—Abundance of the zooplankton *Diaptomus* spp. in Lake Pocasse.

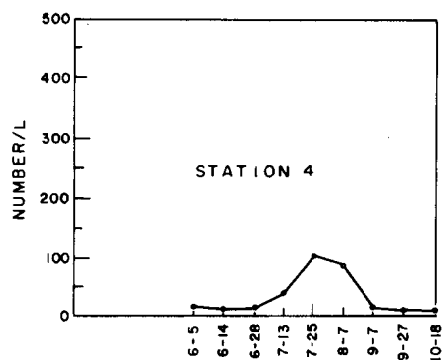
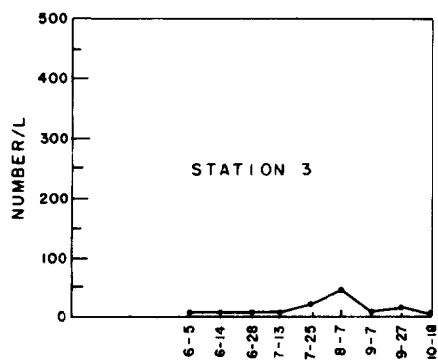
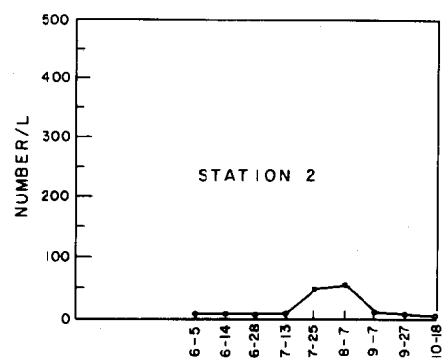
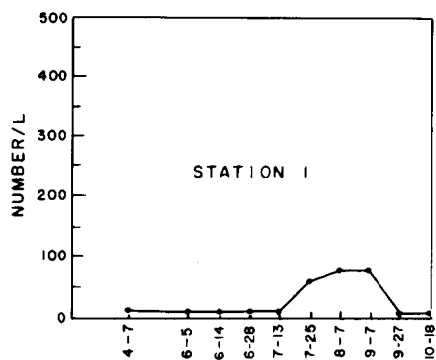


Figure 19.—Abundance of the zooplankton *Cyclops* spp. in Lake Pocasse during 1978.

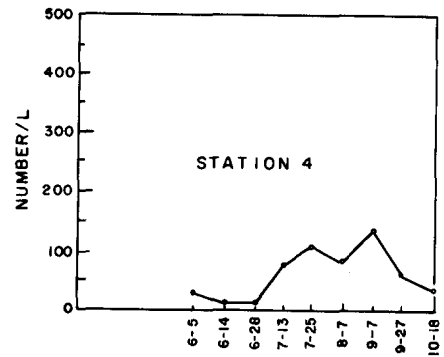
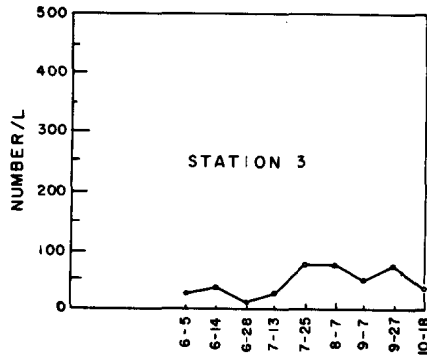
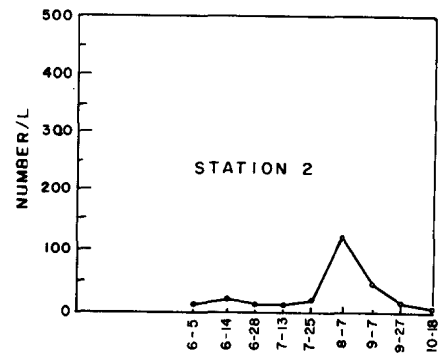
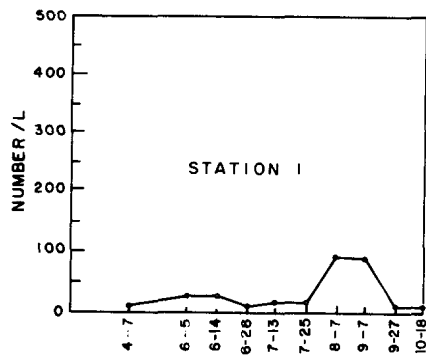


Figure 20.—Abundance of cladocerans in Lake Pocasse during 1978.

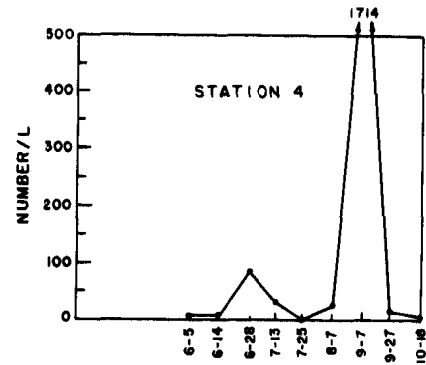
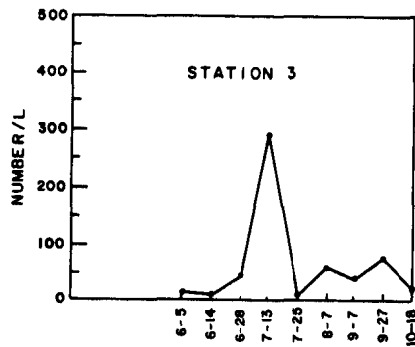
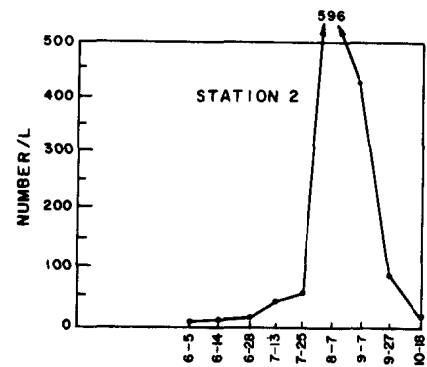
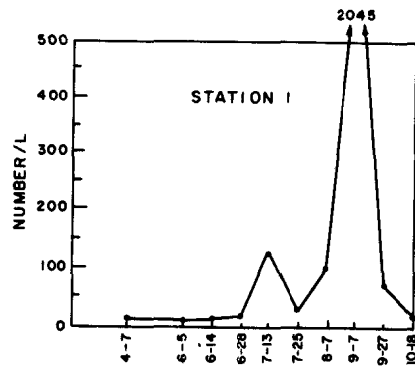


Figure 21.—Abundance of rotifers in Lake Pocasse during 1978.

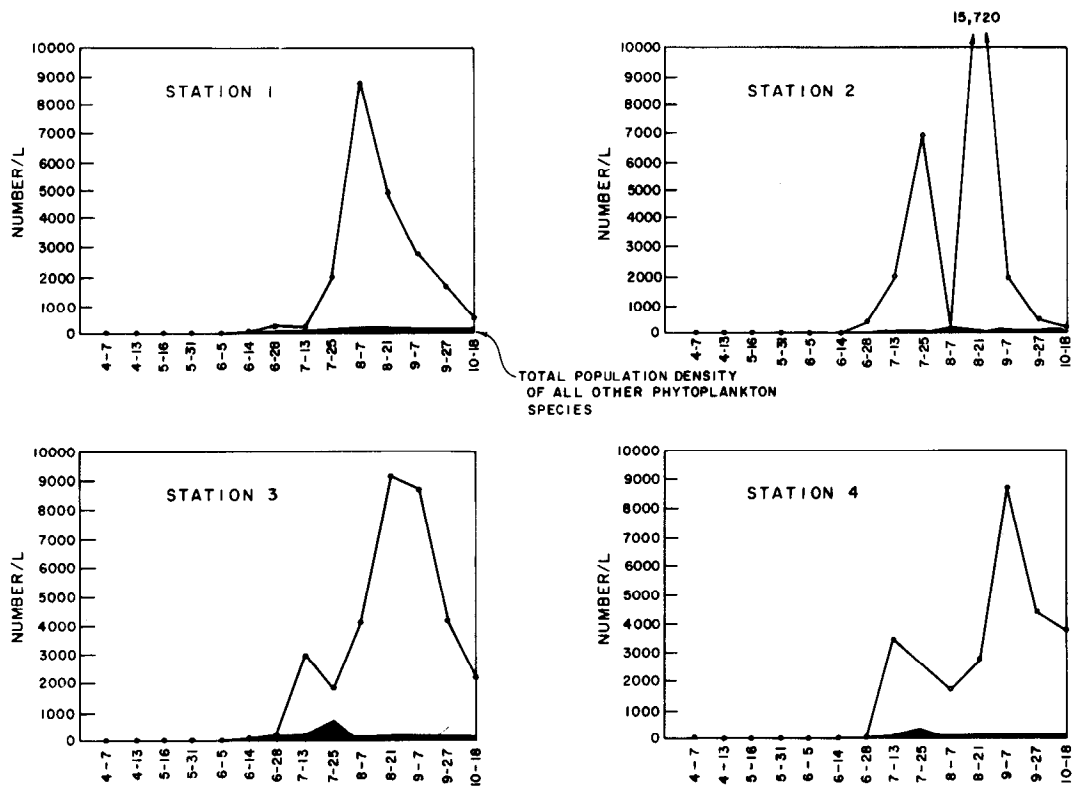


Figure 22.—Abundance of the phytoplankton *Aphanizomenon flos-aquae* trichomes in Lake Pocasse during 1978.

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Table 1.—*Chemical analyses of water from Lake Pocasse, station 1*

Sample date ¹	Conductivity μS/cm	pH	TDS	Ca	Mg	Na	K (mg/L)	CO ₃	HCO ₃	SO ₄	Cl	anions + cations
Nov. 10, 1977	1670	8.60	1140	42.0	51.0	205.0	25.0	10.2	346	421.0	40.5	1140
April 4, 1978	220	7.50	154	14.4	17.6	19.1	21.9	0	87.2	65.8	11.4	255
June 13, 1978	370	7.90	252	28.8	11.7	27.1	13.3	0	185	64.8	0.71	331
	374	7.90	238	31.2	10.2	26.4	13.3	0	155	69.1	2.84	308
June 28, 1978	395	8.40	240	29.6	13.2	29.7	13.7	1.8	152	69.6	4.97	314
	398	7.80	246	32.8	11.2	29.4	13.7	0	155	67.2	2.84	312
July 12, 1978	403	7.90	260	32.0	14.2	34.3	14.9	0	197	79.2	4.97	376
	434	7.90	248	35.2	11.7	33.8	14.9	0	180	89.3	4.97	370
July 25, 1978	438	8.00	274	37.6	11.2	34.3	15.2	0	180	84.5	4.97	368
	439	8.00	278	33.6	15.1	34.0	14.9	0	180	73.4	5.68	357
Aug. 7, 1978	459	9.20	266	33.8	17.0	34.0	15.6	48.1	102	67.7	4.97	324
	445	8.89	280	18.8	27.3	33.1	15.6	33.6	129	72.5	5.33	336
Aug. 21, 1978	459	9.03	284	33.8	18.8	34.0	15.6	48.0	106	77.3	5.68	339
	472	8.55	284	34.0	16.7	34.0	15.6	13.5	179	59.0	6.39	359
Sept. 7, 1978	393	7.79	264	36.0	15.9	30.1	12.5	0	172	75.8	4.97	347
	424	7.80	294	32.8	19.0	38.6	14.9	0	188	84.0	7.10	384
Sept. 27, 1978	418	8.75	290	26.4	19.4	37.3	17.2	9.6	154	85.0	6.04	355
	431	8.82	300	28.0	18.8	38.2	17.6	12.9	153	84.5	6.74	360
Oct. 18, 1978	515	8.30	340	33.6	22.7	43.9	18.0	0	210	98.4	7.10	434
	477	8.30	320	28.8	23.2	40.7	18.4	0	198	91.7	6.04	406

¹ For sample dates with two lines of data, the first line denotes a sample collected near or at the surface, and the second line a sample collected near the bottom. When only one line of data is presented, the sample was collected at or near the surface. This footnote applies to tables 1 through 10.

Table 2.—*Chemical analyses of water from Lake Pocasse, station 2*

Sample date ¹	Conductivity $\mu\text{S/cm}$	pH	TDS	Ca	Mg	Na	K (mg/L)	CO ₃	HCO ₃	SO ₄	Cl	anions + cations
June 13, 1978	376	7.70	228	27.2	12.7	26.4	13.3	0	146	59.0	5.68	290
June 28, 1978	403	7.60	240	30.4	12.7	29.4	13.7	0	157	62.4	4.97	310
July 12, 1978	434	7.80	278	33.6	13.2	33.8	14.9	0	179	86.9	4.26	366
July 25, 1978	482	7.40	290	35.2	13.7	35.2	16.0	0	209	76.3	4.26	390
Aug. 7, 1978	472	8.95	278	35.0	17.0	33.8	15.6	40.8	113	70.6	5.68	332
Aug. 21, 1978	464	8.65	288	37.2	15.2	36.1	16.4	22.2	157	66.2	4.97	356
Sept. 7, 1978	395	7.81	250	31.2	17.4	34.0	13.3	0	174	85.9	4.97	361
Sept. 27, 1978	375	9.10	282	24.0	18.5	30.6	14.5	21.6	126	67.7	4.26	307
Oct. 18, 1978	496	8.05	346	33.4	23.1	43.2	19.2	0	209	97.9	7.10	432

¹ See footnote on table 1.

Table 3.—*Chemical analyses of water from Lake Pocasse, station 3*

Sample date ¹	Conductivity $\mu\text{S/cm}$	pH	TDS	Ca	Mg	Na	K (mg/L)	CO ₃	HCO ₃	SO ₄	Cl
June 13, 1978	449	8.10	276	35.2	13.2	33.6	14.5	0	182	76.3	5.61
	449	8.10	286	34.4	14.2	35.4	14.5	0	181	75.4	5.61
June 28, 1978	458	7.50	286	36.0	13.7	36.3	14.1	0	187	71.5	5.61
	450	7.60	276	34.4	15.1	37.0	14.5	0	190	71.0	5.61
July 12, 1978	426	7.70	266	32.0	13.7	32.2	15.2	0	182	74.9	4.97
	422	7.80	264	33.6	13.2	32.7	15.2	0	185	67.7	5.61
July 25, 1978	436	7.50	282	35.2	14.6	32.2	15.6	0	187	64.8	4.97
	434	7.70	284	34.4	13.7	31.7	15.6	0	190	64.3	4.97
Aug. 7, 1978	461	8.25	294	34.8	17.3	32.4	15.6	0	206	61.9	5.31
	483	7.97	282	38.2	14.3	32.7	15.6	0	212	54.2	6.31
Aug. 21, 1978	461	8.81	288	38.2	17.2	35.6	16.8	35.4	151	64.8	6.31
	479	8.46	260	37.2	18.3	35.6	16.4	0.3	234	64.8	4.97
Sept. 7, 1978	435	7.65	284	36.0	19.0	37.0	14.9	0	199	78.2	6.04
	474	7.75	286	38.0	18.4	42.3	16.0	0	210	103.0	8.11
Sept. 27, 1978	421	8.80	284	17.6	21.2	40.7	18.4	12.0	159	75.8	5.61
	404	8.41	280	28.0	18.8	35.4	15.6	3.9	184	70.1	4.97
Oct. 18, 1978	518	8.16	344	32.8	23.2	44.6	19.2	0	232	85.0	7.81
	494	8.20	338	32.6	22.4	42.1	17.6	0	221	88.8	8.51

¹ See footnote on table 1.

Table 4.—*Chemical analyses of water from Lake Pocasse, station 4*

Sample date ¹	Conductivity $\mu\text{S/cm}$	pH	TDS	Ca	Mg	Na	K (mg/L)	CO ₃	HCO ₃	SO ₄	Cl	anions + cations
June 13, 1978	464	8.30	294	36.8	13.7	36.3	14.1	0	192	77.8	4.97	375
June 28, 1978	512	7.40	320	40.0	18.1	40.3	13.3	0	246	83.0	2.13	443
July 12, 1978	420	7.50	260	32.8	13.2	30.1	15.2	0	175	72.5	7.81	347
July 25, 1978	436	7.60	282	35.2	13.7	31.3	15.6	0	190	64.3	7.81	358
Aug. 7, 1978	483	8.55	276	36.8	17.8	32.4	16.4	16.8	187	63.8	4.26	376
Aug. 21, 1978	508	8.29	296	38.4	16.3	35.9	16.4	0	224	61.0	6.04	399
Sept. 7, 1978	470	7.71	294	36.4	19.8	39.8	15.2	0	212	81.6	6.39	411
Sept. 27, 1978	437	8.80	298	22.8	20.7	38.6	17.6	12.6	167	70.6	6.39	356
Oct. 18, 1978	520	8.00	350	33.8	23.3	45.5	19.9	0	235	80.6	8.88	448

¹ See footnote on table 1.

Table 5.—*Chemical analyses of water from Lake Pocasse, station 5*

Sample date ¹	Conductivity $\mu\text{S}/\text{cm}$	pH	TDS	Ca	Mg	Na	K (mg/L)	CO ₃	HCO ₃	SO ₄	Cl	anions + cations
July 25, 1978	399	7.30	242	30.4	14.6	29.0	13.7	0	195	58.6	4.26	346
Aug. 7, 1978	406	8.21	240	25.6	18.9	29.2	14.5	0	206	31.2	11.7	337
Aug. 21, 1978	406	8.21	222	37.0	7.56	29.4	13.7	0	194	33.6	4.97	320
Sept. 7, 1978	498	7.89	282	21.2	38.7	34.5	14.1	0	284	47.5	6.39	447
Sept. 27, 1978	347	7.95	298	15.6	20.3	34.1	11.7	0	170	56.6	4.97	313
Oct. 18, 1978	549	7.75	358	21.6	27.3	59.8	18.4	0	237	86.9	14.9	466

¹ See footnote on table 1.

Table 6.—Water analyses for the presence of selected heavy metals, station 1

Sample date ¹	Cu	Fe	Pb (mg/L)	Mn	Zn
Nov. 10, 1977 ²	N.D. ³	N.D.	N.D.	N.D.	N.D.
Apr. 4, 1978 ⁴	0.007	1.85	0.05	0.150	0.06
May 2, 1978	.004 .011	0.80 .80	.05 .20	.050 .050	.05 .02
May 16, 1978	.008	1.00	.10	.070	.02
May 31, 1978	.005 .005	3.10 3.45	N.D. N.D.	.020 .015	.02 .02
June 13, 1978	.005 N.A. ⁵	2.30 N.A.	N.D. N.A.	.020 N.A.	N.D. N.A.
June 28, 1978	0.005 .005	3.80 6.20	N.D. N.D.	0.010 .025	0.01 .02
July 12, 1978	.260 .445	0.65 .65	0.07 .07	.185 .212	.13 .11
July 25, 1978	.140 .065	.15 7.50	N.D. N.D.	.050 .440	.01 .04
Aug. 7, 1978	.100 .065	0.13 .32	N.D. N.D.	.070 .225	.01 .01
Aug. 21, 1978	.070 .065	.48 .55	N.D. N.D.	.070 .225	.01 .01
Sept. 7, 1978	N.D. N.D.	.73 .77	0.05 .10	.260 .300	.01 .16
Sept. 27, 1978	0.010 .030	.91 1.06	.04 .11	.160 .180	.02 .03
Oct. 18, 1978	.020 .020	1.14 1.03	.06 .07	.090 .090	.02 .03

¹ See footnote on table 1.

² On this date detection limits in mg/L: Cu = 0.02; Fe = 0.05; Pb = 0.10; Mn = 0.05; Zn = 0.02.

³ Not detectable.

⁴ From this date forward detection limits in mg/L: Cu = 0.002; Fe = 0.05; Pb = 0.05; Mn = 0.010; Zn = 0.01.

⁵ Not analyzed.

Table 7.—*Water analyses for the presence of selected heavy metals, station 2*

Sample date ¹	Cu	Fe	Pb (mg/L)	Mn	Zn
May 2, 1978 ²	0.004	0.90	0.10	0.050	0.02
May 16, 1978	.006	1.20	.10	.130	.02
May 31, 1978	.005	3.10	N.D. ³	.025	.02
June 13, 1978	.005	2.00	N.D.	.010	N.D.
June 28, 1978	.005	6.75	N.D.	.015	0.01
July 12, 1978	.370	0.75	0.06	.173	.05
July 25, 1978	.095	.15	N.D.	.065	.01
Aug. 7, 1978	.085	.15	N.D.	.100	.01
Aug. 21, 1978	.060	.45	N.D.	.100	.01
Sept. 7, 1978	N.D.	.39	0.08	.270	.01
Sept. 27, 1978	0.020	.73	.09	.130	.02
Oct. 18, 1978	.020	1.05	.06	.090	.02

¹ See footnote on table 1.

² Detection limits in mg/L: Cu = 0.002; Fe = 0.05; Pb = 0.05; Mn = 0.010; Zn = 0.01.

³ Not detectable.

Table 8.—*Water analyses for the presence of selected heavy metals, station 3*

Sample date ¹	Cu	Fe	Pb	Mn	Zn
	(mg/L)				
May 2, 1978 ²	0.003	0.80	0.10	0.050	0.02
May 16, 1978	.007	1.85	.10	.300	.02
May 31, 1978	.005	1.95	N.D. ³	.040	.02
	.005	2.10	N.D.	.035	.03
June 13, 1978	N.D.	1.30	N.D.	.030	N.D.
	0.005	3.20	N.D.	.180	0.02
June 28, 1978	.005	1.20	N.D.	.020	N.D.
	.005	2.50	N.D.	.025	0.01
July 12, 1978	.170	0.80	0.06	.405	.05
	.360	1.35	.23	.450	.28
July 25, 1978	.085	0.30	.08	.135	N.D.
	.070	.30	N.D.	.160	N.D.
Aug. 7, 1978	.065	.23	N.D.	.120	0.01
	.095	9.50	N.D.	1.950	.05
Aug. 21, 1978	.055	0.41	N.D.	0.250	.01
	.055	.76	N.D.	.295	.01
Sept. 7, 1978	N.D.	.36	0.07	.290	.01
	N.D.	1.25	.09	.340	.01
Sept. 27, 1978	0.020	0.43	.06	.300	.02
	.030	.58	.13	.320	.04
Oct. 18, 1978	.020	.50	.07	.210	.02
	.030	.52	.12	.200	.03

¹ See footnote on table 1.

² Detection limits in mg/L: Cu = 0.002; Fe = 0.05; Pb = 0.05; Mn = 0.010; Zn = 0.01.

³ Not detectable.

Table 9.—*Water analyses for the presence of selected heavy metals, station 4*

Sample date ¹	Cu	Fe	Pb (mg/L)	Mn	Zn
May 2, 1978 ²	N.D. ³	0.55	0.10	0.050	0.02
May 31, 1978	0.005	1.50	N.D.	.035	.03
June 13, 1978	.005	2.60	N.D.	.010	N.D.
June 28, 1978	.010	2.40	N.D.	.015	0.01
July 12, 1978	.270	0.90	0.08	.295	.15
July 25, 1978	.090	.20	N.D.	.210	N.D.
Aug. 7, 1978	.090	.18	N.D.	.180	0.01
Aug. 21, 1978	.070	.45	N.D.	.320	.01
Sept. 7, 1978	N.D.	.22	0.07	.340	.01
Sept. 27, 1978	0.020	.55	.07	.240	.02
Oct. 18, 1978	.040	.68	.21	.130	.03

¹ See footnote on table 1.² Detection limits in mg/L: Cu = 0.002; Fe = 0.05; Pb = 0.05; Mn = 0.010; Zn = 0.01.³ Not detectable.Table 10.—*Water analyses for the presence of selected heavy metals, station 5*

Sample date ¹	Cu	Fe	Pb (mg/L)	Mn	Zn
July 12, 1978 ²	0.535	0.20	0.15	0.065	0.30
July 25, 1978	.105	.20	N.D. ³	.530	.01
Aug. 7, 1978	.110	.32	N.D.	.310	.01
Aug. 21, 1978	.055	.40	N.D.	.100	.01
Sept. 7, 1978	N.D.	.18	0.06	.220	.02
Sept. 27, 1978	0.060	.38	.22	.200	.06
Oct. 18, 1978	.020	.42	.08	.080	.02

¹ See footnote on table 1.² Detection limits in mg/L: Cu = 0.002; Fe = 0.05; Pb = 0.05; Mn = 0.010; Zn = 0.01.³ Not detectable.

Table 11.—*Lake Pocasse field measurements, June 29, 1978¹*

Station	Depth (m)	Temperature (°C)	Dissolved oxygen (mg/L)	Conductivity (μS/cm)	pH	Oxidation- reduction potential (mV)
1	0.1	25.0	8.6	350	8.45	135
	1.0	24.5	8.5	350	8.45	140
	3.0	23.5	7.5	350	8.20	50
	3.3 ²	23.5	6.6	360	7.25	-85
2	0.1	24.0	8.15	350	8.40	130
	2.0	23.5	8.15	360	8.35	135
3	0.1	24.0	8.4	410	8.50	145
	1.0	24.0	8.4	410	8.50	150
	3.0	22.5	5.4	420	8.20	150
	3.3	22.5	5.4	420	7.80	145
4	0.1	24.5	7.8	440	8.50	160
	2.0	24.3	7.6	440	8.60	150

¹ Measured with Hydrolab Corporation Surveyor.

² Probes were in very soft mud bottom during readings.

Table 12.—Nutrient analyses of Lake Pocasse water

Sample collection date	Station and description	PO ₄	Total P	NO ₃	NO ₂	NH ₃	Total TKN
		(mg/L)					
April 7, 1978 ¹	1—Surface	0.475	0.540	0.365	0.035	0.650	1.50
May 3, 1978	1—Surface	.400	.500	.410	.050	.360	0.99
	—Bottom	.400	.450	.370	.110	.340	.84
	2—Surface	.400	.500	.520	.050	.340	1.02
	3—Surface	.380	.380	.320	.030	.370	0.69
	—Bottom	.350	.500	.305	.035	.192	1.14
	4—Surface	.500	.700	.080	.060	.340	0.93
May 16, 1978	1—Surface	.300	.330	.530	.040	.146	.90
	—Bottom	.320	.330	.580	.120	.360	.96
	2—Surface	.350	.380	.500	.150	.166	.75
	3—Surface	.400	.450	.250	.200	1.860	1.05
June 13, 1978	1—Surface	.650	.650	.438	.045	0.300	0.90
	—Bottom	.680	.700	.380	.020	.154	.96
	2—Surface	.650	.650	.290	.010	.118	.96
	3—Surface	.600	.630	.175	.005	.110	.75
	—Bottom	.930	.930	.600	N.D. ²	.158	2.10
	4—Surface	.650	.650	.180	N.D.	.044	1.05
June 29, 1978	1—Surface	.650	.650	.520	.020	.040	1.50
	—Bottom	.650	.650	.495	.125	.162	1.56
	2—Surface	.700	.700	.350	.010	.050	1.50
	3—Surface	.700	.700	.290	.010	.054	0.96
	—Bottom	.950	.900	.300	.060	.098	1.20
	4—Surface	.500	.550	.115	.010	.060	0.99
July 13, 1978	1—Surface	.620	.675	7.000	.015	.065	1.50
	—Bottom	.580	.580	0.125	.002	.035	0.90
	2—Surface	.480	.490	.025	N.D.	.165	1.26
	3—Surface	.575	.675	.015	N.D.	.250	1.23
	—Bottom	.650	.725	4.600	.010	.050	1.35
	4—Surface	.575	.650	0.080	N.D.	.350	1.50
	5—Surface	.110	.130	.010	N.D.	.050	1.26
July 24, 1978	1—Surface	.275	.260	N.D.	N.D.	.155	0.99
	—Bottom	.450	.510	0.020	N.D.	.500	1.08
	2—Surface	.300	.340	N.D.	.015	.850	3.60
	3—Surface	.440	.480	N.D.	.005	.410	2.07
	—Bottom	.475	.490	0.005	N.D.	.220	1.14
	4—Surface	.525	.590	N.D.	.005	.280	2.55
	5—Surface	.340	.370	N.D.	.005	.420	1.95

Table 12.—Nutrient analyses of Lake Pocasse water—Continued

Sample collection date	Station and description	PO ₄	Total P	NO ₃	NO ₂	NH ₃	Total TKN
		(mg/L)					
Aug. 7, 1978	1—Surface	0.225	0.320	N.D.	N.D.	0.650	4.25
	—Bottom	.320	.320	0.015	N.D.	.480	1.20
	2—Surface	.230	.295	.010	N.D.	.430	2.04
	3—Surface	.225	.275	N.D.	N.D.	.200	1.44
	—Bottom	.350	.365	0.010	N.D.	.500	1.80
	4—Surface	.400	.610	.010	.005	.160	1.53
	5—Surface	.080	.170	.020	N.D.	.230	1.26
Aug. 21, 1978	1—Surface	.425	.660	.005	N.D.	.360	1.74
	—Bottom	.435	.730	.005	N.D.	.300	0.87
	2—Surface	.460	.820	N.D.	N.D.	.250	1.95
	3—Surface	.580	.900	N.D.	N.D.	.380	1.95
	—Bottom	.540	.890	N.D.	.010	.330	1.20
	4—Surface	.570	.810	0.010	N.D.	.180	1.50
	5—Surface	.050	.100	.005	.005	.150	1.11
Sept. 7, 1978	1—Surface	.680	.930	.010	N.D.	.450	1.41
	—Bottom	.610	.770	.010	N.D.	.300	1.20
	2—Surface	.640	.810	.005	.010	.425	1.20
	3—Surface	.700	.900	N.D.	N.D.	.380	1.80
	—Bottom	.670	.910	N.D.	N.D.	.300	1.80
	4—Surface	.650	.920	N.D.	.005	.250	1.65
	5—Surface	.060	.150	N.D.	N.D.	.050	0.90
Sept. 27, 1978	1—Surface	.390	.480	0.300	.050	.630	.75
	—Bottom	.330	.500	.165	.055	.450	1.20
	2—Surface	.430	.630	.255	.065	.425	1.14
	3—Surface	.610	.830	.010	.005	.330	1.29
	—Bottom	.615	.830	.035	.015	.330	1.35
	4—Surface	.550	.835	.038	.012	.350	1.53
	5—Surface	.040	.100	.010	.010	.300	1.29
Oct. 18, 1978	1—Surface	.300	.380	.535	.015	.150	1.20
	—Bottom	.325	.380	.530	.020	.130	1.05
	2—Surface	.300	.430	.525	.025	.130	1.20
	3—Surface	.500	.680	.240	.025	.420	1.80
	—Bottom	.460	.525	.200	.030	.275	1.35
	4—Surface	.520	.550	.170	.030	.475	1.65
	5—Surface	.020	.050	.010	N.D.	N.D.	0.85
Averages for entire study =		0.462	0.560	0.337	0.023	0.297	1.35
¹ Detection limits =		0.001	0.001	0.001	0.001	0.010	0.030
² Not detectable.							

Table 13.—*Chlorophyll concentrations in Lake Pocasse*

Station	Date	Depth (m)	Chlorophyll (mg/m ³)		
			<i>a</i>	<i>b</i>	<i>c</i>
1	July 13, 1978	0.1	17.55	0	1.67
2		.1	35.11	0	0.59
3		.1	15.30	0	.66
4		.1	18.13	0	1.44
1	July 25, 1978	.1	35.11	0	0.59
2		.1	21.47	0	1.16
3		.1	22.63	0	0.70
4		.1	18.13	0	1.44
1	Aug. 21, 1978	.1	25.06	0	1.37
2		.1	26.18	0	1.23
3		.1	12.77	0	0.47
4		.1	4.21	0	.38
1	Sept. 7, 1978	.1	3.98	0	0.31
2		.1	27.12	0	2.64
3		.1	7.97	0	0.61
4		.1	12.48	0	2.74
1	Oct. 18, 1978	.1	6.98	0.43	3.21
2		.1	5.30	1.25	1.60
3		.1	18.47	4.42	0
4		.1	31.47	2.93	0

Table 14.—*Insecticide, herbicide, and PCB analyses—July 1978*

Station No. and location	Compound	Levels detected (mg/L)
1—Lake Pocasse 4—Lake Pocasse 5—Spring Creek (at Herreid) 6—Oahe Reservoir (Spring Creek arm)	Lindane, heptachlor, Aldrin, epoxide, Dieldrin, DDE, TDE, DDT	< 0.001
	Methoxychlor, malathion, Parathion, chlordane	< 0.001
	Endrin	< 0.0002
	2,4-D, Silvex, Tordon	< 0.001
	Toxaphene	< 0.005
<hr/>		
5—Spring Creek (at Herreid)	PCB	0.001
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1—Lake Pocasse 4—Lake Pocasse 6—Oahe Reservoir (Spring Creek arm)	PCB	< 0.001

Table 15.—Comparison of abundances of benthic fauna (excluding mollusks)

Location	Abundances (No./m ²)	Bibliography
Twin Lakes, Colo. (upper)	0 to 200	[15]
Lake Shaswap, Canada	214	[16]
Apache Lake, Ariz.	144 to 488	[17]
Lake Okanagan, Canada	364	[18]
Lake Okanagan, Canada	342	[16]
Waterton Lake, Canada	370	[18]
Roosevelt Lake, Ariz.	210 to 999	[17]
Canyon Lake, Ariz. (Feb. sampling)	43 to 1025	[17]
Bow Lake, Canada	706	[18]
Saguaro Lake, Ariz. (Feb. sampling)	0 to 1471	[17]
Lake Maligne, Canada	805	[18]
Lake Cultus, Canada	1087	[16]
Lake Minnewanka, Canada	1141	[18]
Lake Paul, Canada	1363	[18]
Boomer Lake, Okla.	520 to 1850	[19]
Lake Itasca, Minn.	1617 (sublittoral)	[20]
Great Slave Lake, Canada	1603	[21]
Queechy Lake, Conn.	1640	[22]
Loch Levan, Scotland	2027 (sand area)	[23]
Twin Lakes, Colo. (lower)	1300 to 3800	[15]
<i>Lake Pocasse, S. Dak.</i>	0 to 5220	
Lake Francis Case, S. Dak.	564 to 5929	[24]
Mississippi River, Iowa	2924	[25]
Gulf of Maine	4000	[26]
Volcanic Lakes (3) of South Australia	2018 to 7922	[27]
Candlewood Lake, Conn.	5500	[22]
Lake Cayuga, N.Y.	6000	[27]
Mt. Tom Pond, Conn.	9380	[22]
Jobs Pond, Conn.	12 320	[22]
Kempton Park East Reservoir, England	5565 to 36 000	[14]
Third Sister Lake, Mich.	2000 to 70 000 (profundal)	[28]

Table 16.—*Comparison of dry mass of benthic fauna (excluding mollusks)*

Location	Dry mass (kg/ha)	Bibliography
Twin Lakes, Colo. (upper)	0 to 0.16	[15]
McLeod Bay, Canada	0.7	[29]
Watertown Lake, Canada	1.7	[18]
Christie Bay, Canada	1.7	[29]
Lake Okanagan, Canada	2.0	[18]
Bow Lake, Canada	2.3	[18]
Twin Lakes, Colo. (lower)	1.2 to 3.35	[15]
Apache Lake, Ariz.	2.53 to 3.98	[17]
Lake Maligne, Canada	3.3	[18]
Canyon Lake, Ariz. (Feb. sampling)	0.34 to 7.63	[17]
Great Slave Lake, Canada	3.7	[21]
Lake Athabaska, Canada	4.1	[29]
Lake Minnewanka, Canada	4.5	[18]
Lake Ontario, Canada	4.8	[29]
Lake Nipigon, Canada	5.2	[29]
Roosevelt Lake, Ariz.	2.85 to 8.26	[17]
Lake Superior	9	[30]
Lake Simcoe, Canada	12.4	[21]
Lake Huron	14.8	[30]
Waskisiw Lake, Canada	24.7	[21]
Lake Michigan	34	[30]
Lake Paul, Canada	36.4	[21]
Lake Erie	46.3	[30]
Lake Mendota, Wis.	50.8	[31]
Cayuga Lake, N.Y.	88	[27]
<i>Lake Pocasse, S. Dak.</i>	0 to 124.1	