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# Build-up of Ions in Areas of Lake Dardenelle as Affected by Stream Flow

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# Build-up of Ions in Areas of Lake Dardanelle as Affected by Stream Flow

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ABSTRACT

The poultry industry in the Lake Dardanelle watershed annually introduces large amounts of poultry effluents into the system. This, plus the large concentrations of chloride ions that are introduced into the lake from salt deposits in the upper Arkansas River watershed, has definite effect on the limnological conditions of the lake. The buildup of chloride ions in areas of the lake depends on the amount of flow from streams into these parts of the lake. This stagnation phenomenon is especially noticeable in pocket areas which are generally cut off from the major influence of the river as it flows in its channel and through the dam.

## INTRODUCTION

Lake Dardanelle is a manmade flow-through lake, completed by the U.S. Army Corps of Engineers in 1969 as a major unit in the mulitple-purpose project for the improvement of the Arkansas River and its tributaries in Arkansas and Oklahoma.

The Dardanelle Lock and Dam is between the cities of Dardanelle and Russellville in west-central Arkansas. The lake is 50 mi long and 2 mi wide at its maximum width. The shoreline is 315 mi long. The top of the conservation pool is 338 ft above mean sea level. The surface area of the reservoir is 34,300 acres and storage capacity is 486,200 acre-feet. The mean stream flow rate is 35,620 cfs. The 153,703 sq mi of drainage area above the dam includes parts of both the Ozark and Ouachita National Forests.

The watershed area of the Illinois Bayou, which includes drainage of Baker's Creek, Mill Creek, Prairie Creek, and Shiloh Creek, totals 391 sp mi (Sullavan and Terry, 1970). Most of the poultry houses and turkey ranges of Pope County are in this area. The total poultry population in 1970 for Pope County, 13,290,000, included birds in five catagories (USDA, 1970).

| | |
|---|---|
| 1. Birds in commercial table egg flocks | 408,000 |
| 2. Broilers | 11,788,000 |
| 3. Birds in broiler hatchery supply flocks | 339,000 |
| 4. Turkeys | 705,000 |
| 5. Birds in table egg hatchery supply flocks | 50,000 |

The concentrations of poultry effluents introduced into the lake are varied and depend on several factors which include:

1. Time of year - poultry populations vary greatly, especially turkey populations, according to the time of year.
2. Amount of rainfall and the area affected - whether localized or general, whether the amount is sufficient to produce runoff.
3. Location of litter - whether litter is intact in the poultry houses or if it has been spread on pasture lands.
4. Amount of stream flow - whether stream flow (particularly in certain streams) is sufficient to cause flushing action from various isolated areas of the lake.

## MATERIALS AND METHODS

Sampling for the first year of testing ran from 3 June to 21 October 1970. During the second year the sampling period ran from 1 June to 18 November 1971. Collections were on a weekly basis during June, July, and August, and thereafter were generally on a biweekly schedule. The same plan was followed each year.

Surface samples were collected at all stations during both years of testing. Bottom samples were collected during the second year of testing at stations C, D, E, G, I, and N for chemical analysis only.

In this study only flows at stations A and D (Table I) were checked regularly; others were checked occasionally. The flowmeter available to the project was incapable of measuring the very small amounts of flow at times in the streams. Only visible stream flow was recorded.

A Kemmerer water bottle was used to collect the bottom samples. Part of the water sample was filtered by a Millipore filtration apparatus with a 0.45-micron pore size filter. The filtrate was refrigerated at 4C until it was analyzed.

Plankton samples were collected by two methods. In both methods only net plankton (Welch, 1948) were collected, by means of a plankton net with a No. 25 silk bolting cloth equipped with an adaptor and a 30-cc bottle. Stations in the lake proper were sampled by the horizontal drag method. With the use of the standard formula for the volume of a cylinder ($V = \pi r^2 h$), a 4.383-m horizontal drag would represent a 200-l sample. No vertical samples were taken. Plankton samples were collected from an area that ranged from surface to approximately 46 cm below the surface. At all other stations a sample representing a 10 or 20 l concentration was collected by means of a plankton net with bottle and precalibrated bucket. The size of this sample was dependent on the turbidity and/or debris in the water.

Plankton samples were fixed and preserved with approximately 3 ml of formaldehyde in the laboratory. They were analyzed for zooplankton both quantitatively and qualitatively. In this project the identification of zooplankton was taken only to genus. The taxonomic scheme of Pennak (1953) was used to place those flagellated organisms which possess both plant and animal characteristics. Other sources used in identification were works by Hyman (1951), Needham and Needham (1966), Eddy and Hodson (1967), and Ward and Whipple (1959).

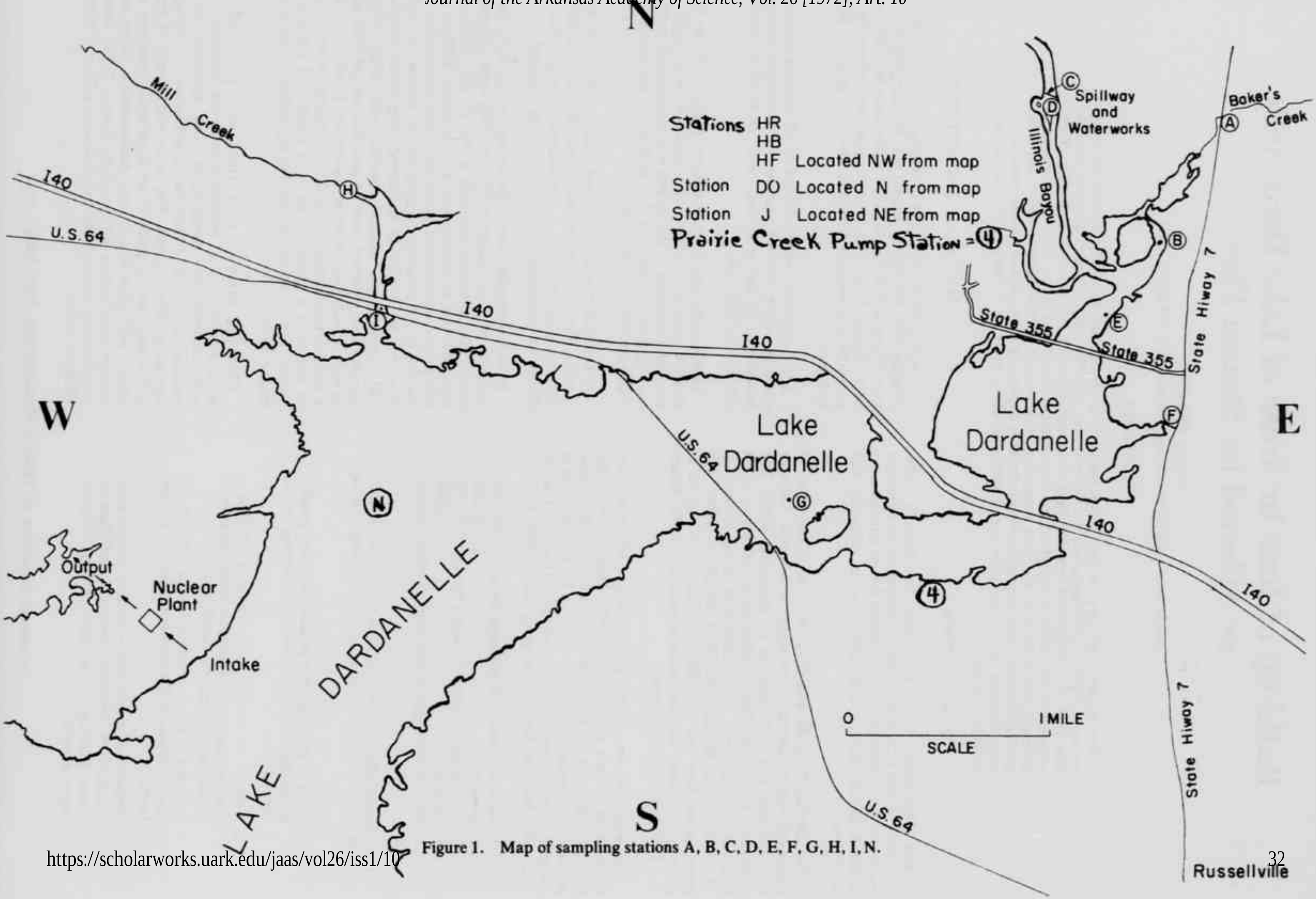


Figure 1. Map of sampling stations A, B, C, D, E, F, G, H, I, N.

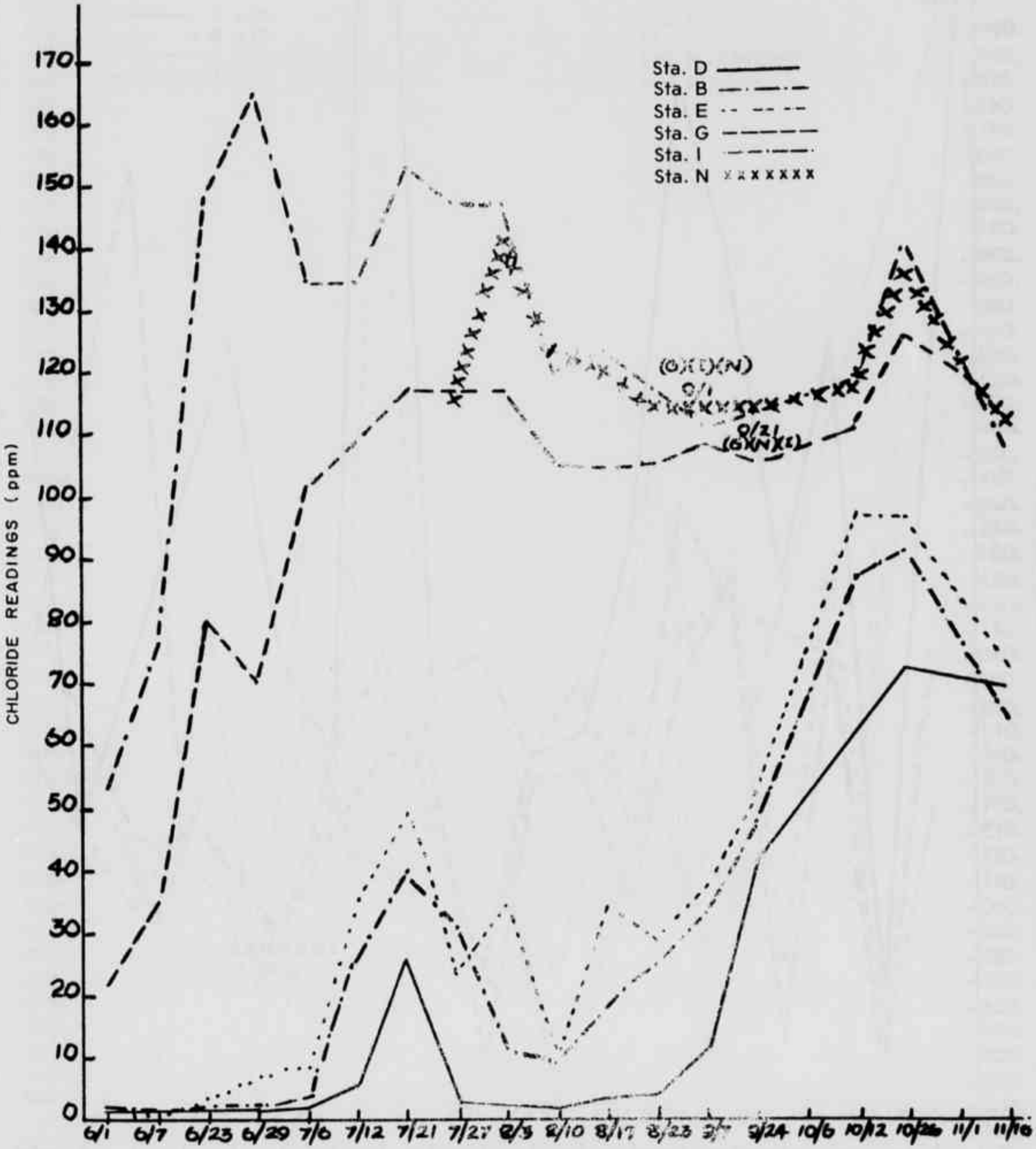


Figure 2. Surface concentrations of Cl⁻ in ppm at stations D, B, E, G, I, and N recorded during 1971 testing period.

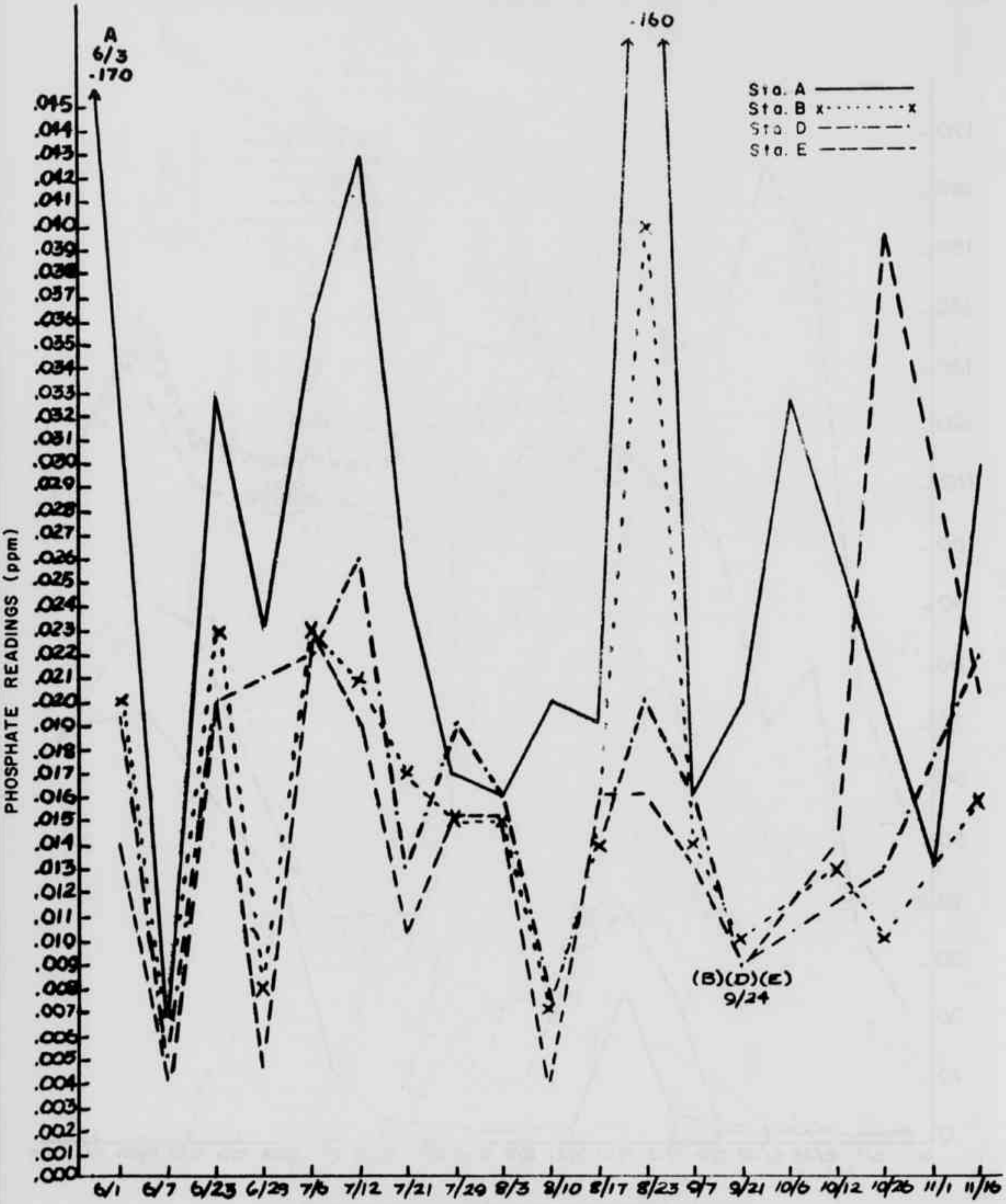


Figure 3. Surface concentrations of $PO_4^{---}$ in ppm at stations A, B, D, and E recorded during 1971 testing period.

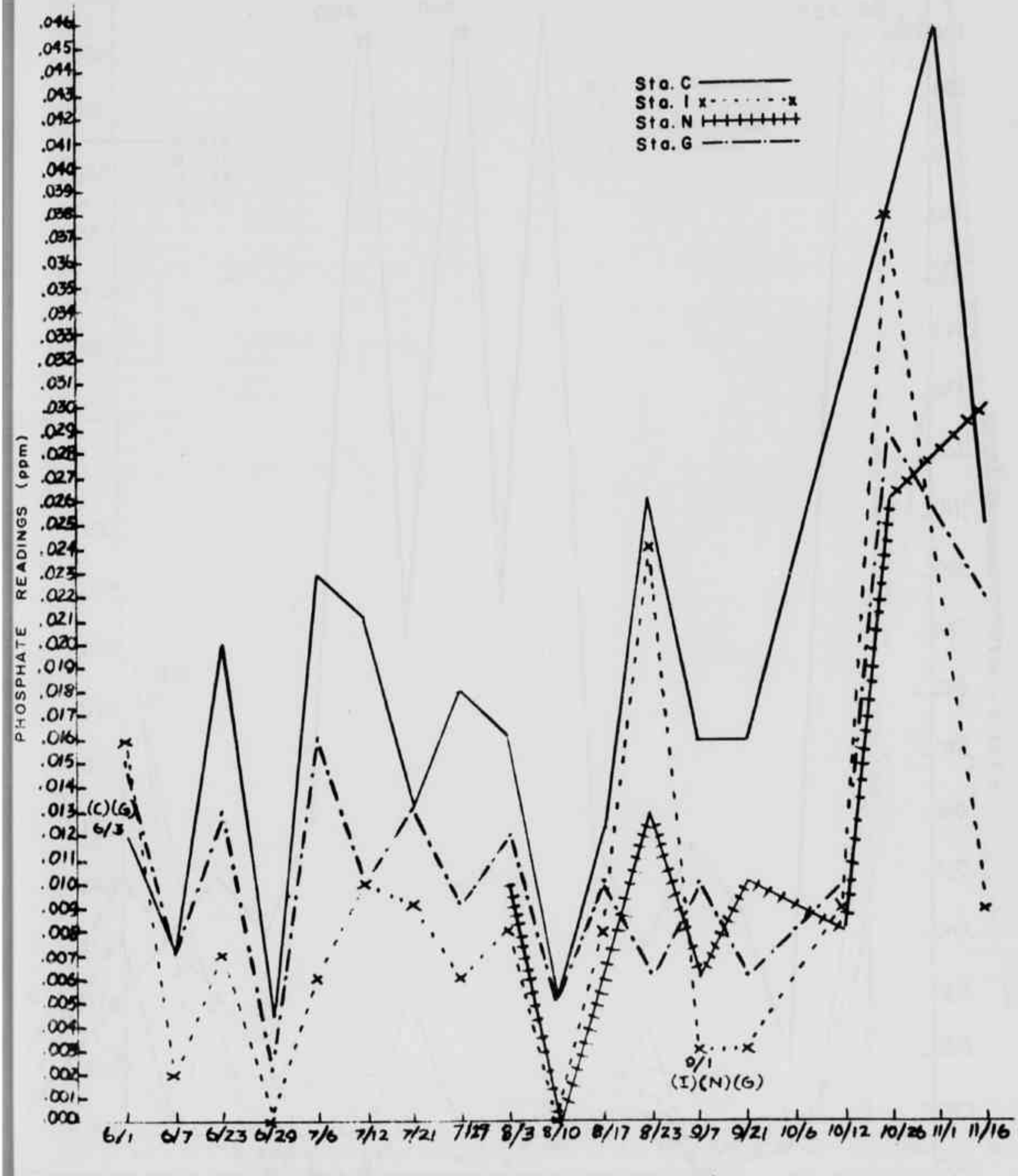


Figure 4. Surface concentrations of $PO_4^{---}$ in ppm at stations C, I, N, and G recorded during 1971 testing period.

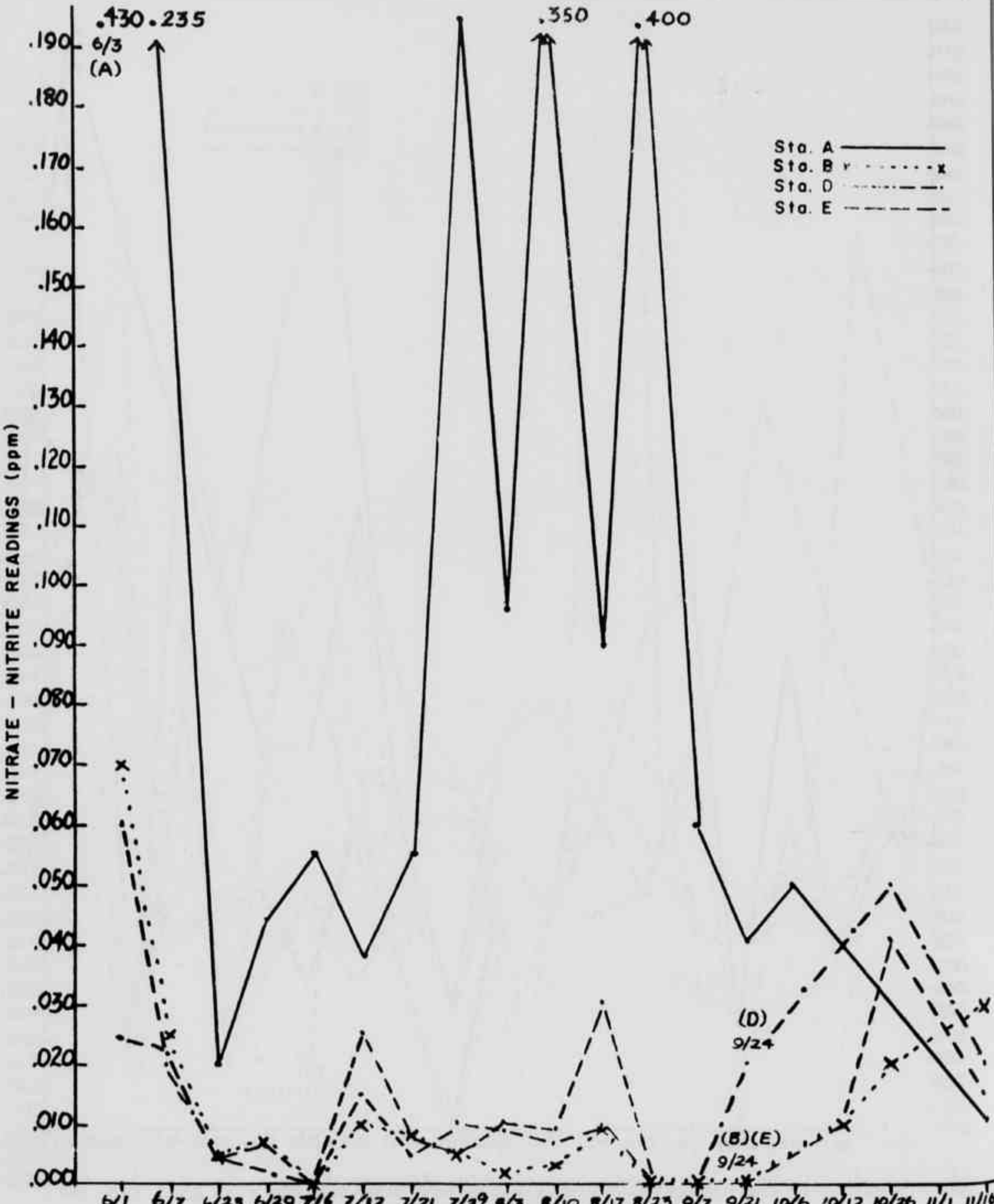


Figure 5. Surface concentrations of $NO_3^-$—$NO_2^-$ in ppm at stations A, B, D, and E recorded during 1971 testing period.

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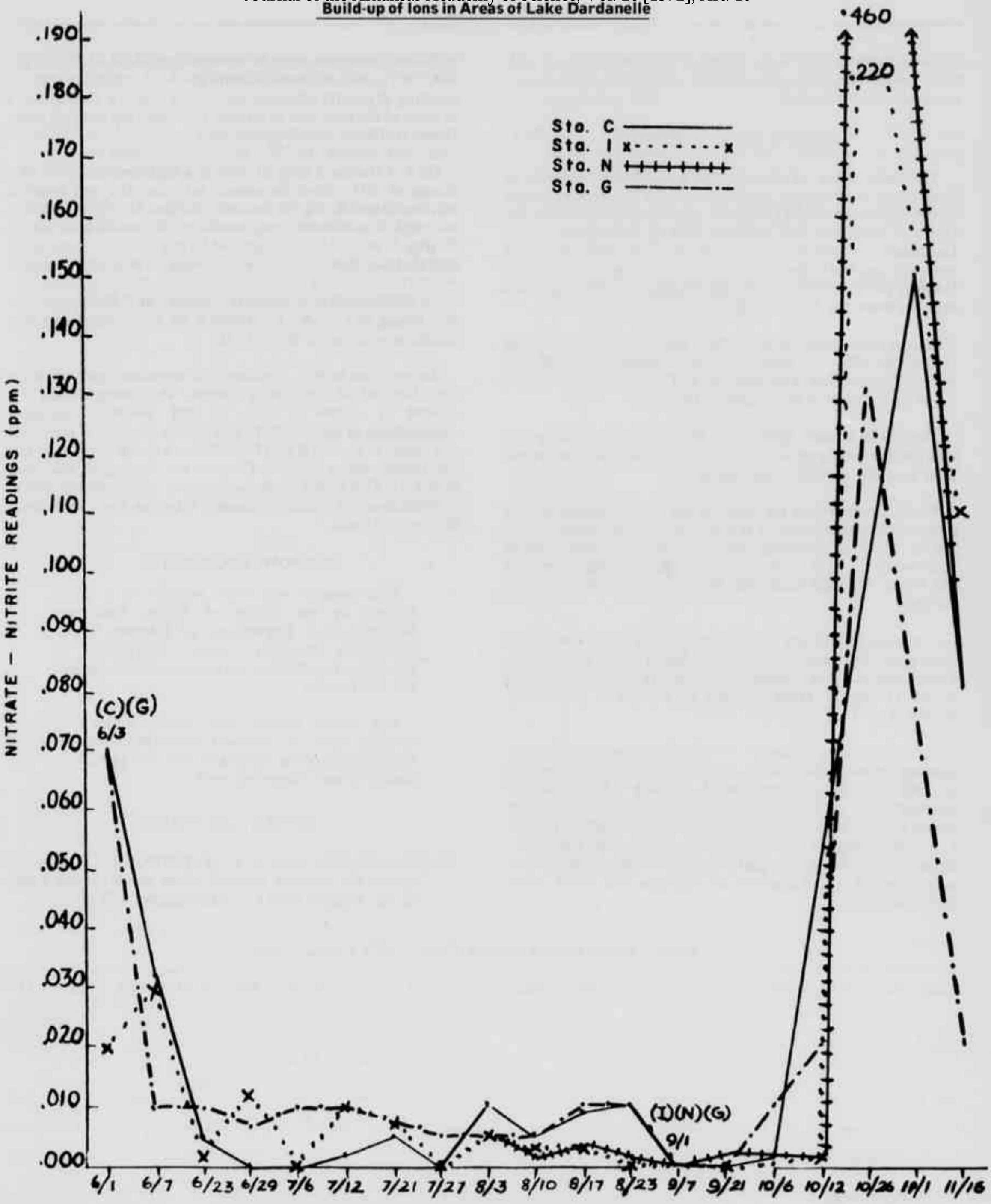


Figure 6. Surface concentrations of $NO_3$ —$NO_2$ in ppm at stations C, I, N, and G recorded during 1971 testing period.

Tests performed on water samples included turbidity, pH, $CO_2$, nitrate-nitrite, ortho-phosphate, chloride, total hardness, ammonia, and uric acid.

## RESULTS AND DISSCUSSION

The stabilization of concentrations of certain materials in backwaters of the lake is related directly to the amount of flow of the tributaries feeding the lake in those areas (Veatch and Huphrys, 1966). The best indicator of this phenomenon in Lake Dardanelle is chloride-ion buildups. Chloride levels are generally very low in the tributaries proper, whereas in the river channel the levels are very high because of concentrations brought down the Arkansas River.

Five regular water sources feed the study area of Lake Dardanelle (Fig. 1): Baker's Creek, Shiloh Creek, Illinois Bayou, Prairie Creek, and Mill Creek. The Illinois Bayou is the major contributor in this sector of the lake.

The flow in Baker's, Shiloh, and Mill Creeks is generally very low, and frequently ceases during periods in the summer except after sporadic periods of precipitation.

Prairie Creek waters are added to the lake by means of a lift pump station at the edge of the lake at the Dike Road (Fig. 1, station 4). This pumping system is an automated device operated by the U. S. Army Corps of Engineers. The water from this system is added to the lake directly opposite the pumping station.

A change in chloride concentrations can be observed in a short period of time when the Illinois Bayou ceases to introduce waters into the lake (except for seepage through the dam) at station D (Fig. 1). These changes are evident in Figure 2 at station D on 7/12, 7/21, and 7/27.

Even strong flow in Baker's Creek is not effective in flushing concentrations of chloride out into the major body of the lake, as indicated by the continuous buildup of chloride-ion concentrations on 8/23 at station B (Fig. 2), in spite of the strong flow at station A at that time (Table I). Station E (Figs. 1, 2), approximately one-half mile from station B, did show a slight decrease during this period, probably because most of the water flows in the channel on the opposite side of the island from station B.

When a sharp increase in the concentrations of $NO_3^-$ and $PO_4^{---}$ is noted in the streams (Figs. 3-6), resulting from the leaching of poultry effluents, one would expect a similar result in areas of the lake near or adjacent to where the streams enter. However, this is not always the case.

On 6/3 station A (Fig. 5) showed a high level of $NO_3^-$; this deluge of $NO_3$ from the stream into the lake was noted at stations B and E (Fig 5), but with far less magnitude than at station A. This decrease may be due to dilution factors. Station D. (Fig. 5) seemed to be influenced by this influx, in spite of the fact that the Illinois Bayou was flowing on that day (Table I).

On 8/23 the station A nitrate reading was 0.400 ppm with a very strong flow (Table I). Station B on 8/23 registered a zero nitrate concentration (Figs. 1, 5).

An elevation in $NO_3^-$ readings was recorded again on 10/26 near the end of the testing period. The concentration was highest at station N (Fig. 6) and generally decreased consecutively at stations G, E, and B (Figs. 4, 5, 6). A lag factor was noted at station B on 11/16. Baker's Creek (station A) and the Illinois Bayou (station D) were not flowing at that time (Table I). This influx in concentrations was probably due to introductions of poultry effluents into the river at a point farther upstream.

## ACKNOWLEDGEMENTS

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Table I. Stream Flow at Stations A and D, 1971 Testing Period

| Date | 6/1 | 6/8 | 6/22 | 7/5 | 7/12 | 7/20 | 7/26 | 8/2 | 8/9 | 8/17 | 8/24 | 9/8 | 9/21 | 10/6 | 11/1 | 11/16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sta. A | + | + S | — | — | — | — | — | — | + | + S | + VLA | + S | — | — | — | — |
| Sta. D | + | + | + | + | + D | — | + | + | + | + | + D | + | 9/24 — | — | — | — |

\+ Flowing.

— Not flowing

Station D is in Illinois Bayou and Station A is in Baker's Creek. The letter D appears below the + sign if a very noticeable decrease had occurred at Station D since the last collection date. The letter S is used to describe a very small flow (trickle) and VLA indicates a very large amount of flow at Station A.

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