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REFERENCES CITED

Beckenbach, E. and R. Bellman. 1961. An Intro. to Inequalities. The L. W. Singer Company.

Brinkley, S. R. 1947. Calculation of the Equilibrium Composition of Systems of Many Constituents. J. Chem. Physics, 15:107-110.

Charnes, A. and W. W. Cooper. 1961. Management Models and Industrial Applications of Linear Programming. John Wiley and Sons, Inc., New York.

Clasen, R. J. 1965. The Numerical Solution of the Chemical Equilibrium Problem. RAND Corp., Memo RM 1:4345-PR.

Clasen, R. J. 1963. The Linear-logarithmic Programming Problem. RAND Corp., Memo RM 6:3707-PR.

Dantzig, G. B., W. B. White, and S. M. Johnson. 1958. Chemical Equilibrium in Complex Mixtures. J. Chem. Physics, 15-5: 751-755.

Dodge, B. F. 1944. Chemical Engineering Thermodynamics. McGraw-Hill Book Company, New York.

Dorn, W. S. 1960. Variational Principles for Chemical Equilibrium. J. Chem. Physics, 1490-1492.

Duffin, R. J., E. L. Peterson, and C. Zener. 1967. Geometric Programming. John Wiley and Sons, Inc., New York.

Hadley, G. 1962. Linear Programming. Addison-Wesley Publishing Company, Reading, Mass.

Hardy, G. H., J. E. Littlewood, and G. Polyn. 1959. Inequalities. Cambridge University Press, England.

Hougen, Watson, and Ragatz. 1954. Chemical Process Principles. John Wiley and Sons, Inc., New York. 2:1043-1052.

James, Glenn, and R. C. James. 1949. Mathematics Dictionary. D. Van Nostrand Company, New York.

Lai, C. L. 1962. A New Method for the Determination of Chemical Equilibrium Composition. Master Thesis, Vanderbilt University, Nashville, Tennessee.

Rossini, F. D. 1958. American Petroleum Institute Research Project. No. 44.

Shapiro, N. Z. 1964. A Generalized Technique for Eliminating Species in Complex Equilibrium Calculations. RAND Corp., Memo RM 9:4205-PR.

Shapiro, N. Z. and L. S. Shapley. 1964. Mass Action Laws and the Gibb's Free Energy Function. RAND Corp., Memo RM 9:3935-1-PR.

Zemansky, Mark W. 1969. Heat and Thermodynamics. McGraw-Hill Book Company, Inc., New York.

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THERMAL STRATIFICATION AND DISSOLVED OXYGEN IN DALE HOLLOW RESERVOIR, TENNESSEE AND KENTUCKY

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ABSTRACT

This paper describes the seasonal cycle of temperature and dissolved oxygen in Dale Hollow Reservoir. The 30,000 acre "two story" impoundment was studied from February, 1971 through January, 1972. Thermal stratification first appeared in March and persisted through November. The seasonal distribution of temperature was indicative of a monomictic lake. The appearance of numerous oxygen maxima along with uniformly high valves suggests oligotrophic conditions.

INTRODUCTION

During the summer months, the deeper waters of Dale Hollow Reservoir stratify into a warm upper layer and a cool lower layer. The cool layer retains high concentrations of dissolved oxygen and the reservoir supports year-round populations of cold-water fish such as rainbow trout. The warm upper layer supports a good population of warm-water fish. The result is a valuable and diverse fishery. Recreational activities other than fishing include boating, swimming, and camping. This paper describes some of the dynamics which occur in the seasonal cycle of temperature and dissolved oxygen in this "two story" reservoir.

Dale Hollow Reservoir is a U.S. Army Corps of Engineers storage impoundment which inundates portions of Clay, Pickett, Fentress, and Overton counties in Tennessee, and portions of Cumberland and Clinton counties in Kentucky. The dam, which was completed in 1943, is located on the Obey River 7.3 river miles above its confluence with the Cumberland River. At maximum pool elevation of 663 feet, the reservoir is 61 miles long and drains 935 square miles. Approximately 21 per cent of the maximum storage capacity of 1,706,000 acre feet is reserved for the impoundment of flood waters. Another 29 per cent of the total capacity is allocated to drawdown for hydroelectric power generation.

The impoundment is formed by the Wolf River, the East Fork of the Obey and the West Fork of the Obey River drainages (Figure 1). Rock formations of the entire basin are of the lower Mississippian geological age. Three major formations are involved. The Fort Payne formation predominates in all areas that are covered by or immediately adjacent to the impounded waters. The drainages flow over Warsaw and St. Louis limestones before entering the reservoir. Limestone is present in all three formations (Swingle, et al., 1966).

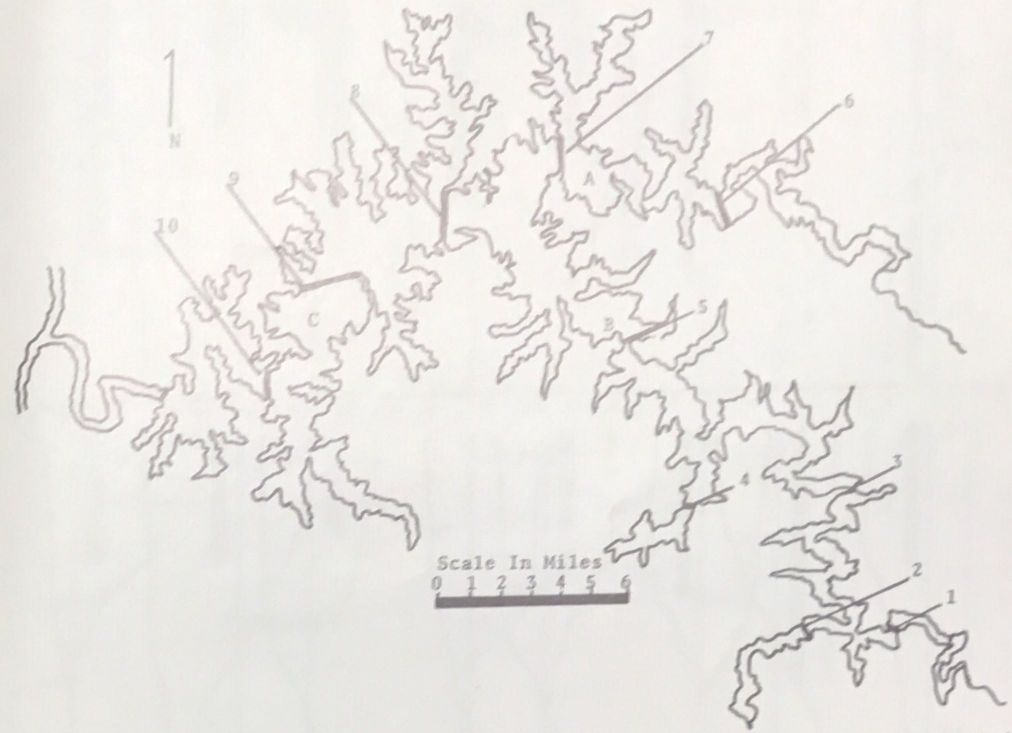

FIG. 1: *Map of Dale Hollow Reservoir, Tennessee, Indicating the Wolf River Embayment (A), Obey Embayment (B), Reservoir Proper (C), and Individual Transects (1 through 10).*

The shape of the reservoir easily lends itself to division into three broad geographic regions. One section extends from the confluence of the East and West Forks of the Obey to the Wolf River, another includes the confluence of the Wolf and Obey Rivers to Dale Hollow dam. These divisions will be referred to as the Obey River embayment, the Wolf River embayment, and the reservoir proper.

MATERIALS AND METHODS

Ten transects, spaced at five to seven mile intervals, were established throughout the reservoir (Figure 1). Whenever feasible transects were positioned immediately downstream of substantial tributaries. Two transects were located on the Wolf River branch of the reservoir, four were located on the Obey River branch, and three were located below the confluence of these two major branches. In order to obtain maximum vertical distribution, samples were taken at the deepest point along the transect as indicated by a Lowrance Model LFP 300 Fish Lo-K-Tor. As a result, the sampling site was often equidistant from both banks and located in the old river channel. Notable exceptions occur at the transects which were located near the headwaters of the reservoir. This was due primarly to the fact that the channel there was usually narrow and normally deeper on one side than the other.

Monthly sampling was conducted from February, 1971, through January, 1972. A YSI Model 51 Oxygen Temperature meter was used to obtain a vertical profile of dissolved oxygen and temperature at each sample station. Readings were taken at two foot intervals from top to bottom. Dissolved oxygen measurements were corrected for temperature and altitude in accordance with instructions furnished by the Yellow Springs Instrument Company.

RESULTS AND DISCUSSION

Dissolved oxygen plays a very critical role in regulating the metabolic processes of aquatic organisms. It is one of the most significant of all chemical substances which can be used to indicate general lake conditions. The dissolved oxygen in a body of water is derived from the atmosphere and from the photosynthetic activity of aquatic organisms. The amount of oxygen that can be dissolved in the water at a given time depends upon the interaction of temperature, partial pressure at the surface, and the concentration of dissolved salts. Dissolved oxygen levels vary inversely with temperature and salt concentrations while the relationship to partial pressure is direct (Reid, 1961).

Figures 2, 3 and 4 illustrate the monthly dissolved oxygen and temperature profiles which were recorded at transects 3, 6 and 9. Although profiles were determined for each transect, only these three representative transects are included here. The dissolved oxygen profiles are intermediate between orthograde and clinograde, suggesting integrading patterns between oligotrophic (poor in nutrients) and eutrophic (rich in nutrients) conditions (Reid, 1961). The sharp increase in dissolved oxygen in the metalimnion during the summer is similar to the oxygen maxima which Ruttner (1963) observed in oligotrophic lakes. Oligotrophic lakes are usually clear for considerable depths and turbidity is low. Such conditions were observed in Dale Hollow.

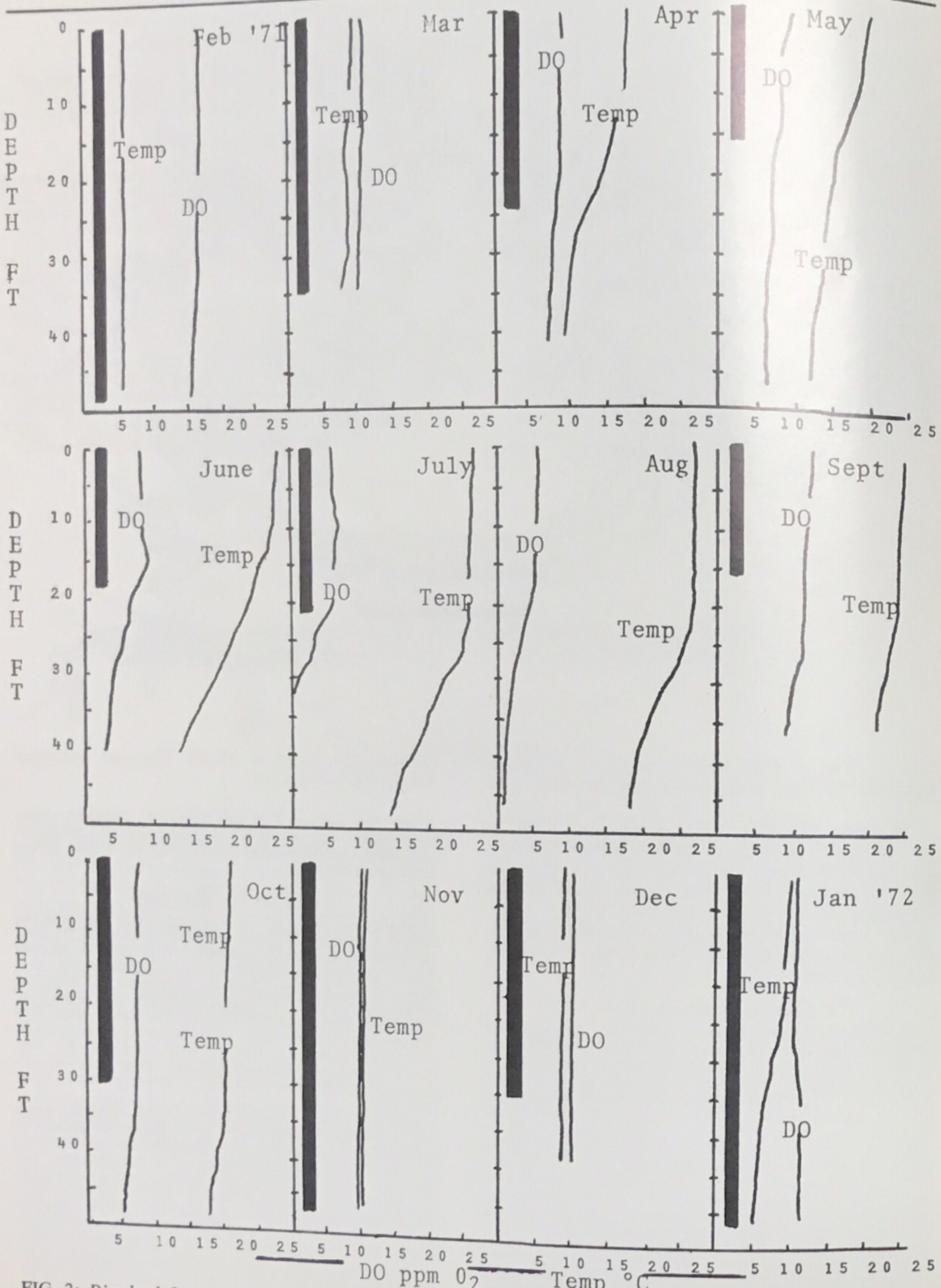

FIG. 2: *Dissolved Oxygen and Temperature Recorded at Transect 3; Heavy Line at Left Corresponds to Dissolved Oxygen Concentrations within 2 ppm of 100% Saturation.*

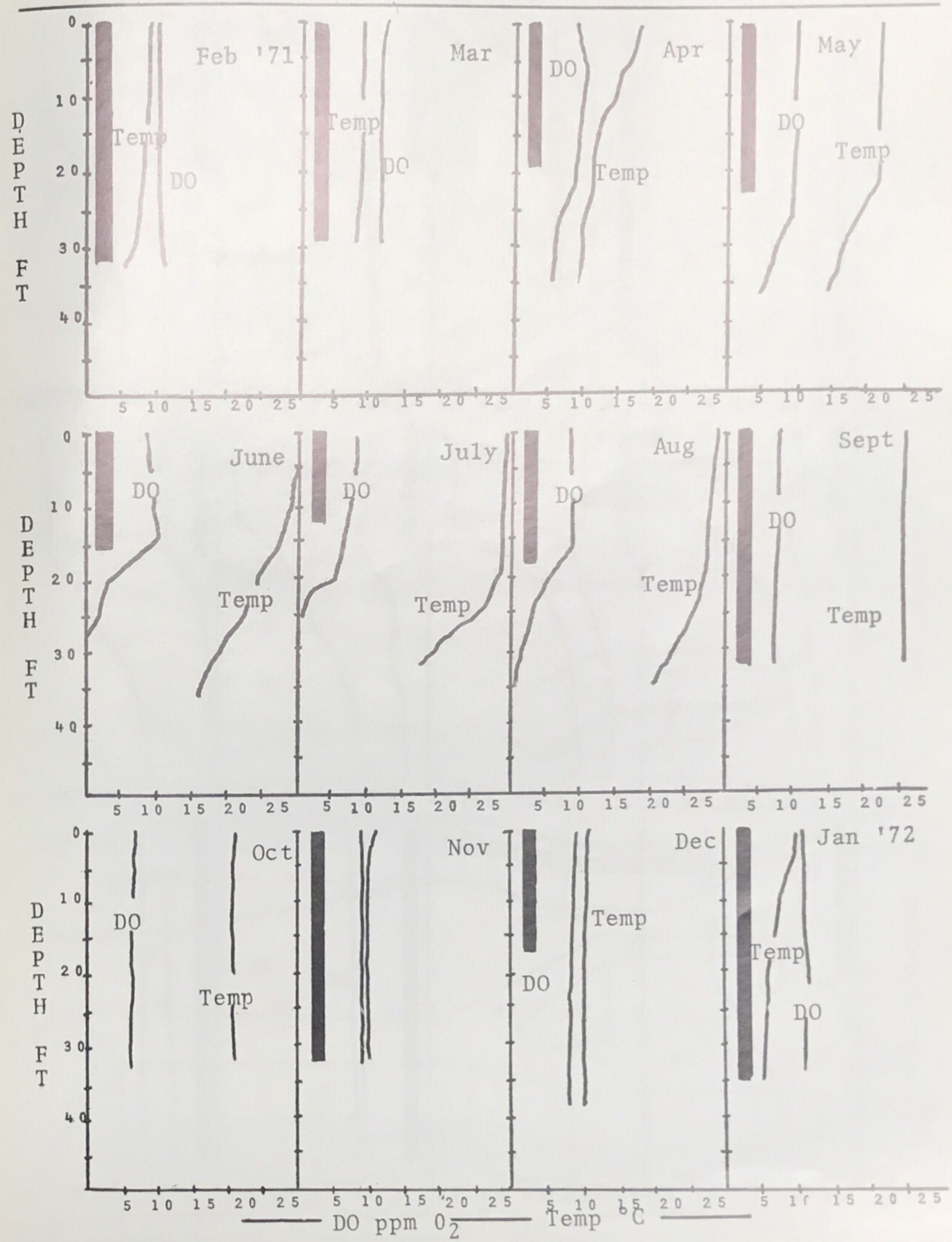

FIG. 3: *Dissolved Oxygen and Temperature Recorded at Transect 6; Heavy Line at Left Corresponds to Dissolved Oxygen Concentrations within 2 ppm of 100% Saturation.*

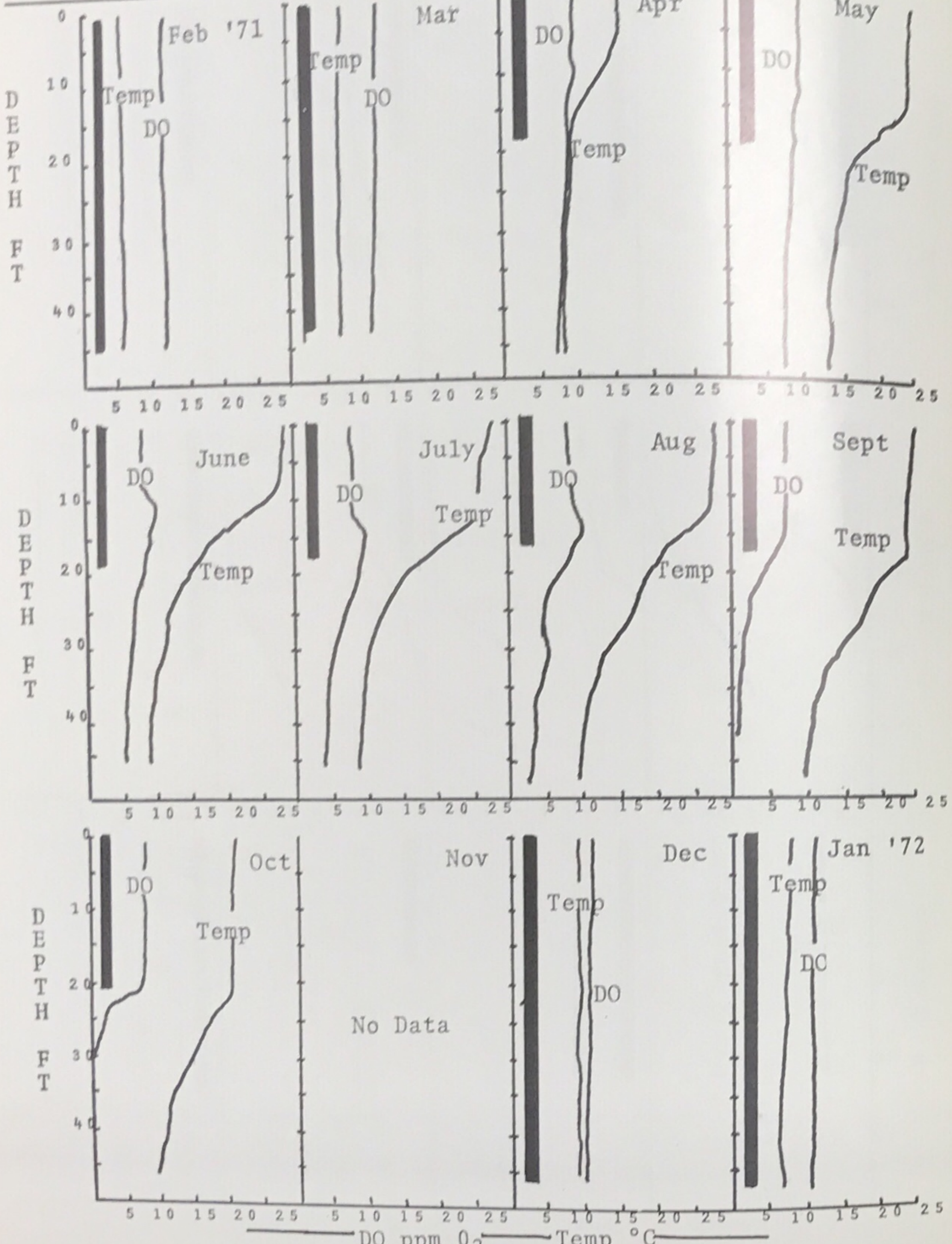

FIG. 4: *Dissolved Oxygen and Temperature Recorded at Transect 9; Heavy Line at Left Corresponds to Dissolved Oxygen Concentrations within 2 ppm of 100% Saturation.*

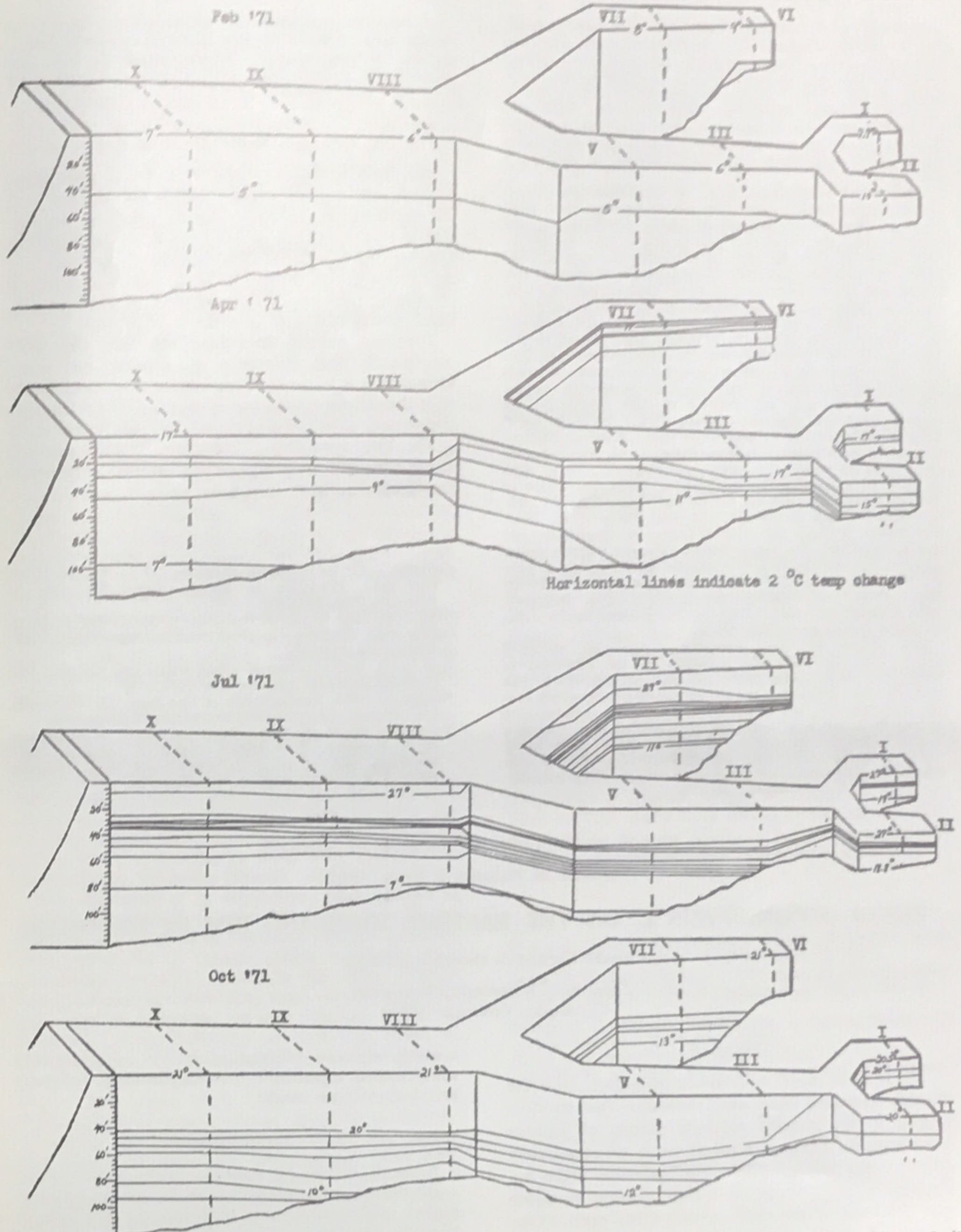

FIG. 5: *Monthly Thermal Distribution for February, April, July, and October, Dale Hollow Reservoir. Numerals Indicate Transects and Horizontal Lines Indicate 2°C Temperature Changes.*