A SURVEY OF SELECTED PHYSICAL, CHEMICAL AND BIOLOGICAL CONDITIONS OF A WOODLAND POND, DICKSON COUNTY, TENNESSEE

BY

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A SURVEY OF SELECTED PHYSICAL, CHEMICAL AND BIOLOGICAL CONDITIONS OF A WOODLAND POND, DICKSON COUNTY, TENNESSEE

A Research Paper

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in Biology

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by

Michael Duel Filson

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To the Graduate Council:

I am submitting herewith a Research Paper by Michael D. Filson entitled "A Survey of Selected Physical, Chemical and Biological Conditions of a Woodland Pond, Dickson County, Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biology.

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CHAPTER I

INTRODUCTION

The science of limnology has undergone a rapid rise in this country and Europe in the past seventy years. This is attested by a comparison of the list of references by limnologists at the turn of the century with more recent bibliographies such as that of Welch (1952). An examination of the rapidly expanding literature shows the general pattern of evolution seen in other branches of biology; the earlier works were chiefly descriptive while the more recent research has been directed toward more dynamic problems. The modern tools and instrumentation of other fields, especially those of physics and chemistry, have opened the door to many new aspects of the subject of limnology.

The term "limnology" was originally used in a somewhat restricted sense, being defined as the study of the biology of lakes. Welch (1935) has defined limnology as "that branch of science which deals with biological productivity of inland waters and with the casual influences which determine it." The nature of these casual influences may be either physical or chemical. This study will be concerned with both.

Statement of the Problem

The purpose of this study was to: (1) gather data on selected physical and chemical properties of a small body of water; (2) monitor the changes in these factors over an extended period of time; and (3) determine what kinds of organisms might be found under such conditions.

Importance of the Study

This study is important to both the student of limnology as well as the researcher. It will aid the researcher by serving as a basis for later limnological studies that might be conducted on small lentic waters both local and afar. To the student, it will serve as a reference source that deals with a local survey.

Limitations of the Study

The study was conducted from March 23, through June 29, 1974. The study was confined to a single woodland pond located in Montgomery Bell State Park, Dickson, Tennessee. The selected group of chemical tests were utilized on the basis of their occurrence in the literature, standardized testing procedures and relation to the specific pond. A checklist of aquatic organisms is provided.

Literature Review

The investigation of chemical and physical characteristics and the associated aquatic organisms has been confined chiefly to the north-eastern and north central United States. The foundation of these studies is the work and researches of Ward and Whipple, Birge and Juday, Needham, Pennak and Hutchinson. Of the southeastern states, studies of the lakes and streams of Florida stand out in limnological literature as exemplified by Shannon and Brezonik's (1972) studies on north and central Florida lakes. In Tennessee numerous works on Reel-foot Lake in the west and streams of the Great Smoky Mountains of the east are presented. In middle Tennessee studies have been conducted by such agencies as the Tennessee Valley Authority (1973) and the State Water Quality Control Board (1967). A study of water quality on the

J. Percy Priest Reservoir was conducted by Perry (1969). Several doctoral dissertations from Vanderbilt University have included limnological investigations; among these are Blair (1968), Parchment (1971), and Wiser (1964).

Many of the limnological studies that have been conducted are on larger more extensive bodies of water and to a certain degree the smaller lentic waters have been over looked.

CHAPTER II

GENERAL CHARACTERISTICS

OF

THE POND

Description and Location

The woodland pond is located in Montgomery Bell State Park, Dickson, Tennessee, about three fourths mile southwest of the park entrance (Figure 1). The pond was formed by rain water filling an abandoned ore pit dug over one hundred years ago. In 1934 the pond and surrounding area (some 4,000 acres) was incorporated into a state park. Since that time the pond has been left in its natural state undisturbed by man or his activities. It is located atop a hill of deciduous woods and is approximately 100 feet higher in elevation and ½ mile distant from the closest lentic waters. A woodland stream flows to the south approximately 100 feet lower in elevation and ¼ mile away.

Water is retained at varying levels throughout the year and populations of invertebrate and vertebrate animals have been observed in and around the water. The trees, during foliage, create an almost closed canopy over the pond and forest vegetation grows down to the water's edge.

History

The area including and surrounding the pond has a well documented history, principally due to the iron ore industry of 1810-1870 (Corlew 1956). During this time Mr. Montgomery Bell was operating a number of furnaces yielding high quality cast iron, a pig of which won first prize at a London, England exposition. Mining operations continued until 1870 at which time Mr. Bell's death resulted in the breaking up of the land into private ownership. It was not consolidated until 1934.

Geology

The main workings are along the crest and slopes of the ridge surrounding the pond. The workings, which occupy about 25 acres of the ridge top, trend northeast-southwest for about 2,000 feet (Figure 2). The elevation ranges from 660 to 780 feet. The entire ridge top is a network of pits, prospect holes, and trenches and is heavily grown up in large trees. There is marked erosion and filling of most of the workings.

The pits average about 30 feet in diameter and 15 feet deep, but the largest, on the northeast end of the mining area, is about 200 feet long, 100 feet wide, and 30 to 40 feet deep.

As is characteristic of iron ore occurrences throughout the Highland Rim, the deposits are in cherty Mississippian residuum along the tops and slopes of ridges which are remnants of an old erosional surface. The weathering of this old surface has formed the deep mantle of siliceous clayey material. The ore, which occurs in the cherty matrix, is believed to have been deposited from iron-bearing ground water percolating through the mantle material during the erosional period (Mineral Resource Summary, 1972). The iron is found in the residuum of the St. Louis and Warsaw formations. The ore is principally limonite, an oxide of iron which is black to brown or reddish-brown.

Regional Climate

Middle Tennessee, having a mean latitude of 36°, has a relatively mild temperate climate, although its position away from the coast and its varied topography produce some rigor to its winters. The mean monthly temperature is approximately 60°F.; it rarely falls below 25°F. and cold spells are of short duration. The summers are not excessively hot; the temperature ranging from 80°F. and rarely over 90°F. The growing period between killing frosts varies from 200 to 225 days; the average date of the last killing frost in the spring is March 30, and the first in the fall is October 30 (Watershed Work Plan, 1971).

Rainfall for the area usually averages about 52 inches per year and is rather uniformly distributed and without distinct wet or dry seasons. Lightest precipitation occurs during the months of September and October and heaviest precipitation usually occurs in January or February. The average humidity is moderate (72%) and sunshine and cloudiness occur in such a manner that clear skies prevail about 130 days, partly cloudy ones 115 days, and cloudy ones 120 days of the year (Harris, Personal Communication).

CHAPTER III

MATERIALS AND METHODS

Introductory Procedure

The physical, chemical and biological investigation of a body of water may include a very large number of widely different procedures. Some of these may be measured or collected directly, some may require mathematical formulae and others may be read directly from a meter or identified by use of a microscope. In undertaking such a study an investigator should decide first which criteria are to be made and then what method is to be used in each individual examination.

Physical Survey

The physical survey included the following: dissolved oxygen concentration, water temperature, and total dissolved solids, per unit of depth; Secchi disc and rain gauge readings; and a survey of the pond morphometry. The dissolved oxygen and water temperature were determined by the use of a Y.S.I. Oxygen meter, while the total dissolved solids were recorded by the use of a Conductivity meter registering in micromohs. Measurements were made at $\frac{1}{4}$ meter intervals from surface to bottom on a bi-weekly basis.

Secchi disc readings were taken (three, of which the average was recorded) on a bi-weekly basis and care was taken to make the readings at the same time each test. Two rain guages were utilized. Rain guage A was placed in the open and rain gauge B beneath the canopy, to compensate for water evaporated from the one in the open.

In addition to those organisms collected in these samples the pond was seined twice (March 30 and June 22). Specimens were also captured on the above dates by the use of insect nets.

CHAPTER IV

RESULTS OF FIELD STUDIES

PHYSICAL DATA (Tables 1, 2 and 3)

Dissolved Oxygen (Figures 3, 4 and 5)

The maximum concentration of dissolved oxygen was 8 p.p.m. (1/4 meter at April 6) while the minimum concentration was .1 p.p.m. (1 1/4 meter at June 29). The mean concentration of dissolved oxygen for 1/4, 1/2, 3/4, 1 and 1 1/4 meters was 6.1, 3.1, 2.0, 1.4 and 1.3 p.p.m. respectively.

Water Temperature (Figures 6 and 7)

The water temperature ranged from a high of 20° C. (1/4 meter on June 15) to a low of 10° C. (1 and 1 1/4 meters April 6). The mean water temperature for 1/4, 1/2, 3/4, 1 and 1 1/4 meters was 17.5, 16.1, 15.2, 14.4 and 14.2° C. respectively.

Total Dissolved Solids (Figures 8, 9 and 10)

The highest micromohs reading was 120 (1 and 1 1/4 meters on May 18) while the lowest was 30 (1/4, 1/2 and 3/4 meter on April 6 and 1/4 meter on April 20). The mean micromohs readings for 1/4, 1/2, 3/4, 1 and 1 1/4 meters was 37.9, 51.4, 76.4, 90.7 and 92.9 respectively.

Secchi Disc (Figure 11)

The highest Secchi disc reading was .58 meter (April 20) and the lowest was .33 meter (June 29). The mean Secchi disc reading was .41 meter.

Pond morphometry was calculated and recorded by standard limnological procedures as outlined by Ruttner (1963). In determining a number of parameters a one meter square grid system was established over the pond surface (Findley, Personal Communication). From Ruttner's and Findley's methods those parameters taken for the pond include: depth profile and contour map; maximum depth, length and breadth; shoreline length and development; area and volume; and mean breadth and depth.

Chemical Survey

The chemical analysis of the water was conducted by the use of a Hach Water Testing Kit, number DR-EL. The tests included: carbon dioxide (CO_2), hydrogen ion concentration (pH), nitrate (NO_3), phosphate (PO_4), iron (Fe) and total hardness. These tests were conducted in the laboratory on water samples taken from two stations, littoral and limnetic regions of the pond, on a biweekly basis. The water samples were collected in one liter containers and refrigerated until analized.

Biological Survey

The biological survey consisted of the collection and classification of aquatic plants and animals found in water samples taken from four areas of the pond (littoral, limnetic, benthic and plantonic communities). Collections were made on a biweekly basis by the use of: 1 liter jars (littoral and limnetic); a modification of a bottom sampler from Smith (1961) for benthic samples; and a planktonic net was used for collecting plankton samples. All water samples were refrigerated until observed. After the initial observation of all samples, each was preserved in a formaldehyde solution and stored for future observations.

Rainfall (Figure 12)

The highest recordings for both rain gauges were 5.08 cm. for a two week period. The lowest reading was 2.54 cm. for rain gauge A on June 15, and 3.04 cm. for rain gauge B on May 18. The total accumulated rainfall for gauge A was 27.67 cm. while gauge B recorded 29.45 cm.

Pond Morphometry (Figures 13 and 14)

The maximum depth, length and breadth were found to be 1.42, 14.16 and 10.31 meters respectively. The shoreline length was 40.7 meters while the shoreline development calculated 1.0049. The surface area was 130.62 square meters while the volume was 78.61 cubic meters. The mean breadth was 8.94 meters and the mean depth was .60 meters. All measurements were taken March 23, 1974.

CHEMICAL DATA (Tables 4 and 5)

Dissolved Carbon Dioxide (Figure 15)

The maximum concentration of dissolved carbon dioxide at the limnetic station was 40 p.p.m. (May 4) and the minimum concentration was 10 p.p.m. (April 20). The maximum concentration for the littoral station was 32 p.p.m. (June 29) while the minimum was 10 p.p.m. (April 6 and 20). The mean concentration for both stations was 19.1 p.p.m. The limnetic station had a mean concentration of 19.3 p.p.m. and the littoral was 18.9 p.p.m.

Total Hardness (Figure 16)

The values for total hardness ranged from a high of 30 p.p.m. (limnetic station, June 15) to a low of 10 p.p.m. (limnetic and littoral stations, April 20). The mean concentration for all stations was

19.4 p.p.m. The mean at the limnetic station was 21 p.p.m. while that of the littoral was 17.8 p.p.m.

Hydrogen Ion Concentration (Figure 17)

The pH ranged from 6.8 (limnetic station, June 29) to a low of 5.7 (limnetic station, May 4). The mean concentration for both stations was 6.45. The mean for the limnetic station was 6.4 and that for the littoral was 6.5.

Dissolved Oxygen (Figure 18)

A maximum concentration of dissolved oxygen (10 p.p.m.) was recorded for both stations on at least two occasions. A minimum of 6 p.p.m. was also recorded for both stations. The mean for both stations was 8.2 p.p.m. The mean for the limnetic station was 8.1 p.p.m. and that of the littoral was 8.3 p.p.m.

Nitrate Concentration (Figure 19)

The nitrate concentration varied from .13 p.p.m. (littoral station, April 6) down to .08 p.p.m. (limnetic station, June 15). The mean for both stations was .1065 p.p.m. while the mean for the limnetic and littoral stations was .106 p.p.m. and .1065 p.p.m. respectively.

Phosphate Concentration (Figure 20)

The highest concentration of ortho-phosphate was 6.5 p.p.m. (limnetic station, May 4) and the lowest was .04 p.p.m. (littoral station, June 6). The mean concentration for both stations was .975 p.p.m. The mean concentration for the limnetic was 1.53 p.p.m. and .42 p.p.m. in the littoral.

Iron Concentration

Tests for iron (Fe) were conducted for both stations on two dates. These results were so small that accurate measurements could not be conducted by the use of the test kit. The iron tests were therefore discontinued.

BIOLOGICAL DATA (Table 6)

The following classification represents a taxonomic listing of organisms collected during the survey. A notation is provided to describe which sample area(s) (limnetic, littoral, benthic or plankton) the organism was identified in. No attempt was made at determing the frequency of their occurrence in the samples nor the dates of their occurrences. Insects and vertebrates collected were obtained by the use of nets or seines. The classification for the plants, invertebrates and vertebrates follows those of Bold (1967), Pennak (1953) and Barbour (1971) respectively.

Division Cyanophycophyta

Class Myxophyceae

Order Oscillatoriales

Family Oscillatoriaceae

Oscillatoria — littoral, limnetic and phytoplankton

Family Nostochineae

Anabaena — littoral and phytoplankton

Division Chlorophycophyta

Class Chlorophyceae

Order Zygnematales

Family Zygenmataceae

Spirogyra	littoral, limnetic and phytoplankton

Order Cladophorales

Family Cladophoraceae

Cladophora	littoral, limnetic and benthic

Phylum Protozoa

Class Sarcodina

Order Testeceae

Family Arcellidae

Arcella	littoral and benthic

Family Difflugidae

Difflugia	littoral

Order Amoebina

Family Amoebidae

Amoeba	littoral, limnetic and phytoplankton

Class Mastigophora

Order Euglenoidina

Family Euglenidae

Euglena	benthic

Class Ciliata

Order Peritrichida

Family Vorticellidae	
Vorticella	littoral and benthic
Order Spirotrichida	
Family Spirostomidae	
Spirostomum	littoral
Family Stentoridae	
Stentor	littoral and benthic
Order Holotrichida	
Family Paramecidae	
Paramecium	littoral and limnetic
Family Didiniidae	
Didinium	littoral, limnetic and planktonic
Phylum Rotatoria	
Class Morogononta	
Order Plioma	
Family Branchioridae	
Keratella	littoral and limnetic
Family Asplanchnidae	
Asplanchna	littoral
Order Notommatidae	
Family Notommatinae	
Cephalodella	littoral
Class Digononta	
Order Bdelloidea	
Family Philodinidae	
Philodina	limnetic and phytoplankton

Phylum Arthropoda

Class Crustacea

Order Cyclopoida

Family Cyclopoidae

Cyclops	littoral

Order Cladocera

Family Bosminidae

Bosminia	littoral, limnetic and Planktonic

Family Daphnidae

Daphnia	littoral, limnetic and planktonic and benthic

Class Insecta

Order Coleoptera

Family Hydrophilidae

Tropisternus	seine

Family Gyrinidae

Gyrinid	seine

Order Hemiptera

Family Notonectidae

Notonecta	seine

Family Gerridae

Gerris	seine

Order Odonata

Family Libelluidae

Plathemis	insect net

Phylum Chordata

Class Amphibia

Order Caudata

Family Ambystomidae

Ambystoma maculatum (larvae) seine

Order Anura

Family Ranidae

Rana pipiens	seine
Rana catesbeiuna	seine
Rana clamitans	seine

Family Hylidae

Acris crepitans	seine

		4/6/74	4/20/74	5/4/74	5/18/74	6/1/74	6/15/74	6/29/74
O_2 (p.p.m.)	1/4 m.	8.0	6.4	4.0	7.0	6.7	6.4	4.2
	1/2 m.	6.4	5.3	2.5	2.2	2.3	2.4	.7
	3/4 m.	5.2	3.0	1.0	1.2	1.5	1.7	.4
	1 m.	4.4	1.5	.5	.5	1.0	1.5	.2
	1 1/4 m.	4.0	1.5	.5	.5	1.0	1.5	.1
Temp. C.°	1/4 m.	13.5	15	16	19	19	20	19
	1/2 m.	11.5	14	16	17	18	19	17.5
	3/4 m.	10.5	13	14.5	16.5	17	18	17
	1 m.	10	11.5	14	15	16.5	17.5	16
	1 1/4 m.	10	11	14	14.5	16.5	17.5	16
Conductivity meter (micromohs)	1/4 m.	30	30	40	50	40	35	40
	1/2 m.	30	35	50	75	70	50	50
	3/4 m.	30	50	80	105	90	90	90
	1 m.	50	50	95	120	110	110	100
	1 1/4 m.	50	50	100	120	110	110	110
Secchi disc (cm.)	mean	41.3	58	44.3	38	36	36	33
Rain gauge (cm.)	A	3.81	4.06	4.57	4.82	2.79	2.54	5.08
	B	3.81	4.57	4.57	3.04	5.08	4.57	3.81

TABLE I

PHYSICAL DATA

		1/4 m.	1/2 m.	3/4 m.	1 m.	1 1/4 m.
O_2 (p.p.m.)	high	8.0	6.4	5.2	4.4	4.0
	low	4.0	.7	.4	.2	.1
	mean	6.1	3.1	2.0	1.4	1.3
Temp. C.°	high	20	19	18	17.5	17.5
	low	13.5	11.5	10.5	10.0	10.0
	mean	17.5	16.1	15.2	14.4	14.2
mohs	high	50	75	105	120	120
	low	30	30	30	50	50
	mean	37.9	51.4	76.4	90.7	92.9
Secchi disc (m.)	high	.58				
	low	.33				
	mean	.41				

		A	B
Rainfall (cm.)	high	5.08	5.08
	low	2.54	3.04
	mean	3.95	4.21

TABLE II

PHYSICAL DATA ILLUSTRATING HIGH, LOW AND MEAN VALUES

Maximum Depth	Maximum Length	Maximum Breadth	Shoreline Length	Shoreline Development	Surface Area	Volume	Mean Breadth	Mean Depth
(m.)	(m.)	(m.)	(m.)		(m.^{2})	(m.^{3})	(m.)	(m.)
1.42	14.16	10.31	40.7	1.0049	130.62	78.65	8.94	.60

TABLE III

MORPHOMETRIC DATA FOR THE WOODLAND POND

Date	CO_2 p.p.m.	Total Hardness p.p.m.	pH	O_2 p.p.m.	NO_3 p.p.m.	PO_4 p.p.m.	
4/6/74	15	20	6.2	7.0	.10	.15	a
	10	20	6.5	10	.13	.05	b
4/20/74	10	10	6.5	7.5	.10	.05	a
	10	10	6.6	9.0	.10	.05	b
5/4/74	40	15	5.7	6.0	.12	6.5	a
	20	15	6.5	6.0	.10	2.0	b
5/18/74	20	25	6.7	8.0	.13	1.23	a
	20	20	6.5	8.0	.10	.45	b
6/1/74	20	27	6.7	8.0	.11	1.5	a
	20	20	6.5	8.0	.10	.28	b
6/15/74	14	30	6.7	10	.08	1.2	a
	20	20	6.55	7.0	.10	.1	b
6/29/74	16	20	6.8	10	.10	.08	a
	32	20	6.45	10	.12	.04	b

a = Limnetic
b = Littoral

TABLE IV

CHEMICAL DATA

		Limnetic	Littoral
CO_2 (p.p.m.)	high	40	32
	low	10	10
	average	19.3	18.9
Total hardness (p.p.m.)	high	30	20
	low	10	10
	average	21	17.8
pH	high	6.8	6.6
	low	5.7	6.45
	average	6.4	6.5
O_2 (p.p.m.)	high	10.0	10.0
	low	6.0	6.0
	average	8.1	8.3
NO_3 (p.p.m.)	high	.13	.13
	low	.08	.10
	average	.106	.107
PO_4	high	6.50	2.00
	low	.05	.04
	average	1.53	.42

TABLE V

CHEMICAL DATA ILLUSTRATING HIGH, LOW AND MEAN VALUES

Benthic	Limnetic	Littoral	Planktonic
	Oscillatoria	Oscillatoria	Oscillatoria
		Anabaena	Anabaena
	Spirogyra	Spirogyra	Spirogyra
Cladophora	Cladophora	Cladophora	
Arcella		Arcella	
		Difflugia	
	Amoeba	Amoeba	Amoeba
Euglena			
Vorticella		Vorticella	
		Spirostomum	
Stentor		Stentor	
	Paramecium	Paramecium	
	Didinium	Didinium	Didinium
	Keratella	Keratella	
		Asplanchna	
		Cephalodella	
	Philodina		Philodina
		Cyclops	
	Bosminia	Bosminia	Bosminia
Daphnia	Daphnia	Daphnia	Daphnia

TABLE VI

AQUATIC PLANTS AND ANIMALS IDENTIFIED FROM THE WATER SAMPLES

CHAPTER V

DISCUSSION AND RESULTS

PHYSICAL SURVEY

General Considerations

The body of water surveyed in this study is considered to be a pond. According to Reid (1961) the term pond generally connotes a small, quiet body of standing water with rooted plants growing across it or capable of supporting plants all the way across. Personal records of park employees indicate the pond is of a permanent type, retaining water at various levels throughout the past forty years.

The pond basin is a result of excavation by man; however, the author concludes that the ability to hold water resulted from a combination of natural processes. One of these includes weathering and erosion of the precipitous slopes of the drainage basin and the subsequent sedimentation along the basin floor. Adding to this event is the annual deposit of the foliage of the canopy eventually creating a floor of leaf litter six inches in depth. The pond has in effect created its own seal, a process characteristic of ponds and lakes (Ruttner, 1963).

Oxygen

Dissolved oxygen is an important measure of productivity in a pond (Reid, 1961). This oxygen normally comes from two sources: the photosynthetic by-product of plants in the water and the surface of the water where there is an exchange of gases with the atmosphere.

This pond is considered eutrophic, being thermally stratified (Figure 7) and losing its supply of oxygen in deeper waters (Figure 4).

Temperature, probably more than any other factor, influences the quantity of dissolved oxygen present in a pond containing no toxic oxidizable polluted material (Ruttner, 1963). Oxygen concentrations were, with the exceptions of the upper 1/4 meter, consistently below the requirements for fish and other gill breathing vertebrates (Welch, 1952). There was a gradual loss of dissolved oxygen for all levels from April 6 through June 29 (Figure 4). This corresponds inversely with the temperature recordings (Figure 7) which resulted in a warming of the lower depths. Besselievre (1952) reported that temperatures below 50° F. will inhibit bacterial life. Temperatures above this increase bacterial action which depletes oxygen supplies in the depths. The bacterial decomposition of the leaf litter on the pond bottom is considered the source of oxygen depletion.

Water Temperature

An important indicator of the total biotic and physical properties of the aquatic system is the temperature. The temperature of the water, by its influence on density, determines the amount of mixing of the water levels and accounts for the periodic stratification that is typical of many ponds and lakes. This mixing and/or stratification of water determines the physical aspects of the water which are directly related to the life-supporting capabilities. Included in the physical aspects are such properties as suspended matter, including organic nutrients and inorganic particulates, and the quantity of dissolved oxygen and other inorganic elements.

With reference to temperature, lakes and ponds are often described as being stratified. Reid (1961) defines stratified water as those waters containing three distinct layers: epilimnion, thermocline (metalimnion) and hypolimnion. The thermocline represents, "the middle layer of a thermally stratified body of water having the greatest temperature variation per one meter depth... often as much as 1° C. per 1 meter depth" (Reid, 1961). The location of the thermocline depicts the development of the other layers and the waters are referred to as stratified.

The minimum temperature gradient of the pond from the surface to the bottom was 2° C. while the maximum was 4 1/2° C. (Figure 7). These figures represent a greater vertical drop in water temperature per one meter depth than those defined by Reid (1961) as suggesting a thermocline.

It is therefore suggested that due to the small size of the pond with its shallow depth there did not exist an epilimnion, metalimnion and hypolimnion.

Total Dissolved Solids

Measurements for the conductivity meter represent the total organic and inorganic solids dissolved in the water. These measurements increased in value from April 6 through May 18 at all depths (Figure 8). This increase coincides with an increased temperature (Figure 6). It is therefore reasoned that the increased temperatures assisted bacterial decomposition which released dissolved solids into the water. Secchi disc values are inversely proportional to the total dissolved solids during these dates (Figure 11).

Secchi Disc

Secchi disc values for the research period are summarized in Table 1. A Secchi disc reading represents the depth at which five per-cent of solar radiation is transmitted (Hutchinson, 1957). Many factors can however alter values obtained with the Secchi disc. At best, such readings give relative values for turbidity or rate of absorption of light.

Turbid waters generally carry greater numbers of bacteria than clear waters (Perry, 1969). With the settling of suspended particles bacteria are carried to the bottom. Secchi disc readings for this study show a brief high followed by steadily declining values (Figure 11).

Rainfall

The mean rainfall per two week period for gauge A (exposed) was 3.95 cm. while 4.21 cm. was recorded for B (covered by canopy). These figures (Table 2) fall within the expected range of precipitation for that time period. Fluctuations of the water level were observed but no noticeable changes took place. Water loss from the pond through evaporation was indicated by deficits of gauge A as compared to gauge B during May and June (Table 1).

CHEMICAL SURVEY

Carbon Dioxide

Dissolved carbon dioxide measurements provide information pertaining to respiration and the decay process. It is also an important environmental buffer against rapid shifts in acidity and alkalinity. Carbon dioxide is also important in regulating biological processes in aquatic communities and serves as a source of carbon (Reid, 1961). The values for carbon dioxide (Figure 15) are inversely proportional to those of dissolved oxygen (Figure 18) for the same stations. These graphs illustrate the inverse relationship of carbon dioxide and oxygen in the photosynthetic and respiration processes. It is felt by the author that oxygen losses and carbon dioxide increases suggest an increase in the decay processes.

Total Hardness

In fresh waters the total hardness consists largely of a few salts: the carbonates, sulphates, and chlorides of calcium, magnesium, sodium and potassium; and small amounts of nitrogen and phosphorus compounds (Ruttner, 1963). These are also dissolved organic solids, various gases and a host of trace elements. However, in most natural waters the predominant anions are bicarbonates associated mainly with calcium, to a lesser degree with magnesium and still less with sodium and potassium. In our immediate area the eroding of limestone bedrock contributes to the total hardness of the water and for the most part the water is considered moderately hard. A moderately hard water is sometimes defined as having hardness between 60 to 120 p.p.m. (N.T.A.C., 1968).

The values of total hardness for the pond were consistently low (Figure 16). These values suggest that the water is of a soft (less than 40 p.p.m.) water quality when compared to other surface waters (N.T.A.C., 1968). This can be attributed to the fact that the only affluent supply of water to the pond is rain, a natural source of soft water.

Hydrogen Ion Concentration

Water is often referred to as the universal solvent due to its ability to dissolve a wide variety of substances. This ability not only exists in the laboratory, but also in natural lotic and lentic waters. The substances dissolved in water determine its position on the acid-base scale referred to as the pH scale. There are a number of different definitions of acids and bases, but for simplification, an acid can be defined as a substance that increases the concentration of hydrogen ions (H^+) in water, a base as a substance that increases the concentration of hydroxyl ions (OH^-) in water (Reid, 1961). The degree of acidity or alkalinity of a solution is usually measured in terms of the pH scale, with 1--6.8 acid; 6.8--7.2 neutral and 7.2--14 alkaline (Ruttner, 1963).

The pH values for the pond suggest a slightly acidic condition (Figure 17) with the limnetic station having the greatest fluctuation. A marked drop in the pH on May 4 (limnetic station) coincides with a marked decrease in dissolved oxygen for that same date and an increase in dissolved carbon dioxide.

Dissolved Oxygen

A discussion of the influence of dissolved oxygen was given in the physical survey section. However, dissolved oxygen values were also determined for the limnetic and littoral stations as a source of comparison (Figure 18). The oxygen values for the limnetic and littoral stations were consistently higher than those of the deeper waters. This suggests a depletion of oxygen from all but the uppermost level.

A marked reduction in dissolved oxygen concentration resulted on May 4 (Figure 18). This is attributed to increased respiration and decay processes as supported by a corresponding increase in carbon dioxide (Figure 15). From this point on there was a gradual increase in oxygen followed by only minor fluctuations between the limnetic and littoral stations.

Nitrate

The determination of nitrates in the water is an important index as to how much nitrogen could be made available to the plants for the synthesis of proteins. The absorbed nitrate is reduced and built into organic compounds such as amino acids, amides and other nitrogen rich compounds. Under normal conditions the percentage of organic and inorganic nitrogen in a lake is 50 : 50 (Reid, 1961). The organic nitrogen is present largely due to amino acids while the inorganic nitrogen is present in such forms as ammonia, nitrate and nitrite (Ruttner, 1963). Nitrate nitrogen usually occurs in relatively small concentrations in unpolluted fresh water; the world average being 0.30 p.p.m. (Reid, 1961). Under normal conditions the amount of nitrate in solution of a given time is determined by metabolic processes in the body of water, i.e., production and decomposition of organic matter (Reid, 1961). Only slight fluctuations were noted in the nitrate values throughout the study (Figure 19). All values fell within the expected range.

Ortho-phosphate

Phosphate is one of the nutrients which is least abundant in natural waters, present in very small amounts. This trace amount of phosphorus may be found in the water in at least three components: (1) organic, (2) dissolved organic and (3) the particulate (Reid, 1961).

Findings in lakes of North America have shown that organic forms of phosphorus are always present in larger amounts than are the inorganic forms (Ruttner, 1963).

Phosphorus enters the water naturally either directly or indirectly from the weathering of phosphatic rocks and from the soil and is present as dissolved phosphate (Ruttner, 1963). Phosphorus is taken up by the phytoplankton algae, but not always in proportion to their demands for growth and reproduction.

All of the ortho-phosphate readings fell within the expected values except those of May 4 (Figure 20). On this date excessively high readings were recorded for both stations. These values are considered erroneous and are attributed to an oxidized ammonia molybdate solution. Subsequent tests conducted with a new supply of the reagent yielded values consistent with those of other sampling dates and with those reported by Hutchinson (1957).

When these erroneous values are discarded the ortho-phosphate readings drop considerably, yielding a mean of .826 p.p.m. for the limnetic station and .186 p.p.m. for the littoral. The highest value for the limnetic station would then be 1.50 p.p.m. while that of the littoral would be .45 p.p.m. (Figure 20).

BIOLOGICAL SURVEY

General Considerations

Due to the limitations of this study specimens collected in the survey were keyed to the genus only; exceptions being those of the phylum chordata. No genera were collected in the survey that have not been previously recorded in lakes and ponds of Tennessee.

A total of twenty-eight genera were accounted for during the survey. One genus, Rana, was represented by three species. These twenty-eight genera represent four phyla of animals and two divisions of plants (Table 6). The animal phyla include Protozoa, Rotatoria, Arthropoda and Chordata. The plant divisions included Cyanophycophyta and Chlorophycophyta. The animal phylum represented by the most genera was the Protozoa (nine genera) and both plant divisions each had two genera recorded. The other phyla and their respective number of genera include: Rotatoria (four genera), Arthropoda (eight genera) and Chordata (three genera).

According to Kluts' (1966) classification of areas of population in lentic waters only one zone of the pond could clearly be defined, the littoral zone. This zone consists of a region of shallow water where light reaches the bottom and rooted plants grow. Although a limnetic station was designated and represented the only open water area of the pond by the strictest definition it was not a limnetic zone. The arguement for a limnetic zone has some basis by its broadest interpretation when considering the definition to include, "sufficient light penetration for photosynthesis" (Reid, 1961). The question then arises: Could light effectively penetrate such turbid waters to facilitate photosynthesis? The minimum Secchi disc reading represents twenty-four percent of the maximum depth of the pond and five percent light transmittance at that depth. It is therefore concluded that light penetration is sufficient for photosynthesis and a maximum depth of 1.42 meters is not sufficient to depict a limnetic zone and is done in this paper only for convenience.

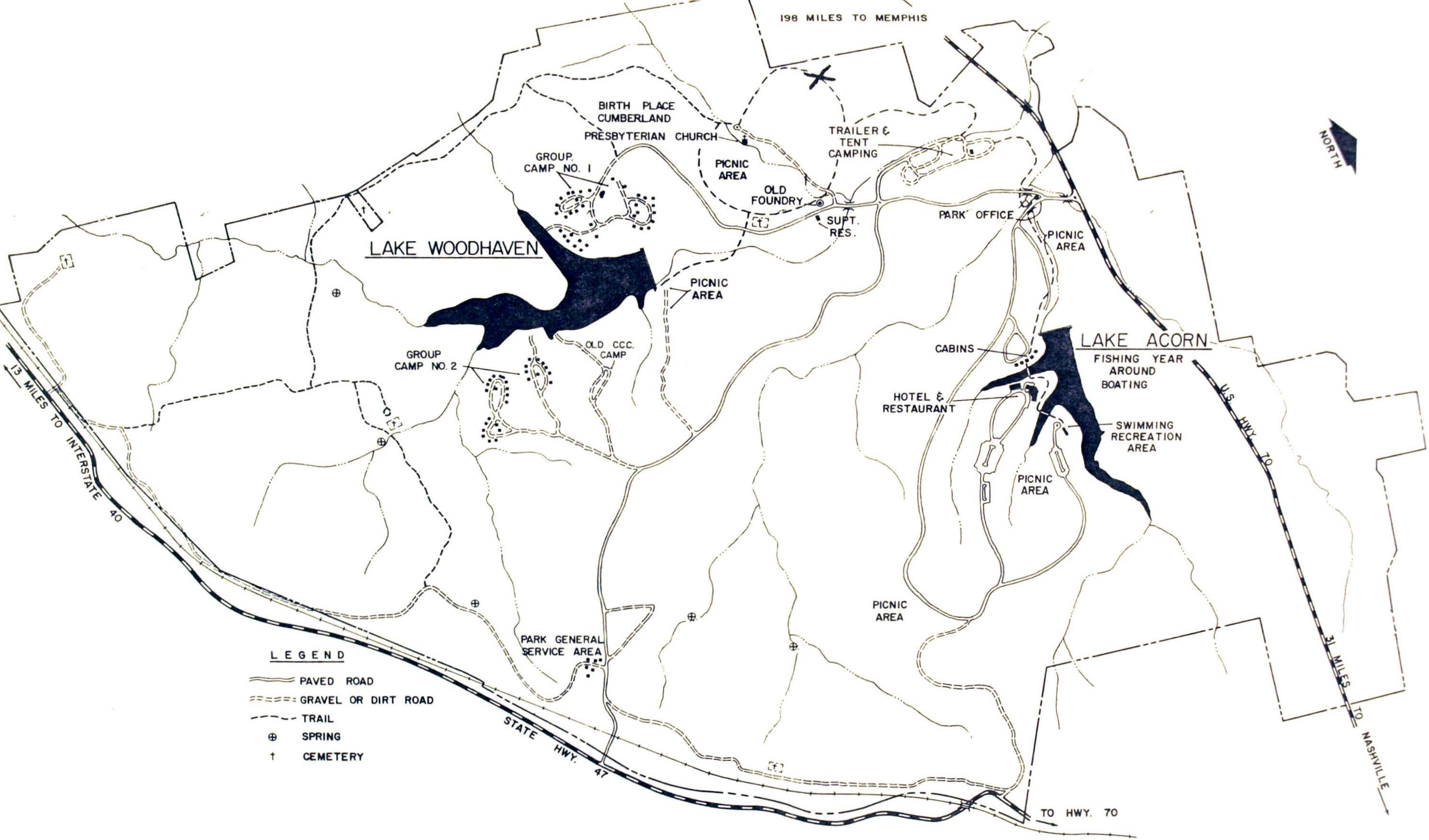


Figure 1. Road and Travel Map of Montgomery Bell State Park

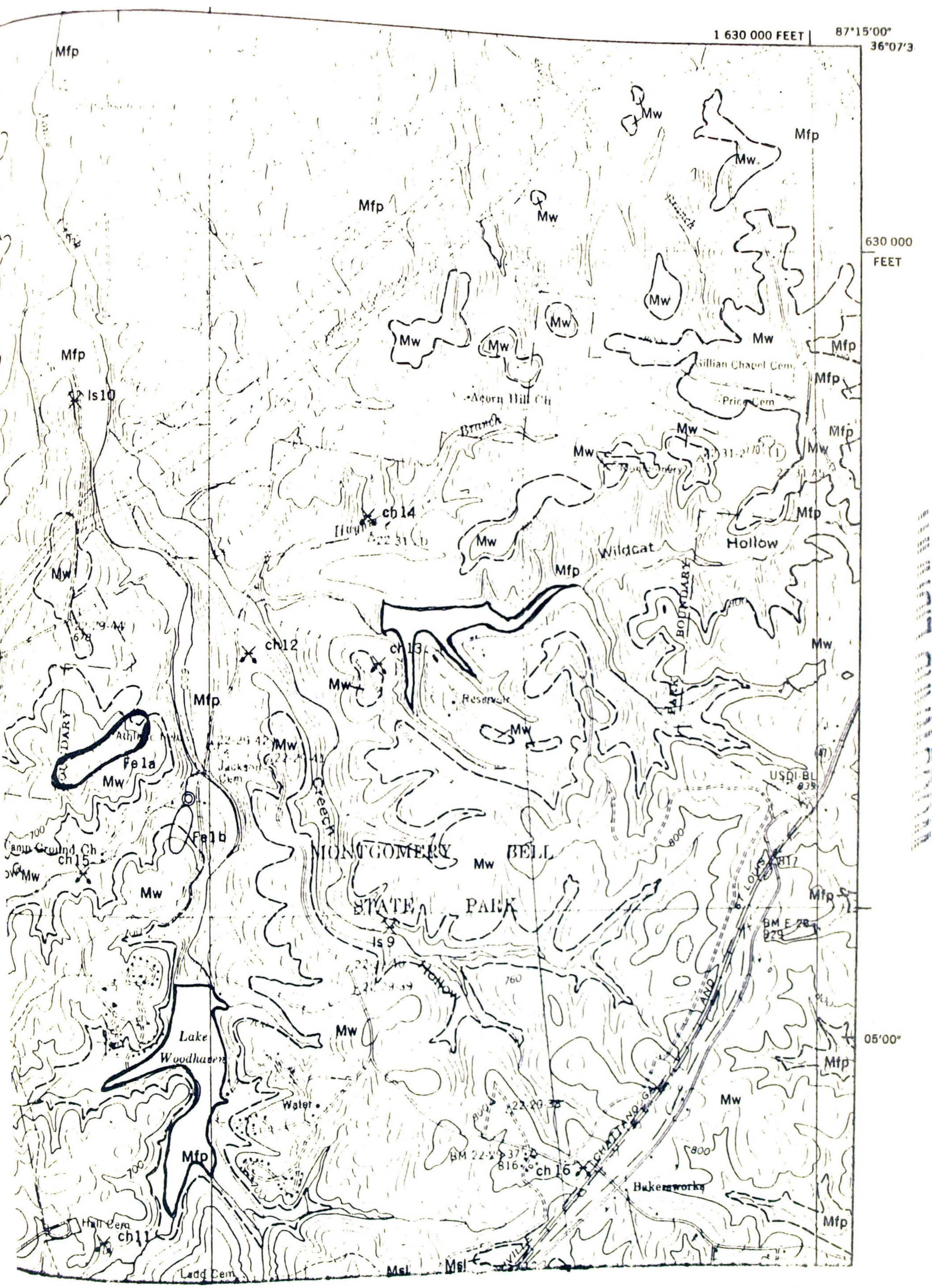


Figure 2. Topographic Map of Montgomery Bell State Park.

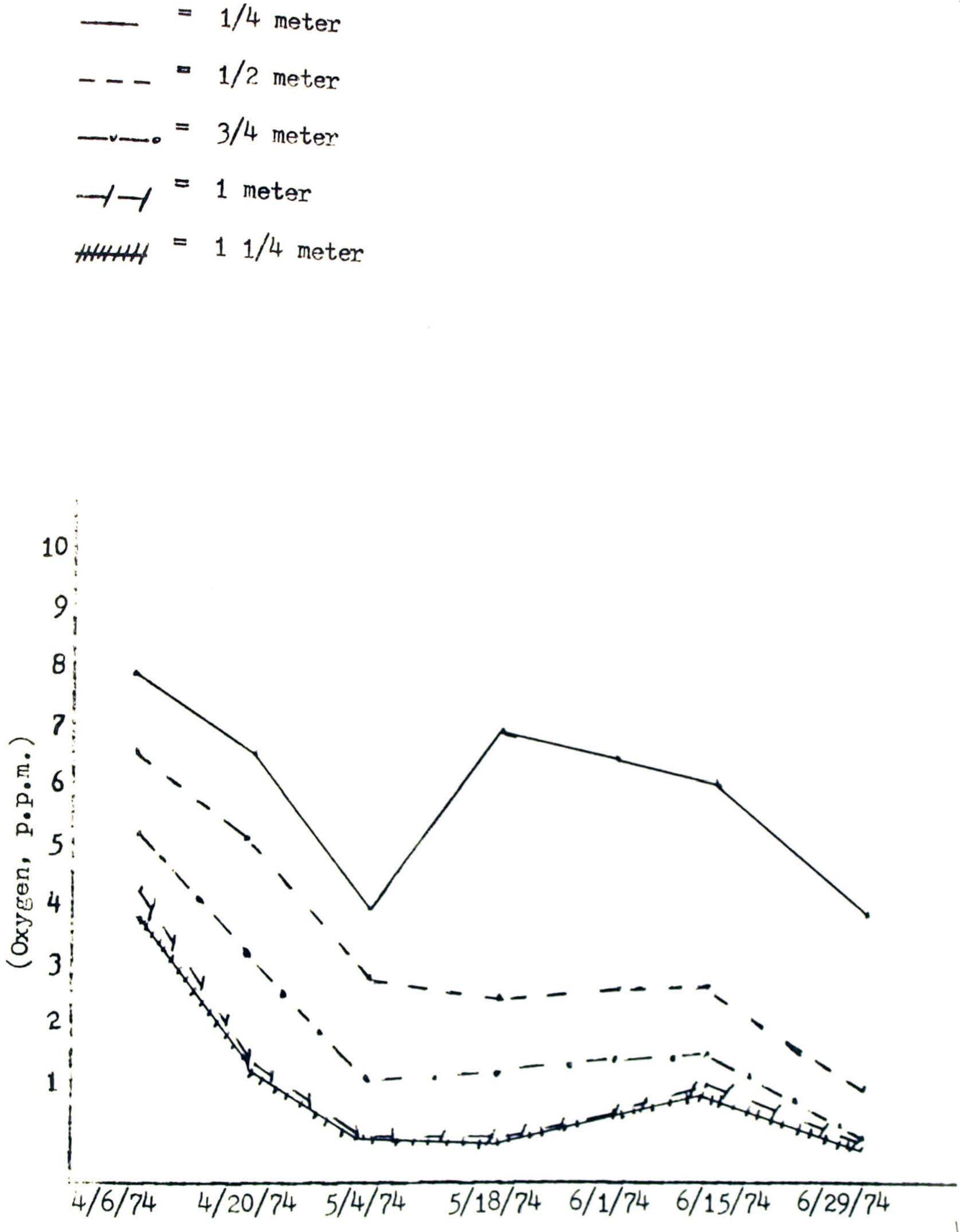


Figure 3. Dissolved Oxygen Concentration at Four Depths within the Woodland Pond.

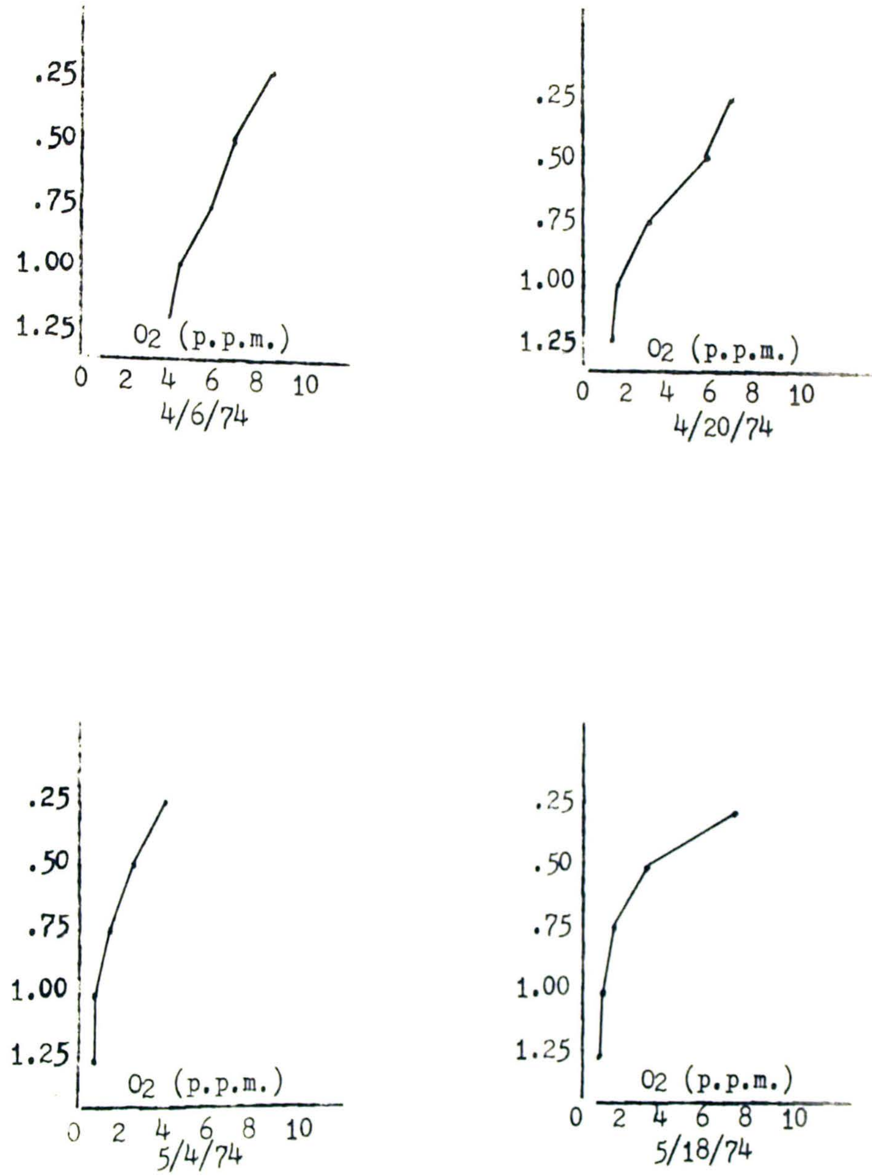
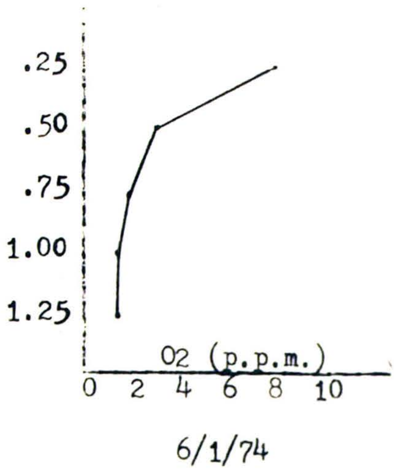
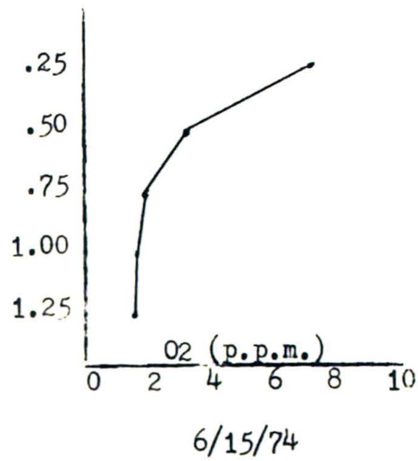


Figure 4. Oxygen and Depth Measurements for Seven Dates within the Woodland Pond.





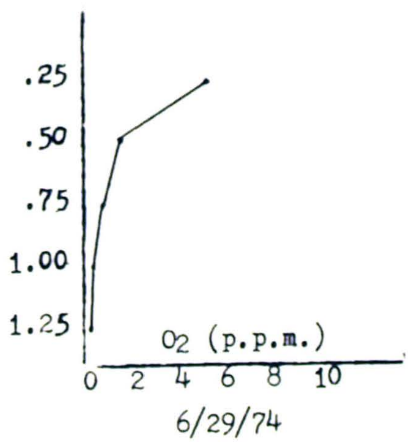


Figure 4 (con't.). Oxygen and Depth Measurements for Seven Dates within the Woodland Pond.

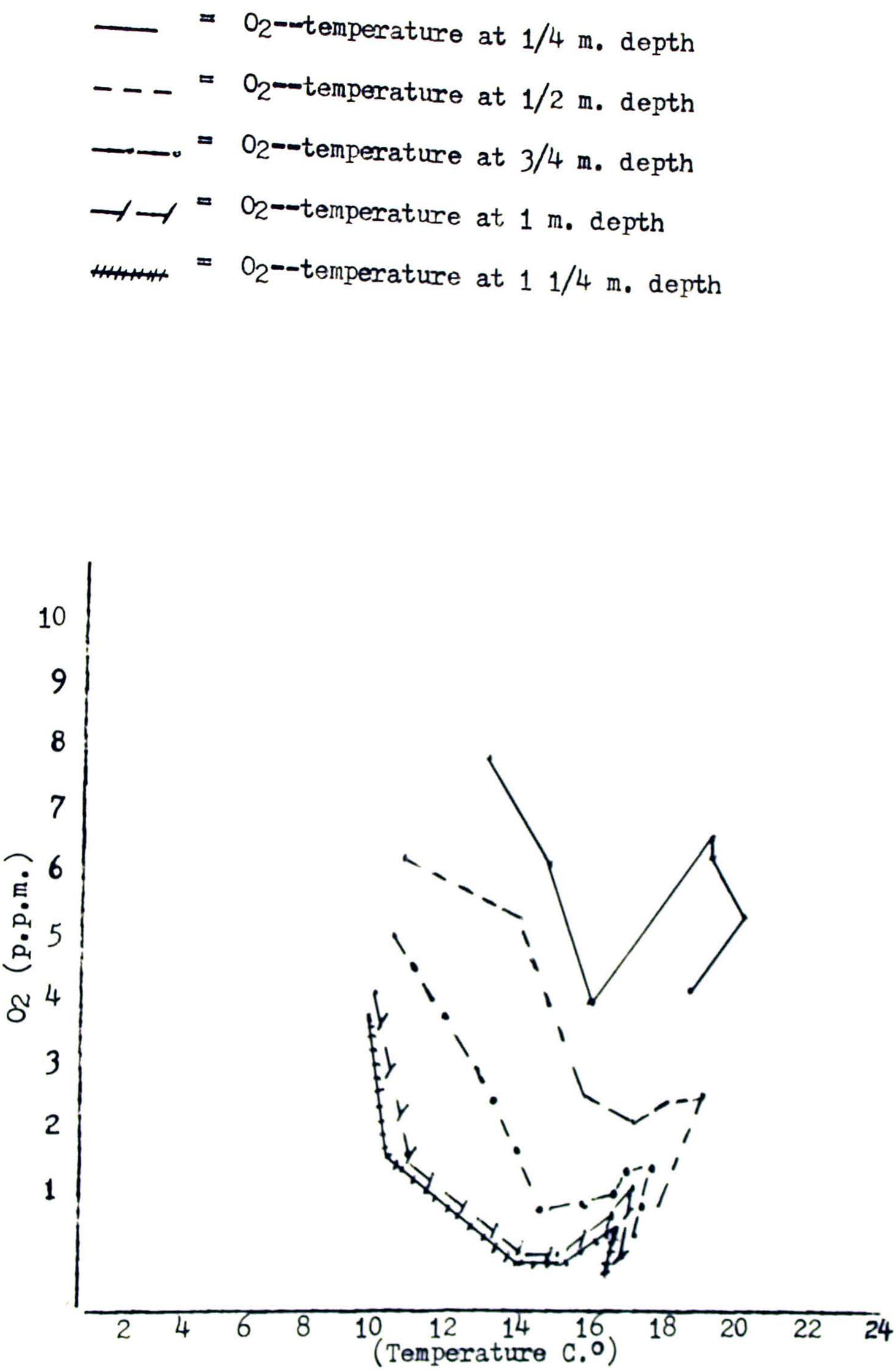


Figure 5. Oxygen and Temperature Measurements for Five Depths within the Woodland Pond.

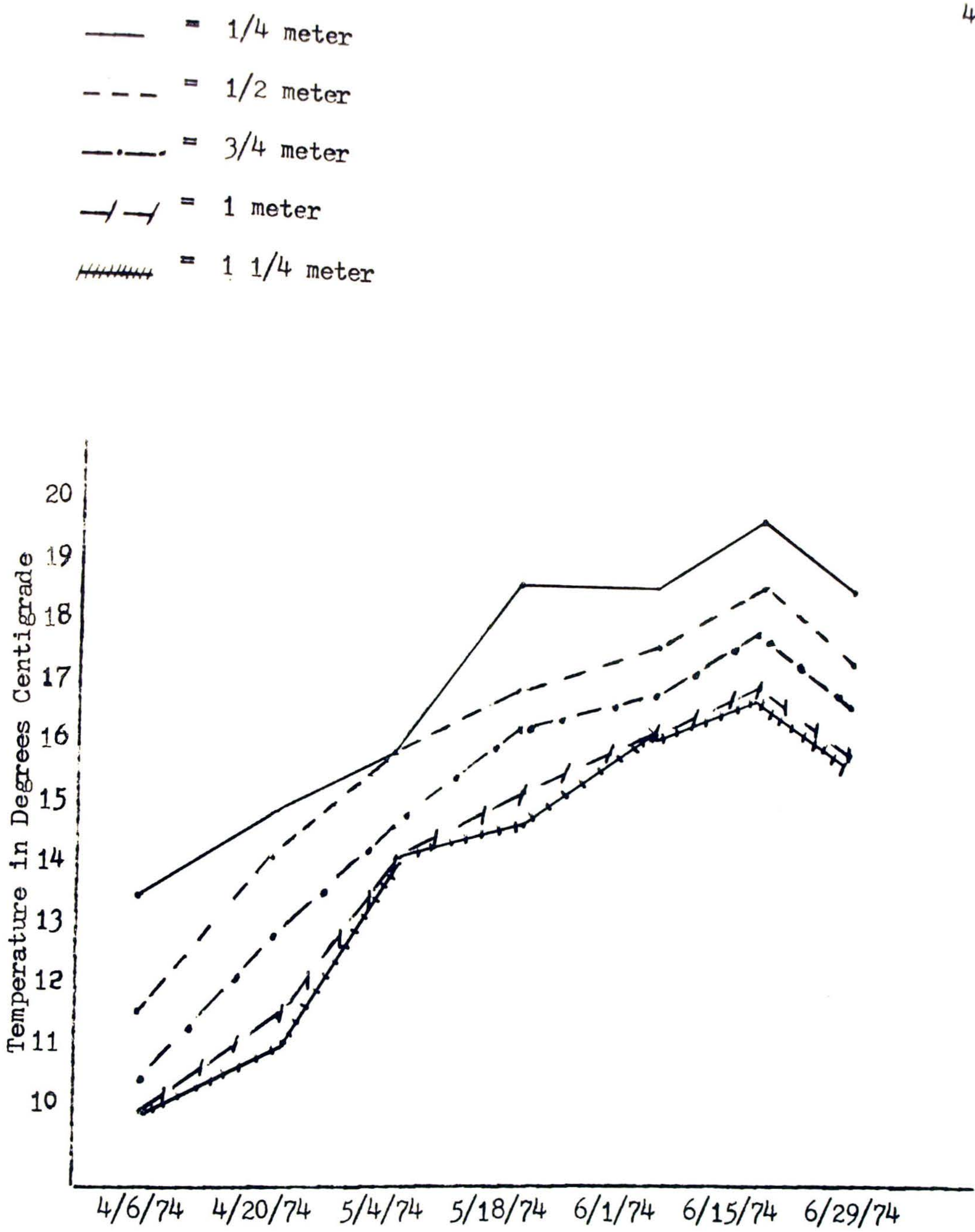


Figure 6. Temperatures Recorded at Four Depths within the Woodland Pond.

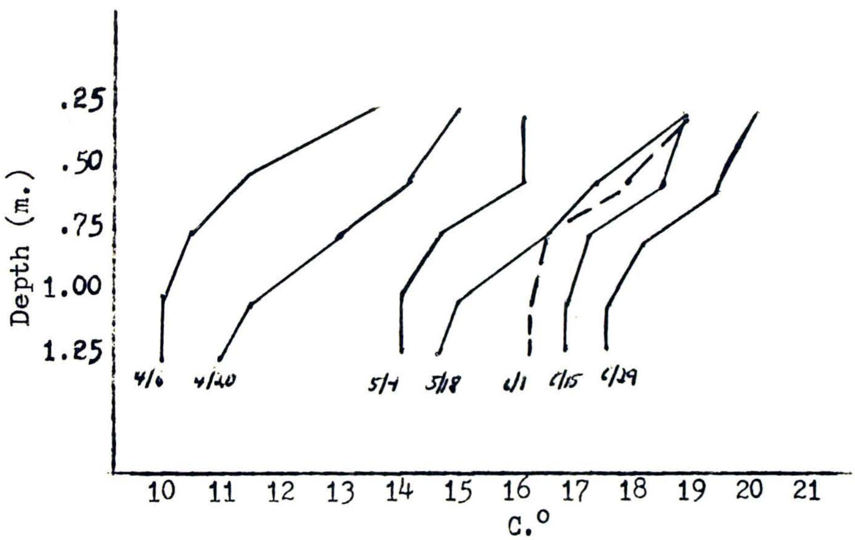


Figure 7. Temperature and Depth Measurements for Seven Dates within the Woodland Pond.

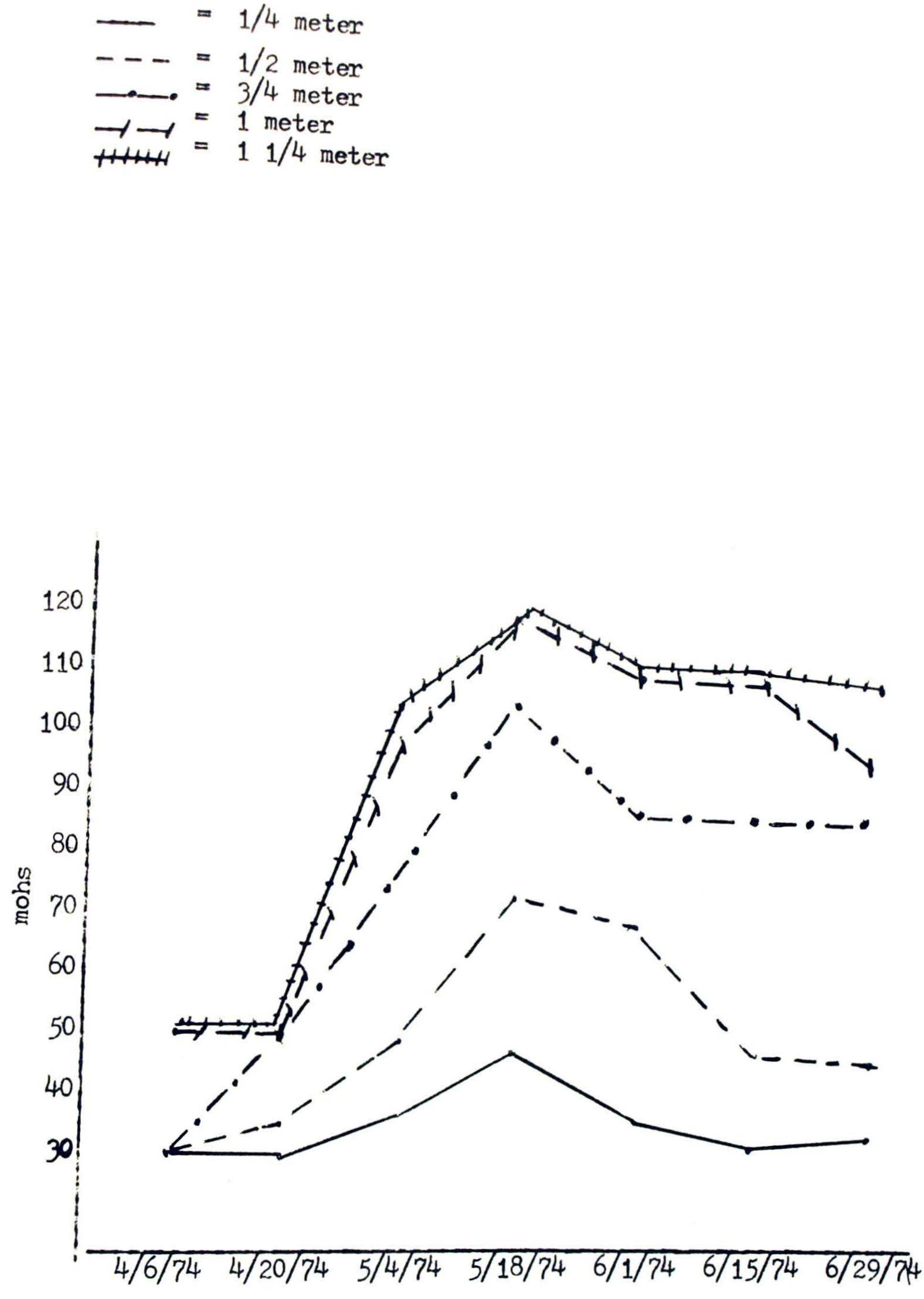


Figure 8. Total Dissolved Solids at Four Depths within the Woodland Pond.

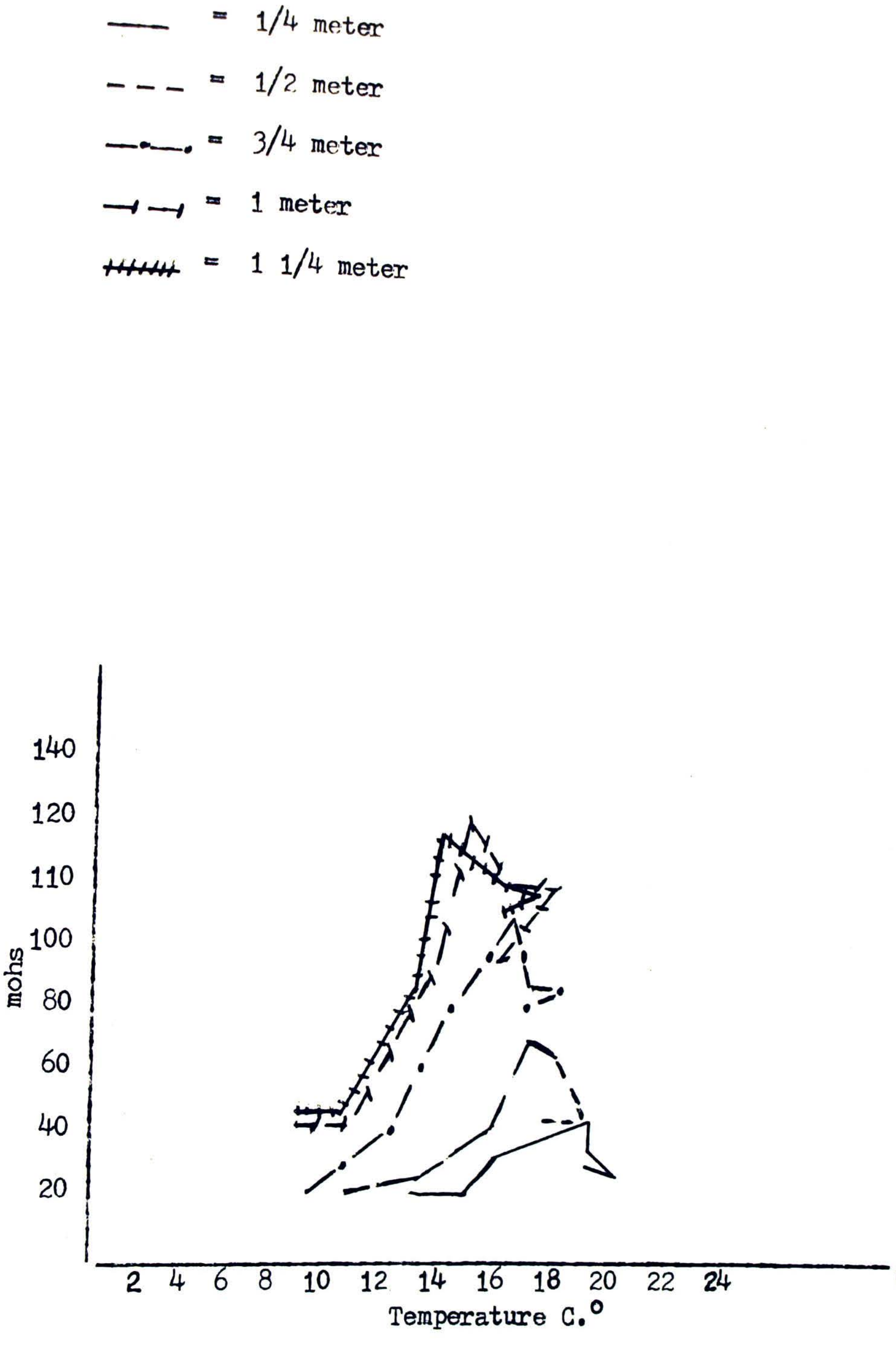


Figure 9. Temperatures and Total Dissolved Solids for Five Depths within the Woodland Pond.

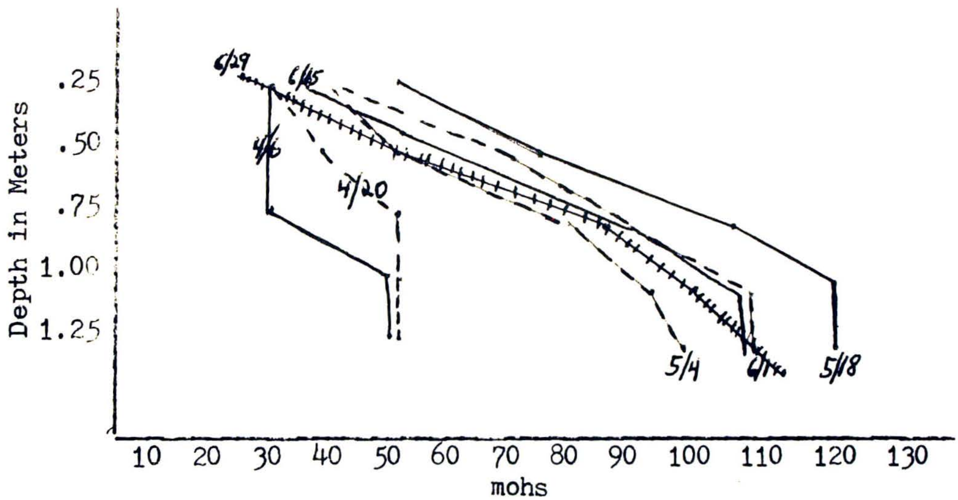


Figure 10. Total Dissolved Solids and Depth Measurements for Seven Dates within the Woodland Pond.

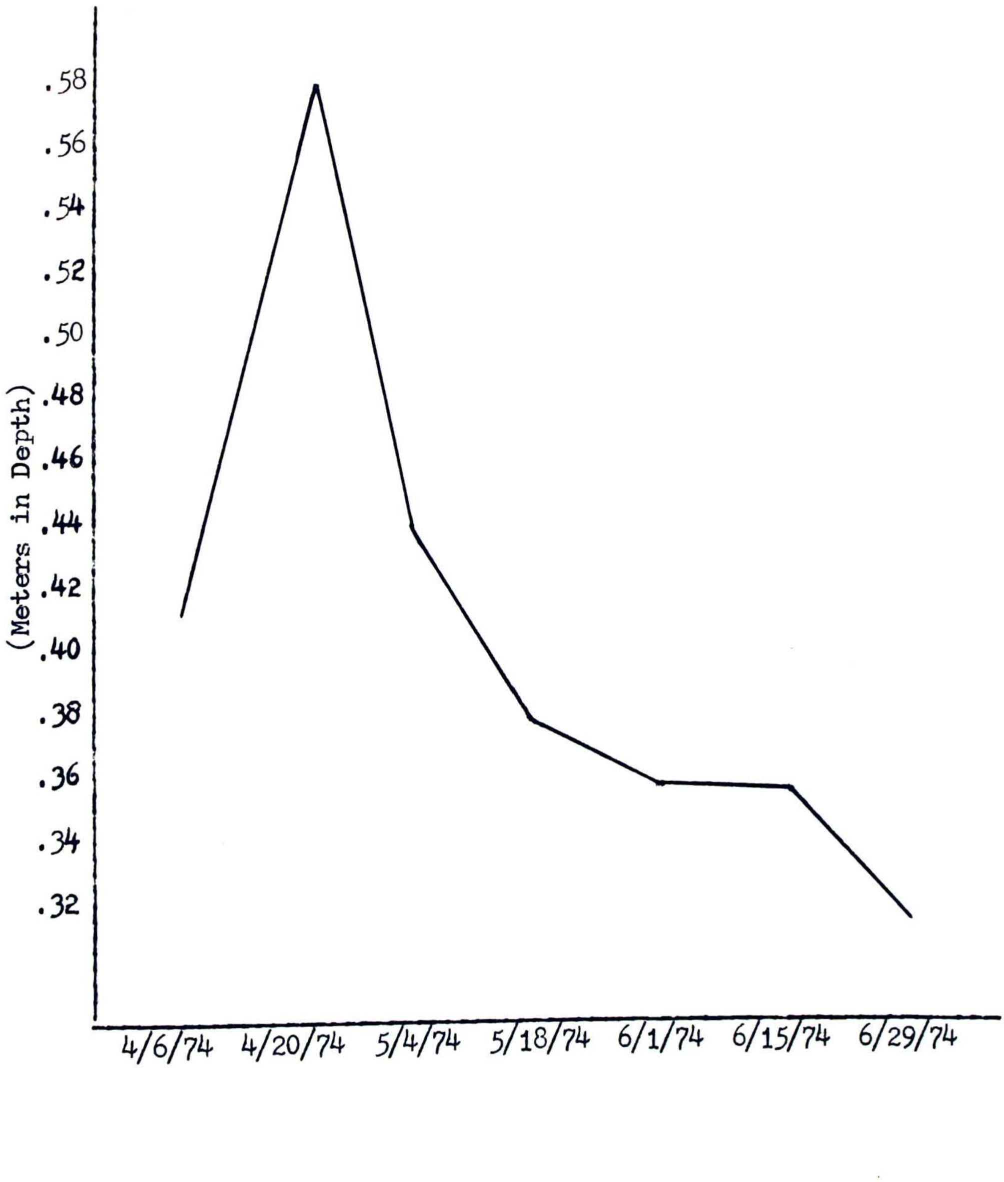


Figure 11. Secchi Disc Readings for Seven Dates within the Woodland Pond

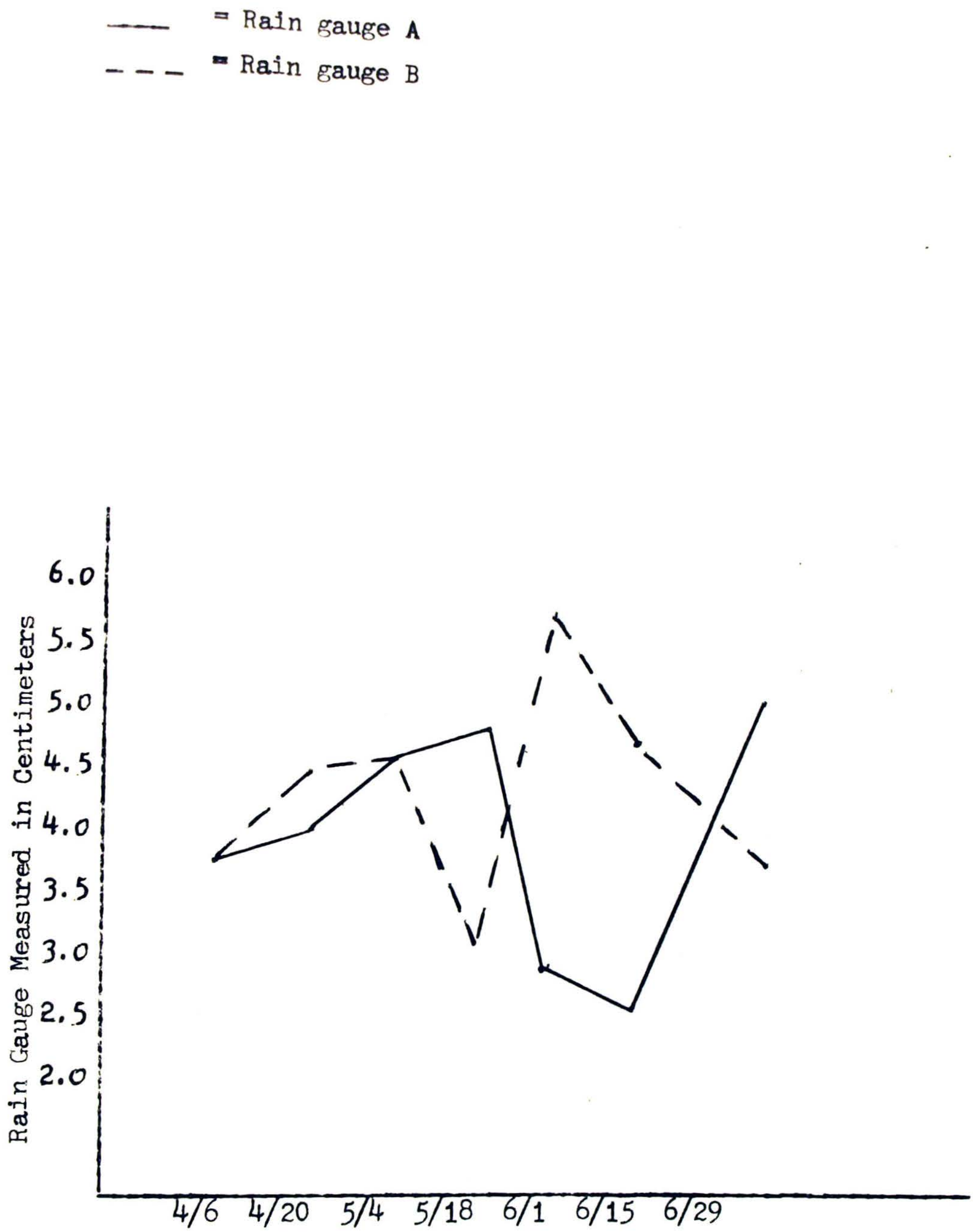


Figure 12. Rain Gauge Readings at Two Localities within the Woodland Pond.

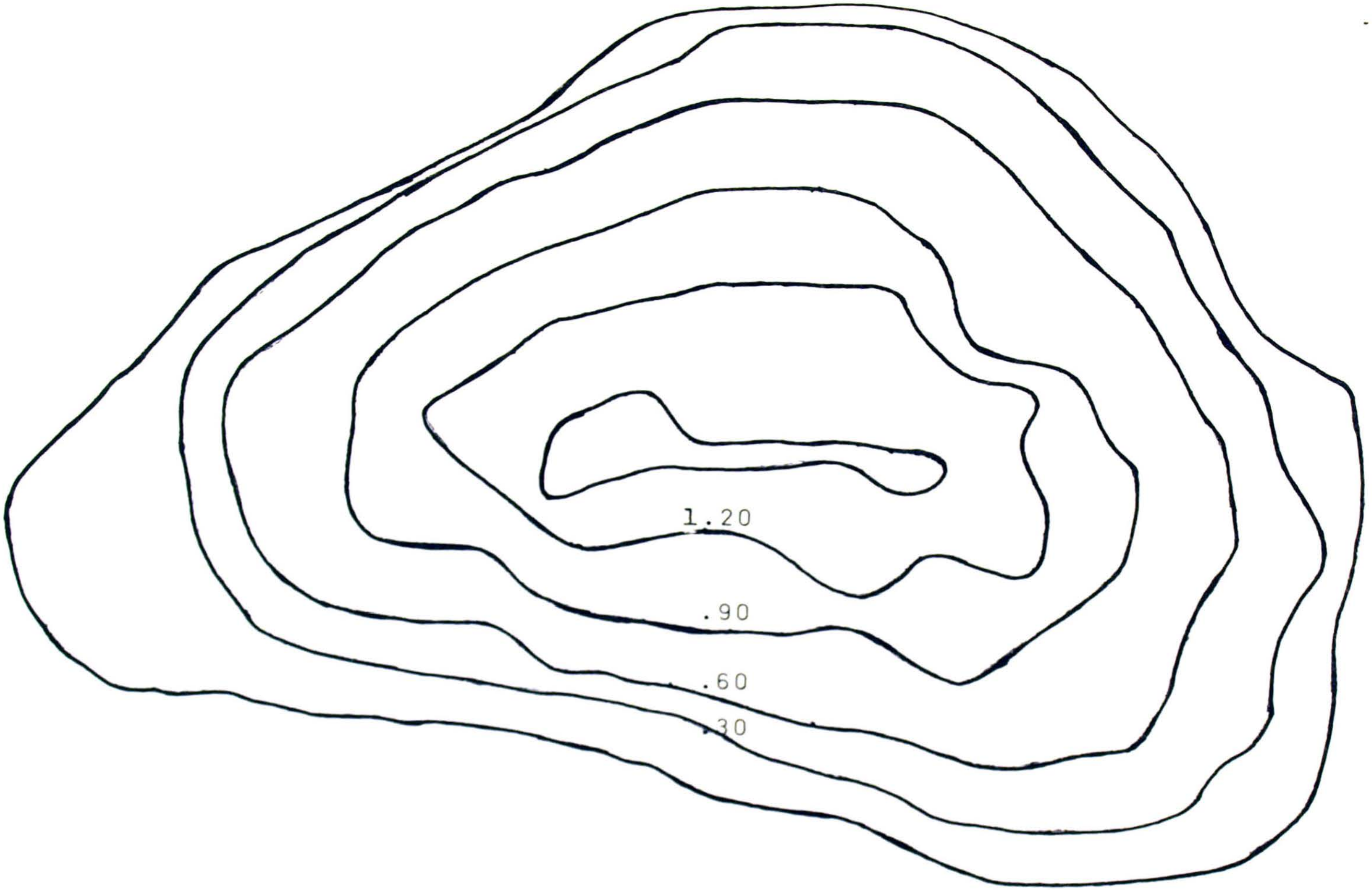


Figure 13. Depth Profile in Meters of the Woodland Pond

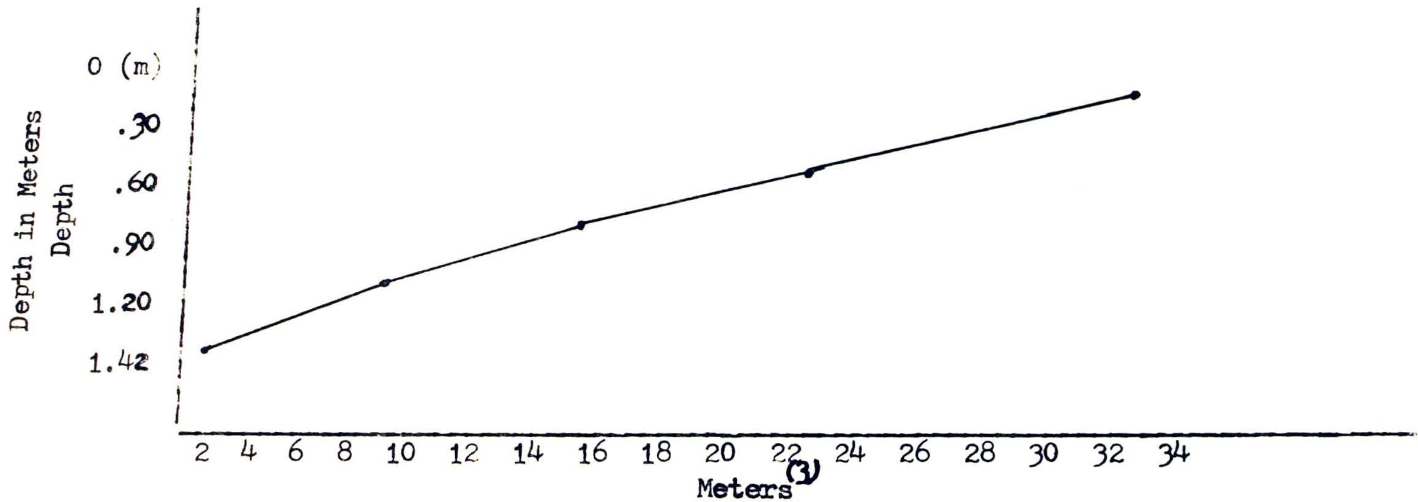


Figure 14. Hypsographic Curve for the Woodland Pond.

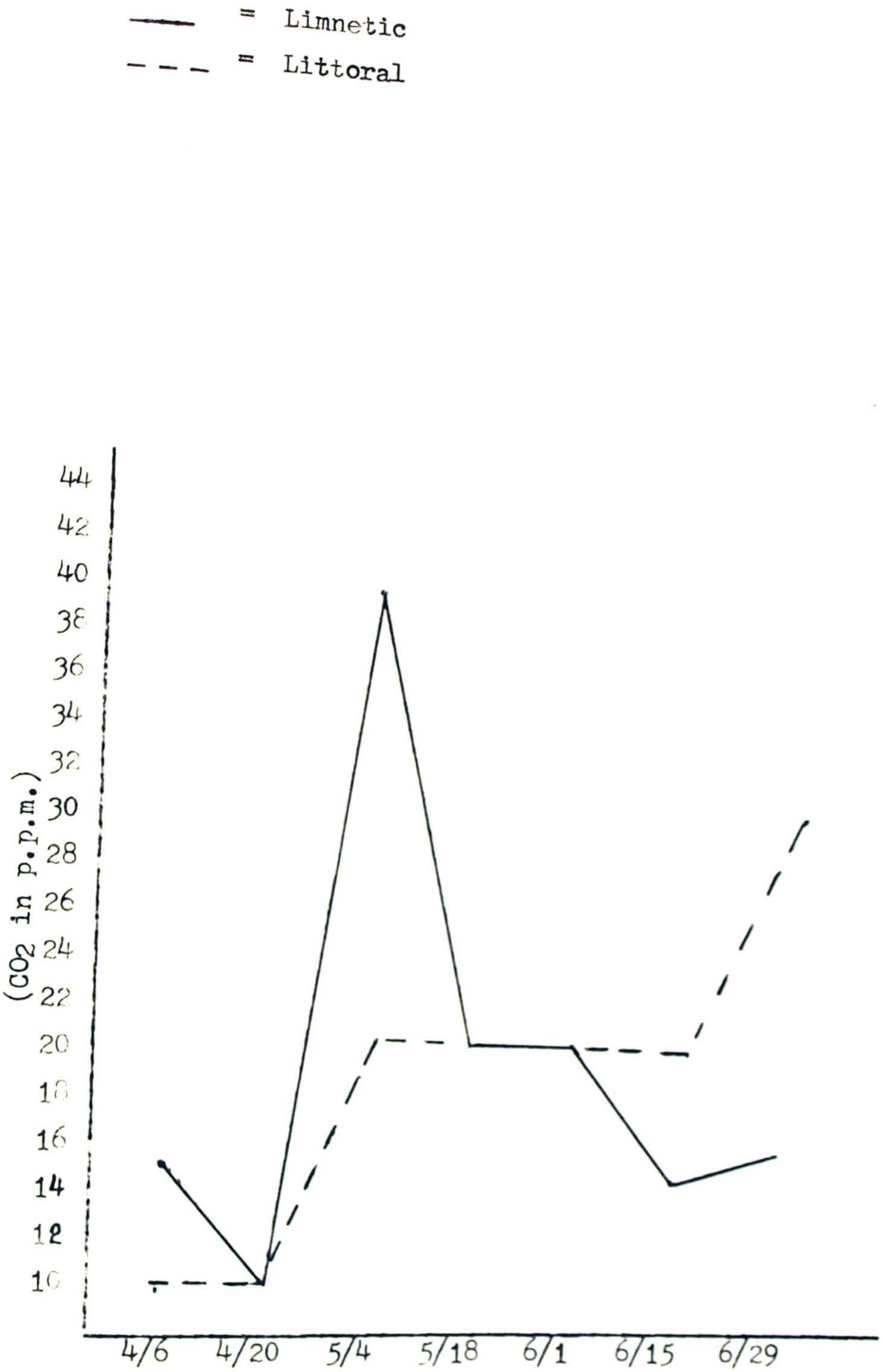


Figure 15. Carbon Dioxide Concentration at Two Stations within the Woodland Pond.

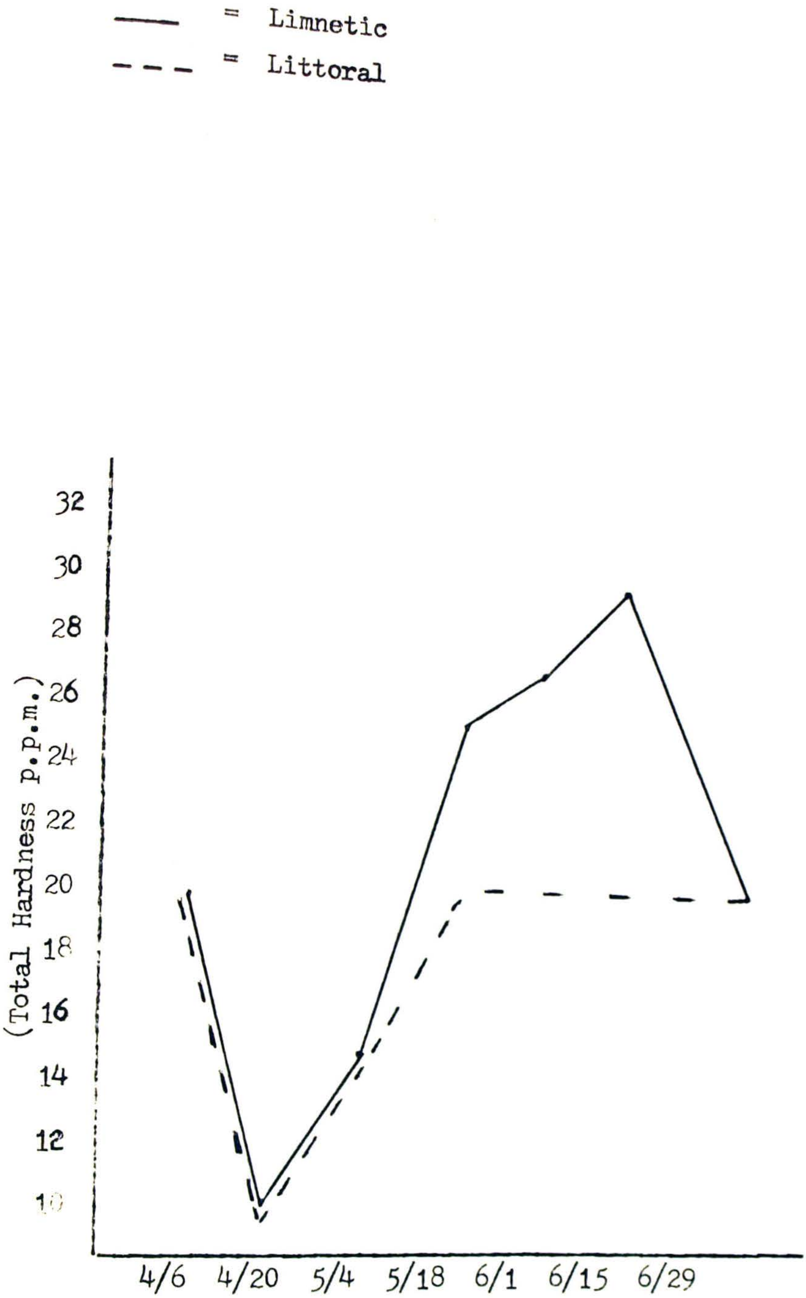


Figure 16. Total Hardness for Two Stations within the Woodland Pond.

——— = Limnetic

– – – = Littoral

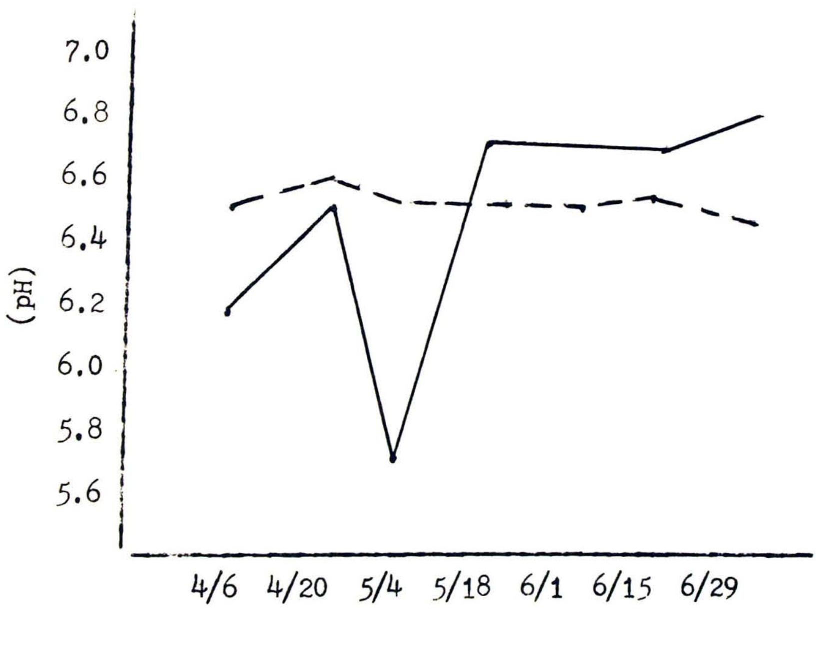


Figure 17. Hydrogen Ion Concentration for Two Stations within the Woodland Pond.

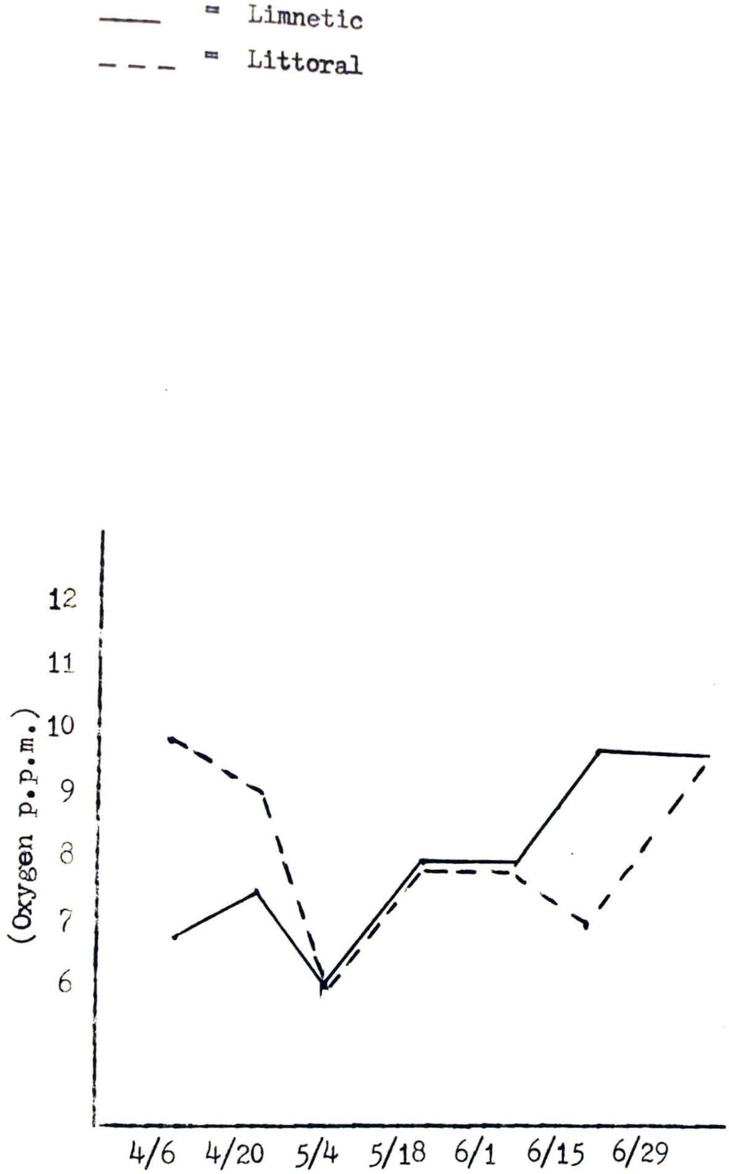


Figure 18. Dissolved Oxygen Concentration for Two Stations within the Woodland Pond.

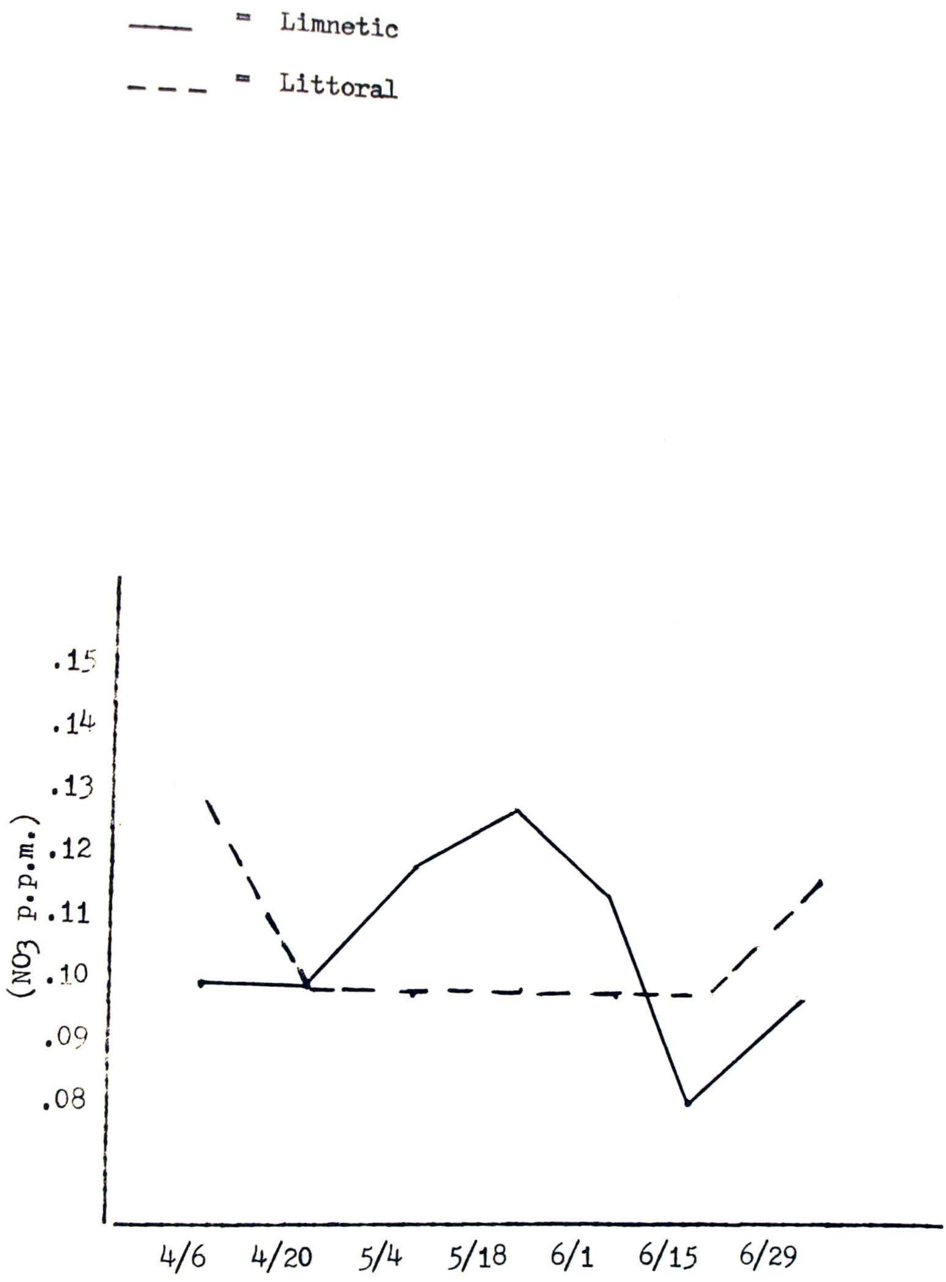


Figure 19. Nitrate-Nitrogen Concentration for Two Stations within the Woodland Pond.

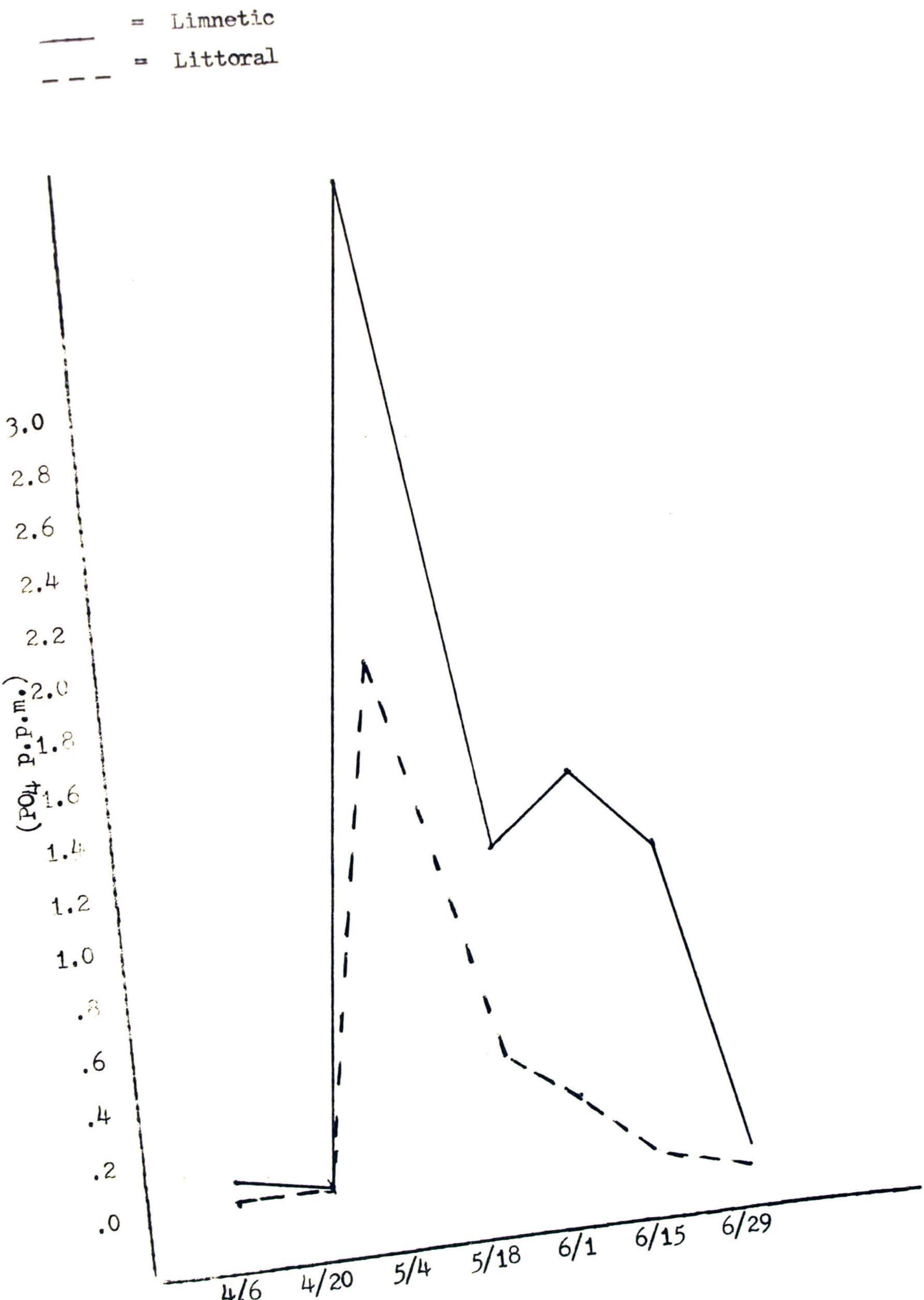


Figure 20. Ortho-Phosphate Concentration for Two Stations within the Woodland Pond.

CHAPTER VI

SUMMARY

A survey of selected physical, chemical and biological criteria on a woodland pond in Montgomery Bell State Park, Dickson, Tennessee, has been documented and evaluated.

The study began March 23, 1974, and extended to June 29, 1974. During this period the pond was sampled bi-weekly.

The pond was found to be of a permanent type, retaining varying amounts of water throughout the year. The pond, its basin a product of excavation, is considered a natural one due to the interaction of biotic and abiotic factors creating a seal.

Oxygen deficiencies were found in all but the uppermost level, and temperature variations were noted with depth.

Turbid conditions existed throughout the survey and correlations were noted between Secchi disc values and total dissolved solids. Rainfall was found to be average for the survey dates and water loss due to evaporation was noted.

Fluctuations in carbon dioxide, total hardness, hydrogen ion concentration, oxygen, nitrate and ortho-phosphate were noted. Consideration was given those values which suggested trends in the physio-chemical make-up of the pond. Excessively high readings for ortho-phosphate on May 4 were considered erroneous due to the oxidation of a chemical reagent used in determining these values.

There were twenty-eight genera accounted for during the study representing four animal phyla and two plant divisions. The animal phyla included Protozoa, Rotatoria, Arthropoda and Chordata. The plant divisions included Cyanophycophyta and Chlorophycophyta.

Only one population zone could clearly be described in the pond, the littoral zone. This zone consists of a region of shallow water where light reaches the bottom and rooted plants grow.

Morphometric data was collected for the pond including: maximum depth, length and breadth; shoreline length and development; surface area and volume; and mean breadth and depth.

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