P 9
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Pretty good
but
eutrophic?

Tuesday Lake and Long Lake
An Aquatic Study

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An aquatic ecosystem can be defined as the interaction between both the living communities and non-living components of freshwater bodies. This paper deals with the studies conducted at the University of Notre Dame Environmental Research Center located at Land-O-Lakes Wisconsin. The study commenced on July 25th, 1983 and continued through August 19th, 1983. Several different aspects of the lakes' ecosystems were considered, such as: water chemistry, zooplankton, phytoplankton, macrophyte, insect, reptile, amphibian, invertebrate, and fish populations of various lakes, streams, ponds and bogs on the UNDERC property.

The main objective of this paper is to compare and contrast two of the lakes on the UNDERC property, Tuesday Lake and Long Lake. Each lake will first be described separately, with a major emphasis on water chemistry, plankton populations and lake environs. Then the two lakes will be compared and contrasted with respect to these characteristics.

The water samples used in the chemical study of Tuesday and Long Lakes were taken with Kemmerers at varying depths. Several chemical tests were done on these samples in the lab.

The phytoplankton samples were obtained with Kemmerers in the epilimnion layer of each lake at the the same time the water chemistry samples were obtained. The zooplankton samples were obtained by taking three-minute plankton tows on each lake

with Wisconsin nets.

The plankton counts were taken from Sedgwick Rafter Cells. The purpose of the count was to determine what species are found in the lake and the relative proportion of each species.

Tuesday Lake is a relatively small lake with a surface area of 1.2 ha. It has a low surface-tovolume ratio. The depth recorded while taking the oxygen/depth/temperature readings was 14m. but depths have previously been recorded up to 20 m.

The lake is more or less oval in shape (see diag. #1) and is situated on relatively flat terrain. The lake is surrounded by a quite extensive Sphagnum mat and has abundant tamarack. Moving farther inland, highly stunted conifers can be found and beyond them, a hardwood forest prevails.

There does not seem to be any inflows from other lakes or streams into Tuesday. Presumably, it gets most of its water from rainfall and snowfall in the area. The lake drains into Bay Lake, beginning a flow chain which runs into Palmer Lake.

The water chemistry samples were obtained the morning of Tues., July 26th. The meterological conditions at the time of collection show a clear, sunny day, with an air temperature of 26°C and a water surface temperature of 25°C. The samples were taken from the center of the lake (although some drifting occurred during the collecting). The epilimnion sample was taken at a depth of 1 m. and the hypolimnion sample at a depth of 7 m.

The results of the chemical tests are shown in Table #1. The oxygen/ depth/temperature profile can be found in Table #2.

The temp/depth curve (shown in blue) shows a very steady drop in temperature . The depth of the epilimnion is small compared to the depth of the hypolimnion. The bottom temperature of the lake is 3°C. The oxygen/depth profile shows a very quick drop in the O_2 concentration at a depth of 1.5 to 2 m." There is an "oxygen bubble" present between the depths of 3-5 m. This "bubble" is termed a positive heterograde distribution. This may be caused by certain phytoplankton species that thrive at lower depths, producing photosynthetic oxygen in large quantities in a specific area. Another cause of this type of distribution could be an abundance of macrophytes growing in the littoral zone and producing oxygen that moves horizontally across the lake and becomes supersaturated at certain levels in the lake. This often occurs during the late summer in the metalimnion region.

The data from the plankton identification and counts are found in Table #3. The most abundant phytoplankton species in the lake are Asterionella and Eudorina. The most abundant zooplankton species are Keratella and Peridinium. There were two sweeps of the Sedgwick Rafter Cell made to obtain these results. There was a larger number and variety of phytoplankton than zooplankton present in the lake. The counts were 324 phyto- and 148 zooplankton.

Asterionella, a pennate diatom, is the dominant phytoplankton in Tuesday Lake. It is characteristic of eutrophic lakes and is auxoallotrophic which means it requires vitamins such as biotin, thiamin, and cyanocobolamin (B_{12}). The second

most abundant phytoplankton is Eudorina which is most likely to be found in ponds or shallow, fertile lakes. Anabaena, which is an important nitrogen-fixing organism, is characteristically found in productive lakes during the summer. Staurastrum, as will as Xanthidium, prefer dilute acid waters which are low in calcium and magnesium concentrations, or low total hardness. Williams (1969) characterized Staurastrum as an olgotrophic-lake species but evidence has been shown that a few species of this organism are present in productive aquatic environments. Dinobryon is noted for its low tolerance to excess phosphate in the ecosystem and the phosphate reading in Tuesday is not very high. Oocystis is a green algae which is found most abundantly in small ponds and productive lakes.

Keratella, the most abundant zooplankton present in Tuesday Lake, is most likely to occur in deep lakes. Studies done by Edmonson (1964) show that the reproductive rate of Keratella is temperature dependent. It usually reaches a maximum in reproductive activity in June, when temperatures are above 20° C. Keratella is one of the most common plankters in the temperate lake regions. Peridinium is another allauxotrophic species. The morphology of this planktonic species, which is small and flagellate, is important for the organism to come into contact with these essential vitamins dissolved in the water. Bosmina longirostris, found in Tuesday Lake, is often present in lakes that are passing form oligotrophy to eutrophy. The species of Ploesma found usually appear from April to the middle of October, reaching a maximum abundance in June and July.

There are several different factors to be considered when attempting to classify an aquatic ecosystem. Tuesday Lake is a deep lake with a small epilimnion to hypolimnion ratio. These factors are characteristic of oligotrophic lakes, However, if one considers the extensive Sphagnum mat, low Secchi disc reading, and practically non-existence of oxygen at the bottom of the lake, one would be inclined to label Tuesday a fairly productive lake. Not all characteristics of eutrophy are present, but most of the phytoplankton and zooplankton species in Tuesday are normally abundant in productive lakes. The extensive Sphagnum mat and stunted conifers suggest that the lake is developing into a bog lake.

But?

The presence of the Sphagnum moss on the periphery of the lake can be cited as an explanation for the low specific conductance of the lake, because this moss takes up hydrogen and metal ions. This, in turn, can explain the low acidity, alkalinity and hardness in the lake because all of these factors depend on ion concentrations.

The presence of 3 mg/l of sulfate in the hypolimnion can be a source of confusion because it really should read 0.0 mg/l. The presence of a strong rotten egg odor indicates that H_2S can be found in the hypolimnion. This H_2S is generated due to the lack of oxygen in the bottom of the lake. As soon as this H_2S comes in contact with atmospheric oxygen it is converted into sulfate. Therefore, there is actually not any sulfate in the hypolimnion and the reading should be regarded as insignificant.

When a comparison between the epilimnion and hypolimnion is made, the acidity, alkalinity, hardness, pH, and conductance are

all higher in the hypolimnion. This phenomenon can be related to the presence of Sphagnum moss which takes up ions in the epilimnion region only. The nitrogen and phosphate readings are also higher in the hypolimnion because the decomposition of organic materials that takes place here produces more free forms of these nutrients dissolved in the water as opposed to them being bound in organic molecules. This decomposition takes place in the hypolimnion because all the dead organisms sink to the bottom. When iron is in an anoxic condition, it is prevented from precipitating out of the solution. This explains why there is more dissolved iron in the hypolimnion, because there is less oxygen present in this region.

Tuesday Lake is tea-colored and the Secchi disc reading is quite low. There is presumably a large amount of humic acid present in the lake which can be attributed to eutrophic, productive lakes.

Tuesday Lake is essentially a mesotrophic lake but much closer to eutrophy than oligotrophy. The plankton that live in the lake are mainly eutrophic-lake species or they can only survive in environments with low hardness. Low hardness usually indicates oligotrophy but all the lakes in this region have low hardness because they are situated on igneous bedrock. Thus Tuesday is probably one of the more productive lakes on the UNDERC property.

It is important to consider the possibility of Tuesday developing into a bog. The Sphagnum mat is an excellent indicator of bog waters. The lake also possesses other qualities that are

characteristic of bogs: large depth, low concentration of nutrients, and few fish. The oxygen deficit at the bottom of the lake is an essential part of bog chemistry. This deficit retards the break-down of organic materials and is characterized by the presence of H_2S. The lack of apparent inflows may also be contributing to bog development because this will keep the lake in a more stagnant state and will also decrease the possibility of turnover. In fact, an air bubbler was used in Tuesday in the 1950's in order to destratify the lake.

Long Lake is a larger lake than Tuesday, with a surface area of 7.6 ha. It is dumbbell shaped with two basins on each end with depths of 14m. each and a shallower region with a depth of 5m. connecting the two basins. It has a larger surface-to-volume ratio than Tuesday. Surrounding the lake are several species of shrubs, tamarack and conifers, with a hardwood forest farther inland. Several patches of lily pads can be found growing in the littoral zone of the lake. The fish population consists mainly of large and smallmouth bass with a smaller population of perch. The two species of bass are believed to exhibit some species partitioning. Long can be characterized as a seepage lake because there are no apparent inflows or outflows.

The water chemistry and plankton data was obtained on July 27th, 1983 in the morning hours. The meterological conditions were quite favorable: it was a warm, sunny day with an air temperature of 25° C and a water surface temperature of 25° C.

Oxygen/temperature/depth readings were taken at three different sites on the lake (as seen in Diag. #2); one in each basin region and a third in the shallower, central area of the lake. Water samples were collected from the epilimnion at a depth of 1 m. and from the hypolimnion at a depth of 11m. The oxygen profiles (found in Table #4) of sites #1 and #2 are quite similar as are the temperature curves. Site #3, because it is shallower, contains an abundance of oxygen even at the deepest point.

Two sweeps of the Sedgwick Rafter Cell reveal a more diverse and larger population of zooplankton than of phytoplankton. The dominant phytoplankton is Synura and zooplankton is Keratella. Synura is characteristic of oligotrophic lakes, of dilute unproductive waters. It is also an alloauxotrohpic species which requires certain vitamins. Asplanchna feed on Keratella. Holopedium gibberellum is often found in soft water lakes with a Calcium content less than 10 mg/l which is the case in Long. Eubosmina are found in less productive lakes than Bosmina, which is found in Tuesday.

The shape and varying depths of different regions in Long suggest that the lake may be in the process of dividing to form two very similar lakes. Because it is a seepage lake there is not a large amount of waterflow through the lake so the narrow sides of the middle section may easily close to form two lakes at each basin.

Each basin is very similar with respect to the chemical data as well as environment. Looking at the data, one sees very little variation between the two basins in both the epilimnion and hypolimnion. Unfortunately, water samples were not collected

from site #3. There are higher values of acidity, alkalinity, hardness, pH, concentrations of nitrogen, phosphate and iron in the hypolimnion region as compared to the epilimnion region due to bacterial decomposition in the hypolimnion and the uptake of nutrients by plants in the epilimnion. As in Tuesday there are false sulfate readings which show up in the lab tests due to exposure of the anoxic water to atmospheric oxygen.

Long Lake is a relatively clear lake, exhibiting a high secchi disc reading and is quite deep.. There is a steep drop in depth in the littoral zone. There is a poor concentration of phytoplankton and low hardness, acidity, alkalinity, conductance, and nutrient concentration. Many of the species of plankton present are often found in oligotrophic lakes. All of these qualities indicate that Long is an oligotrophic lake. However, the presence of a significant amount of macrophytes suggests productivity. Long is a mesotrophic lake but very close to oligotrophy.

The lakes on the UNDERC property are situated on igneous rock, with little or no limestone present. This is a reason for the low hardness of these lakes and the low concentration of dissolved salts. The lakes probably originated from the retreat of the glaciers at the end of the ice age and are glacial-lake basins. They are temperate (dimictic) lakes which usually undergo turnovers in spring and autumn and are stratified during the summer and winter.

Tuesday Lake's environs differ somewhat from Long's. Tuesday has a sphagnum mat and stunted conifers whereas Long has many shrubs and healthy conifers. The shapes and surface

areas of the two lakes are quite different.

Tuesday is slightly more acidic than Long but their alkalinities are the same. The total hardness in Tuesday's hypolimnion is higher than in Long. The iron readings are only slightly higher in Long, and the lakes have almost identical pH. The phosphate readings are much higher in Tuesday than Long. Tuesday also exhibits a much larger and more diverse phytoplankton and macrophyte population than Long does. Long is a much clearer lake than Tuesday which can be seen by comparing the secchi disd readings.

Both lakes exhibit oxygen deficits in the hypolimnion. The H_2S found in the epilimnion of Long does not make sense because there is oxygen present at this depth and the phytoplankton should have been photosynthesizing at that time of day. A cause for this oxygen deficit could be that the zooplankton out-number the phytoplankton by so much that they use up the photosynthetic oxygen by respiring faster than the phytoplankton can produce it. Tuesday did not show the presence of H_2S in the epilimnion but it has a much larger number of phyto- than zooplankton.

Were you above the thermocline for sure?

The fish populations of the lakes are quite different. Tuesday has only minnows as an abundant species but Long has a larger and more diversified population of fish. There exists almost totally different species of plankton in each lake with the exception of Keratella and Actinastrum. This fact illustrates the fact that Tuesday and Long are quite different communities.

In summary, Long and Tuesday are two different types of aquatic ecosystems. The former possesses many of the qualities of oligotrophic lakes while the latter can be described as closer to eutrophy? Differences can be seen in environment and populations of macrophytes, plankton and fish. The water chemistry does not differ widely but some small distinctions can be made between the two lakes. The distribution and types of organisms may prove to be more reliable in this study because most of the lakes in this area have somewhat similar chemistries, i.e. low acidity, alkalinity, conductance and nutrient concentrations. This can be related to the fact that the lakes lie on igneous rock bed.

The aquatic ecosystem is a delicately balanced environment which strives to keep itself operating at the most efficient rate in spite of the many forces acting to destroy it. A good understanding of lake environments can be aquired through intensive study of the different aspects of lakes. An ideal location in which to do this is on the UNDERC property because there is excellent opportunities for comparison between lakes. This was a fantastic way to spend a summer!

TUESDAY LAKE: DIAGRAM #1

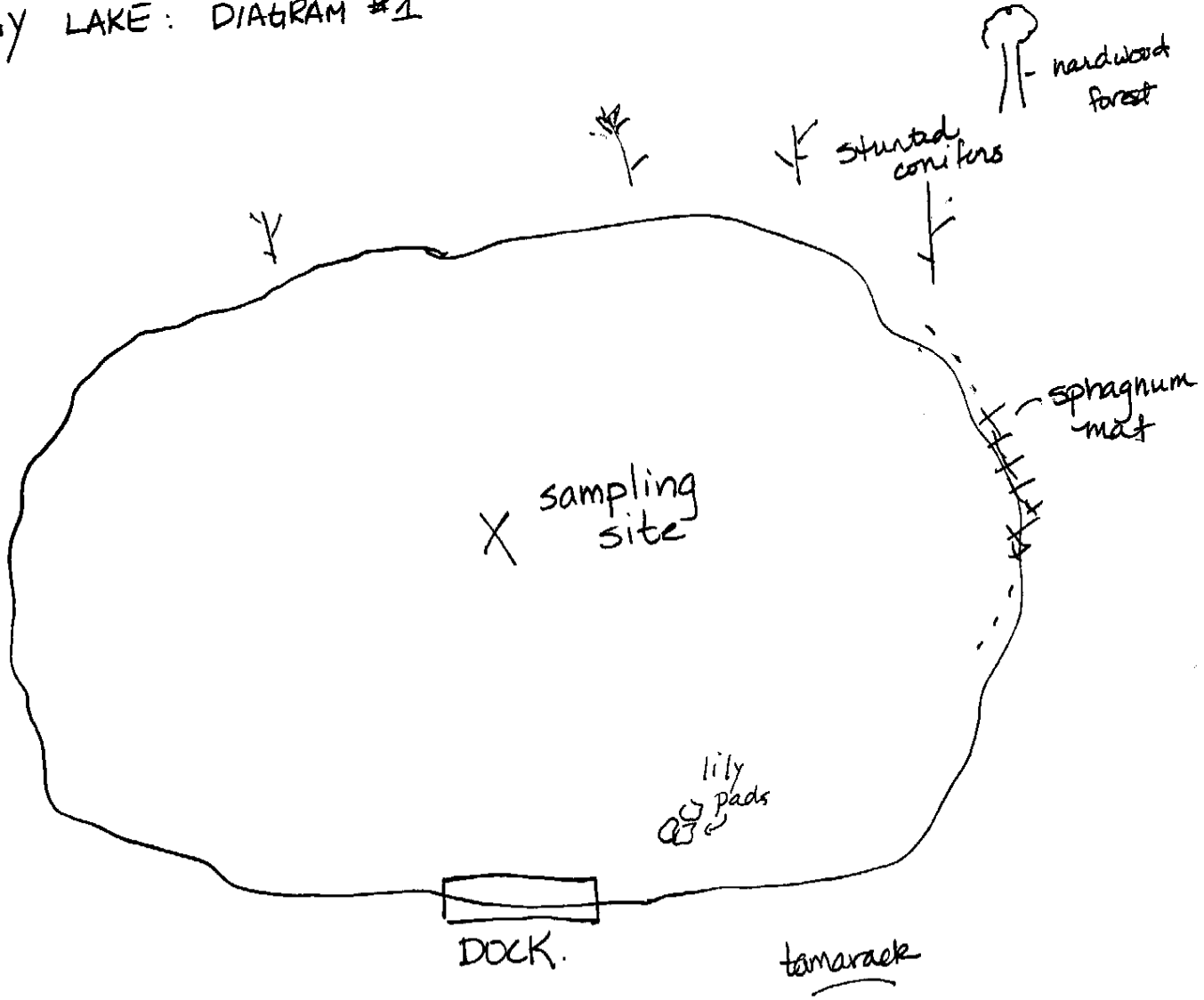


TABLE #1

TUESDAY LAKE : WATER CHEMISTRY DATA

TEST	EPILIMNION	HYPOLIMNION
1) Acidity		
methyl orange-	0.0 mg/l	0.0 mg/l
phenolphalein-	20 mg/l	30 mg/l
2) Alkalinity	10 mg/l	15 mg/l
3) Hardness		
Ca^{++}-	10 mg/l	10 mg/l
Mg^{+}-	0.0 mg/l	20 mg/l
Total-	10 mg/l	30 mg/l
4) Iron	.08 mg/l	.72 mg/l
5) Nitrogen, Nitrate	0.5 mg/l	0.5 mg/l
6) pH	6.1	5.4
7) Phosphate, Total	0.35mg/l	0.39mg/l
8) Specific Conductance	19 μmhos/cm	20.25 μmhos/cm
9) Sulfate	0.0 mg/l	3 mg/l
10) H_2S	-----	present

11) Secchi disc - 1.6 m.

OXYGEN/TEMPERATURE/DEPTH PROFILE:

DEPTH	TEMP. (° C)	PPM (O_2)
0	25	6.2
1	24	6.1
2	20	1.5
3	10	1.1
4	6.5	1.8
5	4.5	.9
6	4	.6
7	3	.6
8	3	.6
9	3	.6
10	3	.5
11	3	.5

TUESDAY LAKE : water chemistry TABLE #2

oxygen / temperature profile:

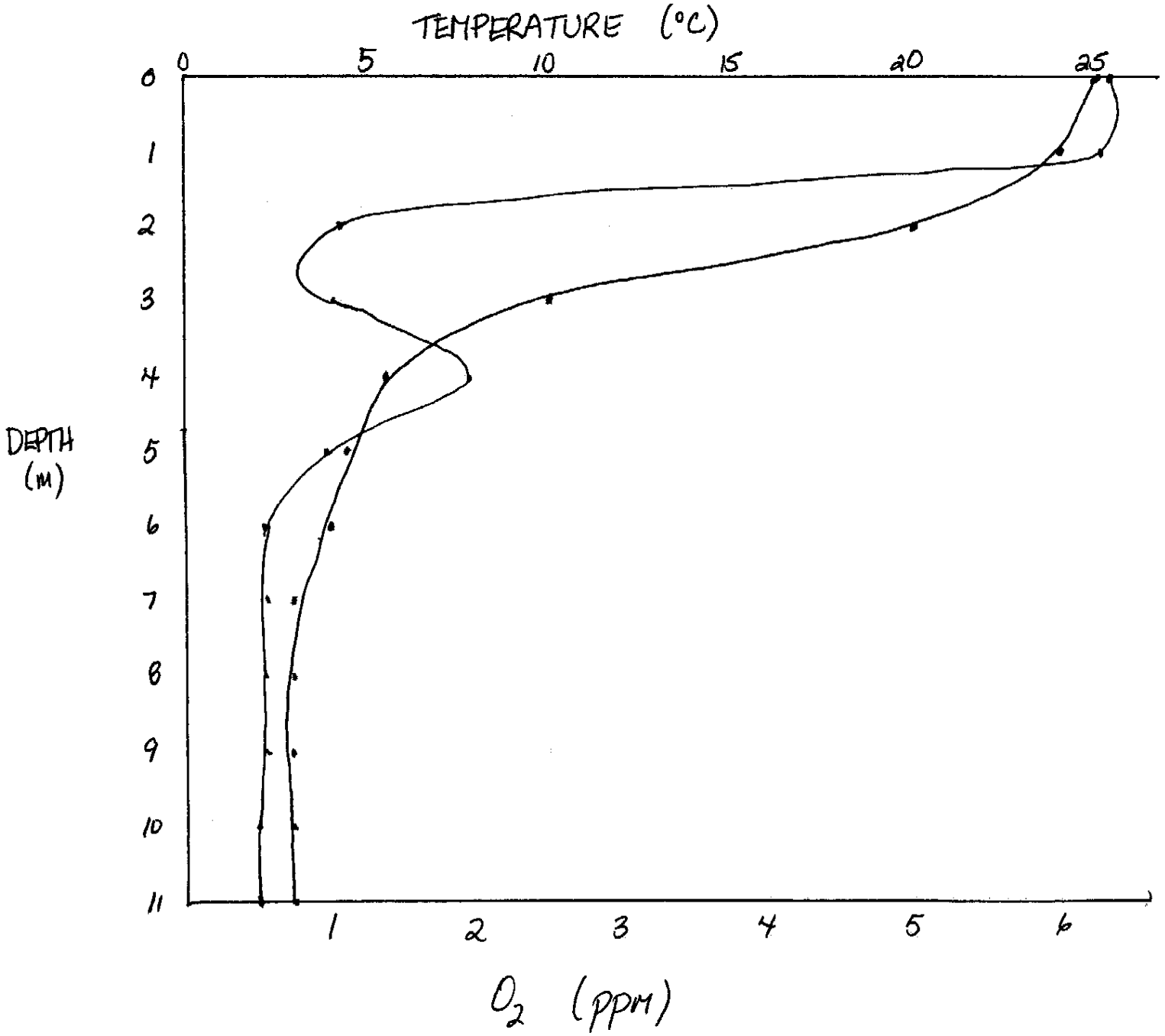


TABLE #3

TUESDAY LAKE: ZOOPLANKTON AND PHYTOPLANKTON COUNTS

PHYTOPLANKTON	NO. COUNTED
Asterionella	181
Eudorina	120
Anabaena	6
Actinastrum	4
Staurastrum	7
Dinobryon	2
Xanthidium	2
Desmidium	1
Oocystis	1
Total	324

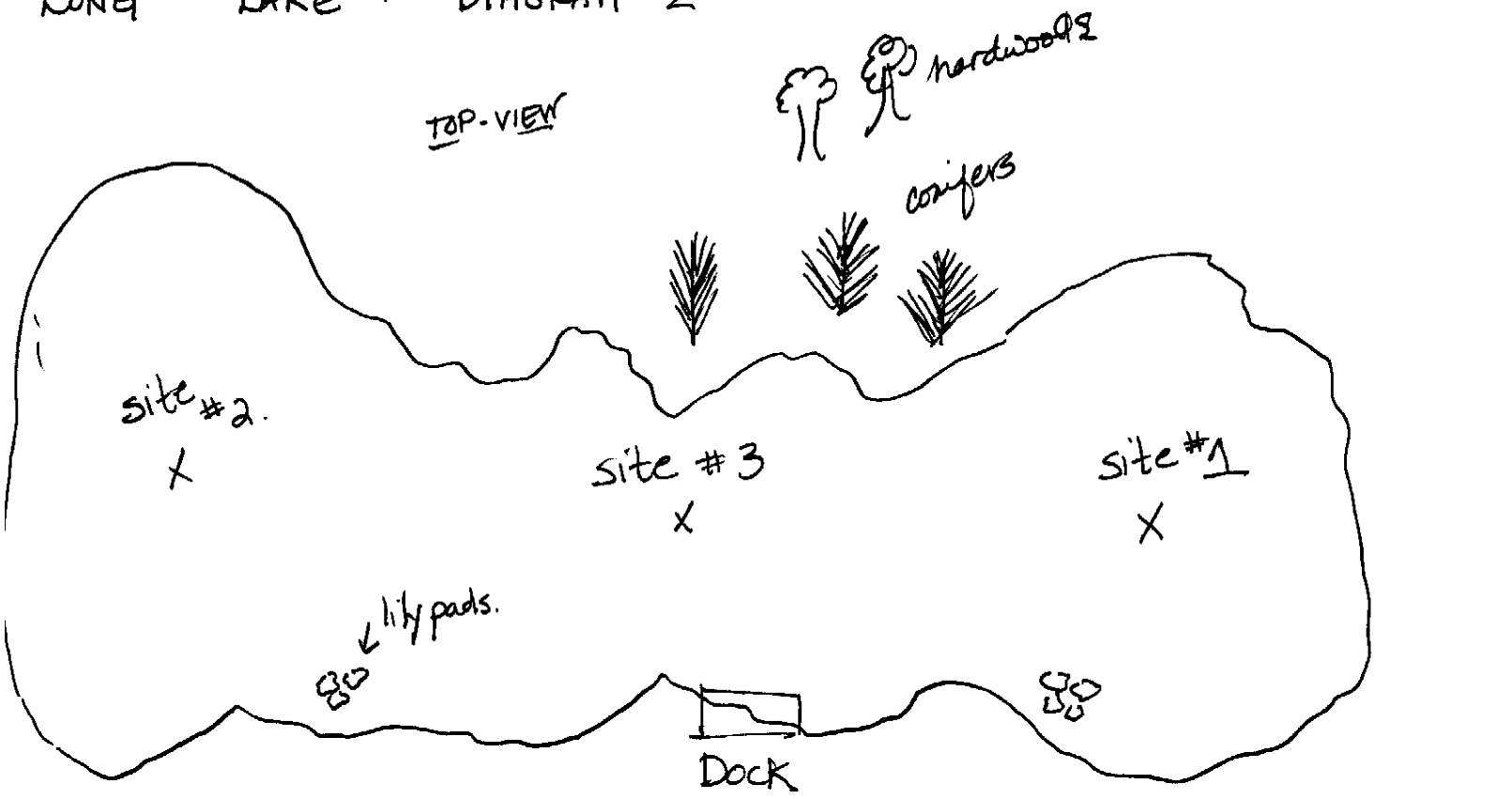
ZOOPLANKTON	NO. COUNTED
Keratella	63
Peridinium	53
Ploesma	16
Polyarthra	5
Eucyclops	4
Bosmina	3
Total	148

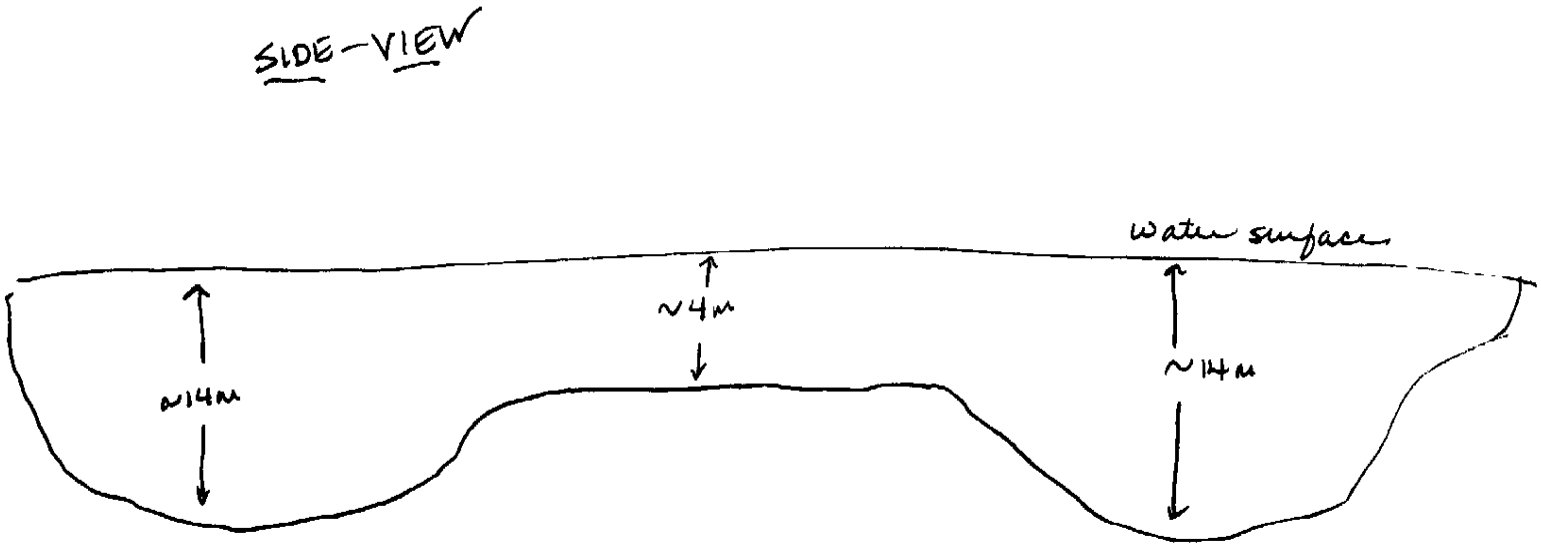
LONG LAKE:

Synura	166
Actinastrum	2
Diaptomus	1
Gomphosphaeria	1 (colony)
Total	170

Keratella	230
Nauplius	25
Holopedium gibberium	22
Asplanchna	6
Paracyclops	6
Trichocerca	6
Eubosmina	5
Ceratium Hirundinella identified but none counted from cell	
Total	300

LONG LAKE : DIAGRAM #2

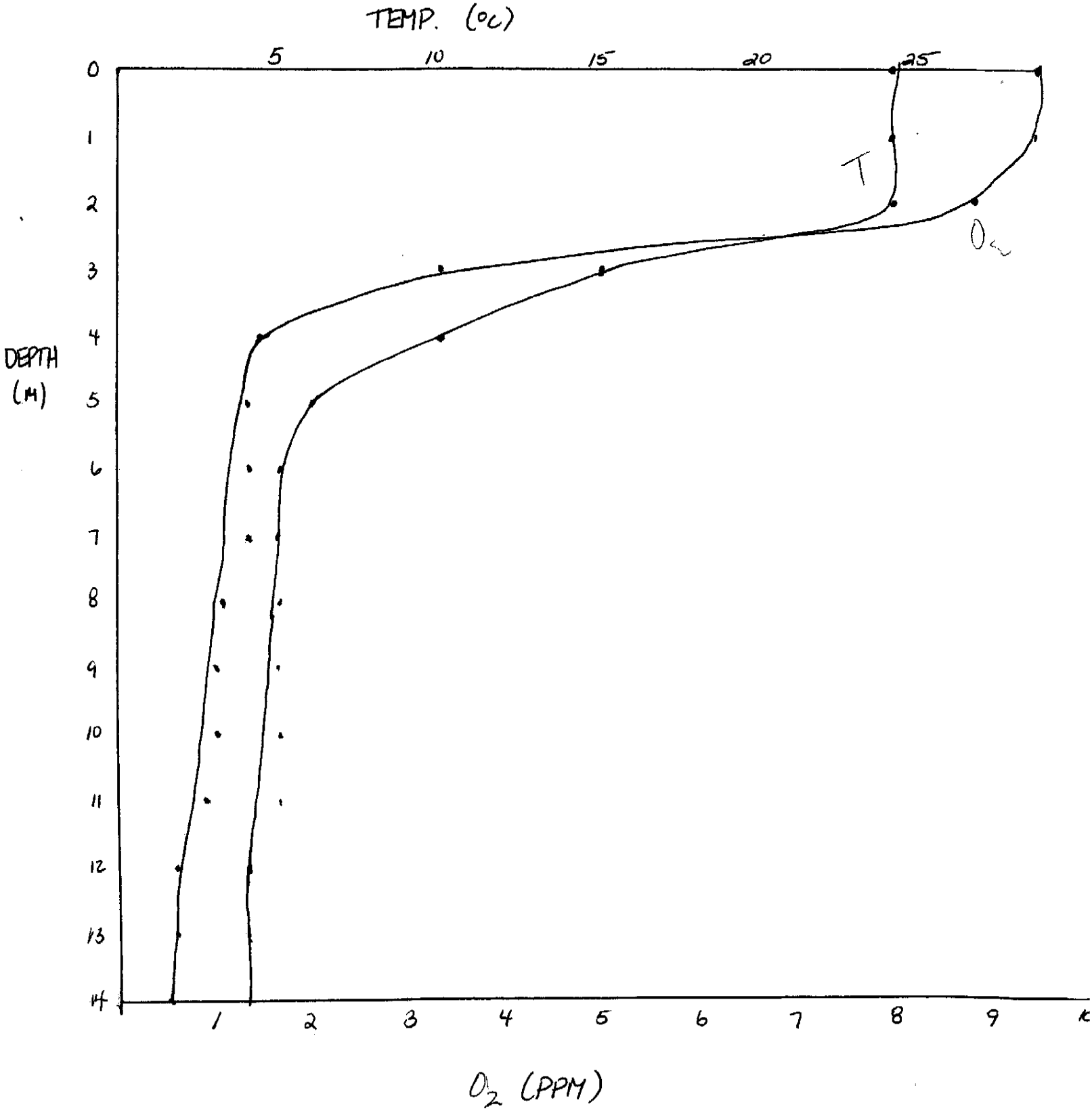




LONG LAKE: water chemistry TABLE #4

oxygen/temperature profile:

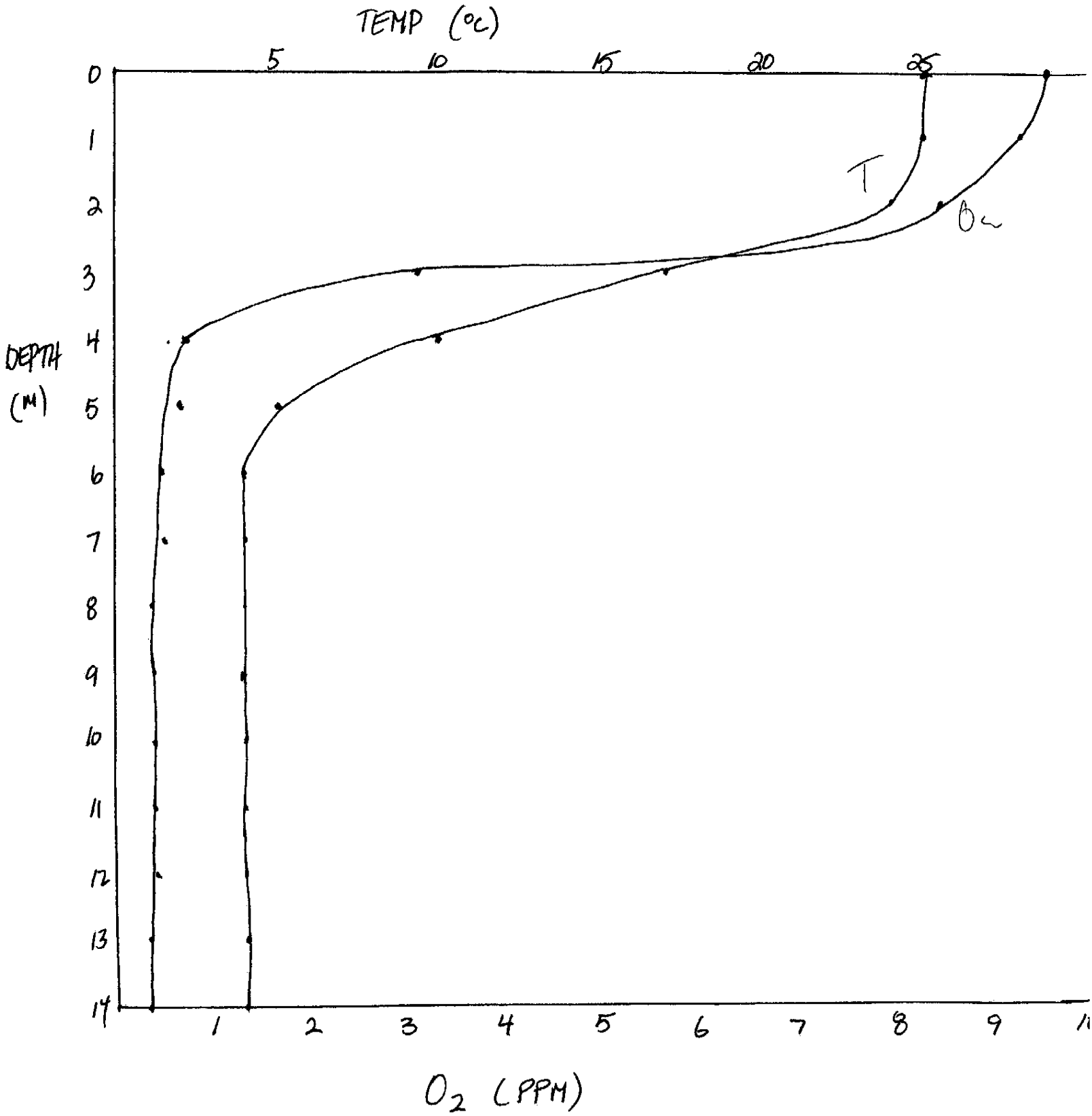
SITE #1



LONG LAKE: water chemistry TABLE #4

oxygen / temperature profile:

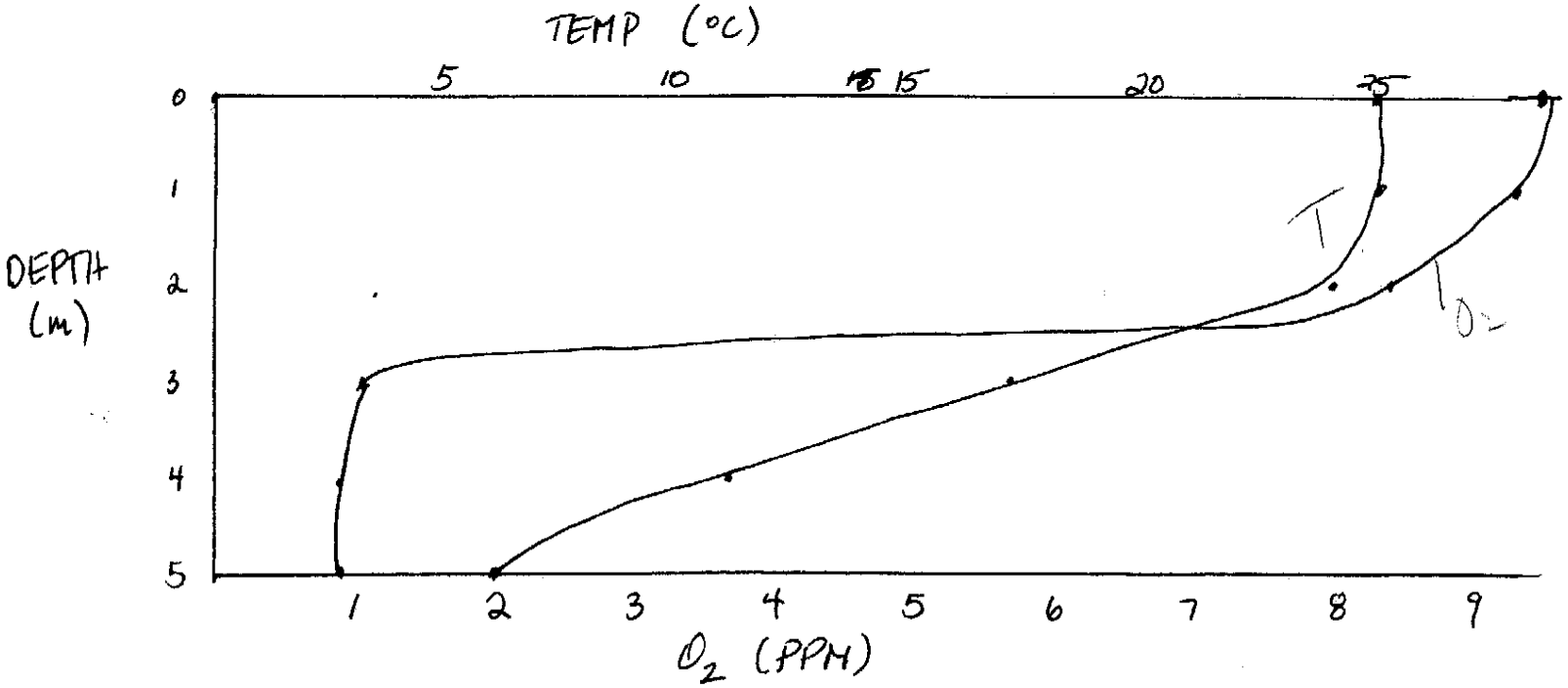
SITE #2



LONG LAKE : water chemistry TABLE #4

Oxygen/temperature profile

Site #3.



DEPTH	SITE #1 (°C) TEMP	SITE #1 (PPM) O_2	SITE #2 (°C) TEMP	SITE #2 (PPM) O_2	SITE #3 (°C) TEMP	SITE #3 (PPM) O_2
0	24	9.5	26	9.7	25	9.5
1	24	9.5	25	9.3	25	9.0
2	24	8.5	24	8.5	24	8.4
3	15	3.3	17	3.1	17	1.1
4	10	1.4	10	.7	11	.9
5	6	1.3	6	.6	6	.9
6	5	1.3	5	.5		
7	5	1.3	4	.5		
8	5	1.1	4	.4		
9	5	1.0	4	.4		
10	5	1.0	4	.4		
10	5	.9	4	.4		
12	4	.7	4	.4		
13	4	.7	4	.3		
14	4	.5	4	.3		

LONG LAKE : WATER CHEMISTRY DATA SITE#2

TEST	EPILIMNION	HYPOLIMNION
1) Acidity		
methyl orange-	0.0 mg/l	0.0 mg/l
phenolpthalein	15 mg/l	30 mg/l
2) Alkalinity	10 mg/l	20 mg/l
3) Hardness		
Ca^{+}-	10 mg/l	5 mg/l
Mg^{+}-	0.0 mg/l	5 mg/l
Total-	10 mg/l	10 mg/l
4) Iron	0.09 mg/l	1.2 mg/l
5) Nitrogrn, Nitrate	0.75 mg/l	1.5 mg/l
6) pH	6.0	5.8
7) Phosphate, Total	.07,.13,.18 ave. .13 mg/l	.3, .33, .34 ave. .32 mg/l
8) Specific Conductance	21 μmhos/cm	25 μmhos/cm
9) Sulfate	3 mg/l	4 mg/l
10) H_2S	present	present
11) Secchi disc- 2.2m.		

depth

LONG LAKE : WATER CHEMISTRY DATA SITE #1

TEST	EPILIMNION	HYPOLIMNION
1) Acidity		
methyl orange-	0.0 mg/l	0.0 mg/l
phenolphalein-	15 mg/l	25 mg/l
2) alkalinity	10 mg/l	15 mg/l
3) Hardness		
Ca^{+}-	10 mg/l	10 mg/l
Mg^{+}-	0.0 mg/l	0.0 mg/l
Total-	10 mg/l	10 mg/l
4) Iron	0.09mg/l	0.75 mg/l
5) Nitrogen, Nitrate	0.75mg/l	1 mg/l
6) pH	6	5.8
7) Phosphate, Total	.03,.08,.15 ave.-.09mg/l	.21,.25,.36 ave.- .28 mg/l
8) Specific Conductance	21 μmhos/cm	24 μmhos/cm
9) Sulfate	2 mg/l	3 mg/l
10) H_2S	present	present
11) Secchi Disc	2m.	