UNDERC '81 REVISITED

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GENERAL DESCRIPTIONS

Kickapoo Lake

Kickapoo Lake slopes slightly and is fed on its north end from Emeline Lake and on its west end from Plum Lake. Kickapoo drains at the southeast corner through Brown Creek. Fish populations of muskellunge, yellow perch, crappie, and northern pike have been reported. The lake is relatively shallow with a depth of just over 3 meters. A large percentage of the trees to the east and northeast of the lake are white birch; conifers appear on the west shore. Marshy grasses or reeds grow along the perimeter of the lake, and water lily is also floating there. Because of the rather extensive surrounding marshes, Kickapoo is a relatively open area.

Beaver Bog

Beaver Bog is very well protected, surrounded mostly by conifers and some hardwood trees. There is a large *Sphagnum* mat encircling the bog, upon which were found pitcher plants. Beaver Bog is relatively small, measuring approximately 15m x 50m. It is also a seepage lake, having neither an inlet nor an outlet.

Peter Lake

Peter Lake is surrounded on the south and west by hardwoods, while conifers inhabit the north and east edges. Peter is fed by the smaller Lake Paul through a culvert, and in turn drains into the Cisco Chain through several small streams originating at its northern shore. A *Sphagnum* mat encircles much of the lake. Cattails were also found to be present. Largemouth bass are prevalent in the lake.

Peter and Paul lakes were part of a study done to determine the effects of lime on lake metabolism. The experiment involved liming

Peter Lake extensively between 1951 and 1954, keeping Paul as a control. In the study, Stross and Hasler found that the addition of lime effectively changed the water chemistry and community structure of Peter. Since then the lake has been intermittently limed to the present time.

Paul Lake

At one time Peter and Paul were parts of the same lake separated by only a shallow canal, which was later dammed providing a road between the two bodies of water. The culvert was maintained allowing Paul to drain into Peter and finally into the Cisco Chain. Hardwood primarily surrounds the west side of Paul, while conifers are found on the east side. The beginning of a Sphagnum mat may also be seen around the edges of Paul.

Bergner Lake

Bergner is one of the larger lakes on the Notre Dame Property. It is relatively shallow except for a deep hole in the southeast corner of the lake, where the water chemistry sample was taken. The immediate surrounding area is covered with shrubs, leaving it open, while the forest back from the lake is mostly coniferous. Bergner drains into Tenderfoot Creek via Firestone Lake. In the 1950's some 750 bass were planted in the lake. Yellow perch are also found there.

Tender Bog

Tender Bog is well protected by conifers. Around its edges is a significant Sphagnum mat. The bog is approximately 15m x 40 m, with a depth of about 15m. Although it is a typical bog with respect to the kettleshape, it is atypical in that it is drained by a small rivulet located in the southwest corner of the bog.

WATER CHEMISTRY DATA

Kickapoo Lake

	1m	2.5m
Acidity (mg/l)	30	20
pH	5.5	5.5
Alkalinity (mg/l)	23	29
Ca Hardness(mg/l)	27	30
Mg Hardness(mg/l)	13	20
Total Hardness(mg/l)	40	50
Nitrates (mg/l)	.4	.3
Sulfate (mg/l)	9.5	2.5
Conductivity umhos/cm	45	45
H_2S	---	---
Color reading units Apparent	80	115
True	75	90
Secchi Disc	1.8m	

Air temperature 16.8°

Depth m	Temperature °C	O_2 (ppm)
Surface	17.1	8.8
1	17.0	8.6
1.5	17.0	8.6
1.75	16.2	7.2
2	15.2	6.0
2.25	14.5	3.8
2.5	14	.7
3	14	0.0

WATER CHEMISTRY DATA

Beaver Bog

	.75m	3m
Acidity (mg/l)		
Methyl Orange	10	10
Phenolphthalein	190	300
pH	4.9	4.9
Alkalinity (mg/l)	0	0
Ca Hardness (mg/l)	2.5	5.5
Mg Hardness (mg/l)	2.5	3.5
Total Hardness(mg/l)	5	9
Nitrates (mg/l)	.8	.7
Sulfate (mg/l)	2.75	2.5
Conductivity umhos/cm	24	27
H_2S	---	YES!
Color reading units		
Apparent	185	240
True	165	210
Secchi Disc	1.25m	

Air temperature 25° / O_2 - 9.4 ppm

Depth m	Temperature °C	O_2 (ppm)
Surface	19	6.8
1	12.5	0.0
2	4.4	0.0
3	4.0	0.0

WATER CHEMISTRY DATA

Peter Lake

	1m	3.5m	8m
Acidity (mg/l)	50	60	60
pH	5.2	5.5	5.5
Alkalinity (mg/l)	25	20	40
Ca Hardness (mg/l)	10	15	20
Mg Hardness (mg/l)	5	4	1
Total Hardness (mg/l)	15	19	21
Nitrates (mg/l)	.7	.8	.8
Sulfate (mg/l)	1	3.0	3.0
Conductivity umhos/cm	36	37	42
Color reading units			
Apparent	55	55	55
True	55	55	55
Secchi Disc		5.1m	

Air temperature 24°

Depth m	Temperature °C	O_2 (ppm)
Surface	19.5	10.5
1	18.5	9.8
2	17.8	9.8
3	15.2	11.8
4	12.5	11.0
5	9.5	8.4
5.5	8.0	6.2
6	7.3	2.4
7	6.0	0.0
8	5.3	0.0
9	5.0	0.0

WATER CHEMISTRY DATA

Paul Lake

	1m	3.5m	7m
Acidity (mg/l)	50	47	47
pH	5.5	5.5	5.5
Alkalinity (mg/l)	0	0	0
Ca Hardness (mg/l)	5	7.5	7
Mg Hardness (mg/l)	3	1.5	5
Total Hardness (mg/l)	8	9	12
Nitrates (mg/l)	.9	.9	.8
Sulfate (mg/l)	1.5	3.0	2.5
Specific Conductance	17.5	18	28
Color reading units			
Apparent	65	50	80
True	65	50	80
Secchi Disc		3.4m	

Air temperature 23°C O_2 ppm - 9.2

Depth m	Temperature °C	O_2 (ppm)
Surface	19.0	9.4
.5	18	9.8
1	17.8	9.7
2	16	10.6
3	12	12
3.5	8.8	12.8
4	8	12.4
4.5	6.2	9.8
5	6.5	2.4
6	5.2	1.8
7	4.5	1.8
8	4.2	1.8

WATER CHEMISTRY DATA

Bergner Lake

	1m	7m
Acidity (mg/l)		
Methyl Orange	10	10
Phenolphthalein	60	80
pH	5.0	5.0
Alkalinity (mg/l)	0	0
Ca Hardness (mg/l)	7	10
Mg Hardness (mg/l)	3	7.5
Total Hardness (mg/l)	10	17.5
Nitrates (mg/l)	.6	.7
Sulfate (mg/l)	10.0	19.5
Specific Conductance	33	120
Color reading units		
Apparent	77.5	77.5
True	60	57.5
Secchi Disc	2.6m	

Air temperature 23°

Depth (m)	Temperature(°C)	O_2 (ppm)
Surface	18.7	9.3
1	18.6	9.2
2	17.5	8.7
2.5	17.0	7.7
3	13.5	6.2
4	11.0	4.3
5	9.5	4.0
6	8.8	4.0
7	7	2.7
8	6.3	2.2
9	6.3	1.5
10	6.2	0.0
11	6.2	0.0

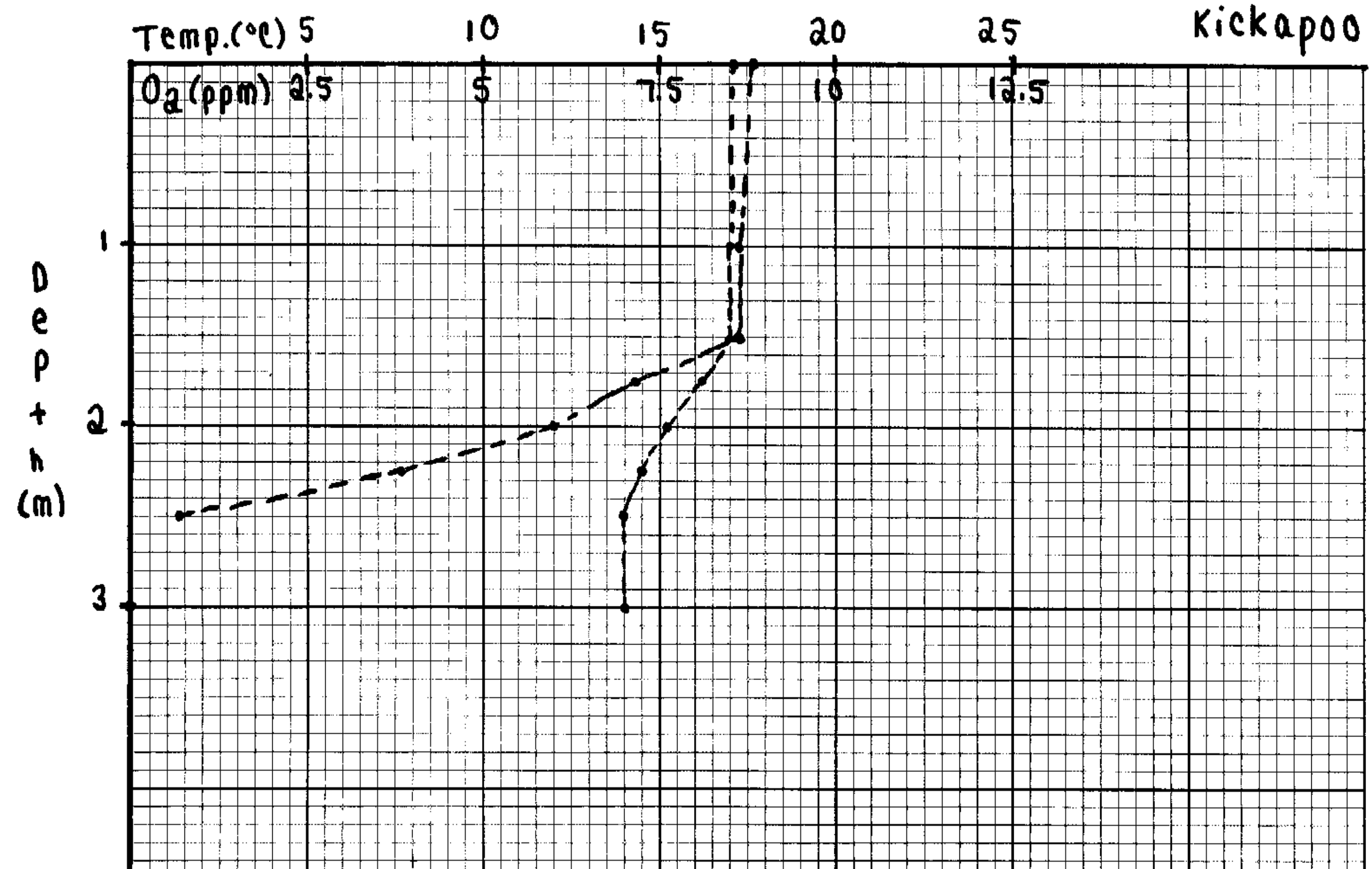
WATER CHEMISTRY DATA

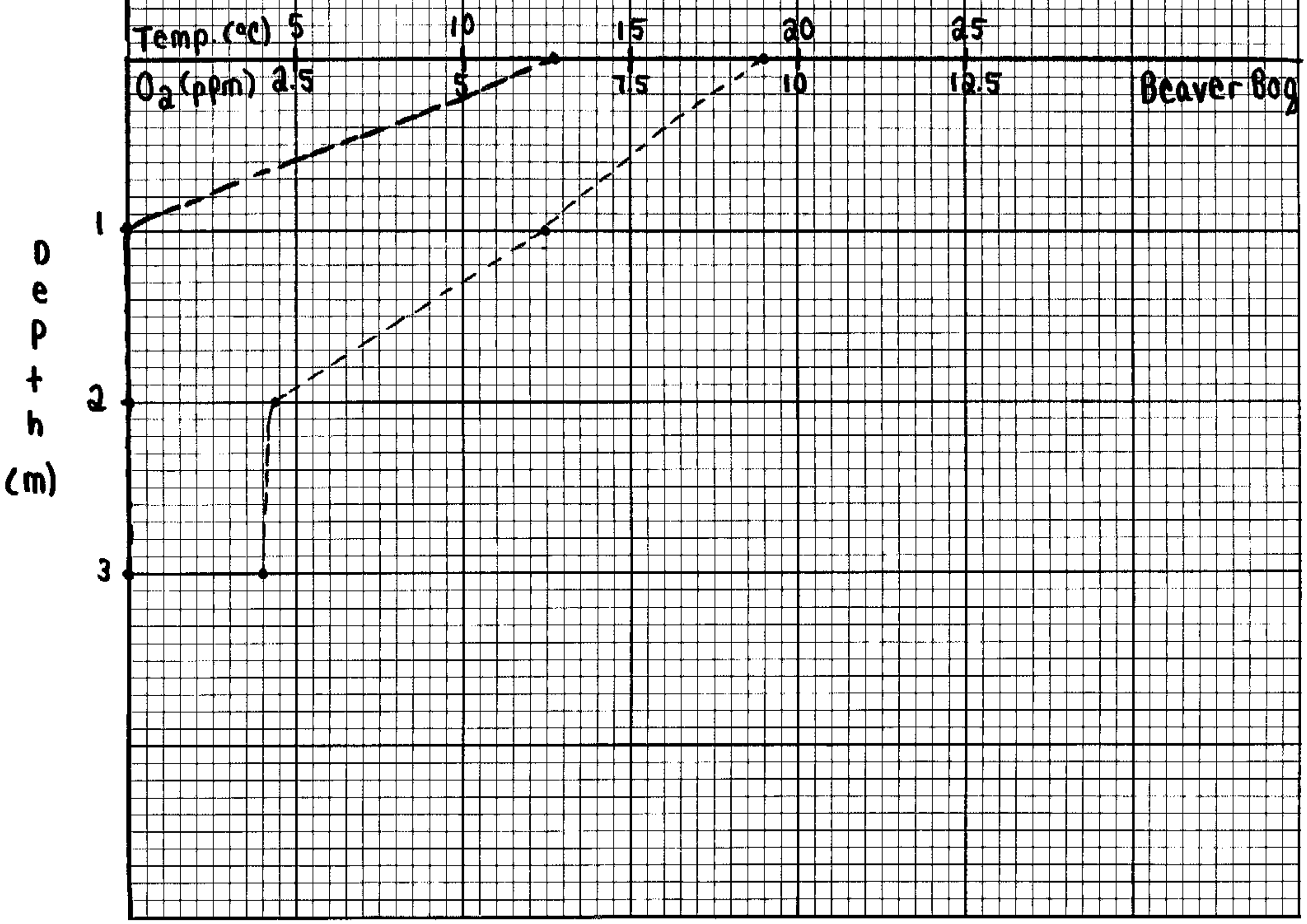
Tender Bog

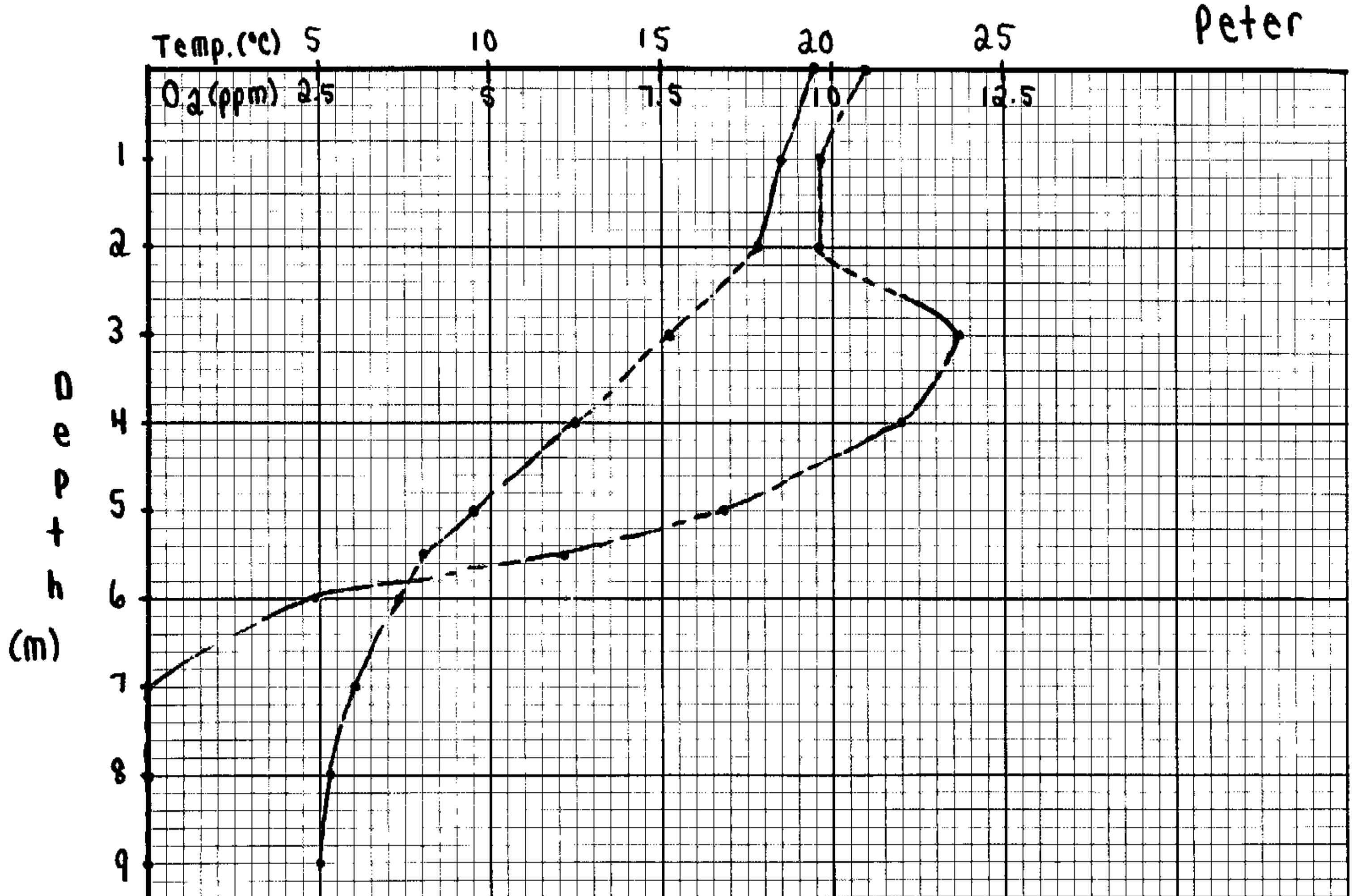
	1m	3m
Acidity (mg/l)	115	115
pH	4.5	4.5
Alkalinity (mg/l)	0	0
Ca Hardness (mg/l)	5	5
Mg Hardness (mg/l)	15	15
Total Hardness (mg/l)	20	20
Nitrates (mg/l)	.8	.9
Sulfate (mg/l)	0	0
Specific Conductance	62	30
Color reading units		
Apparent	190	190
True	190	190
Secchi Disc	1.5m	

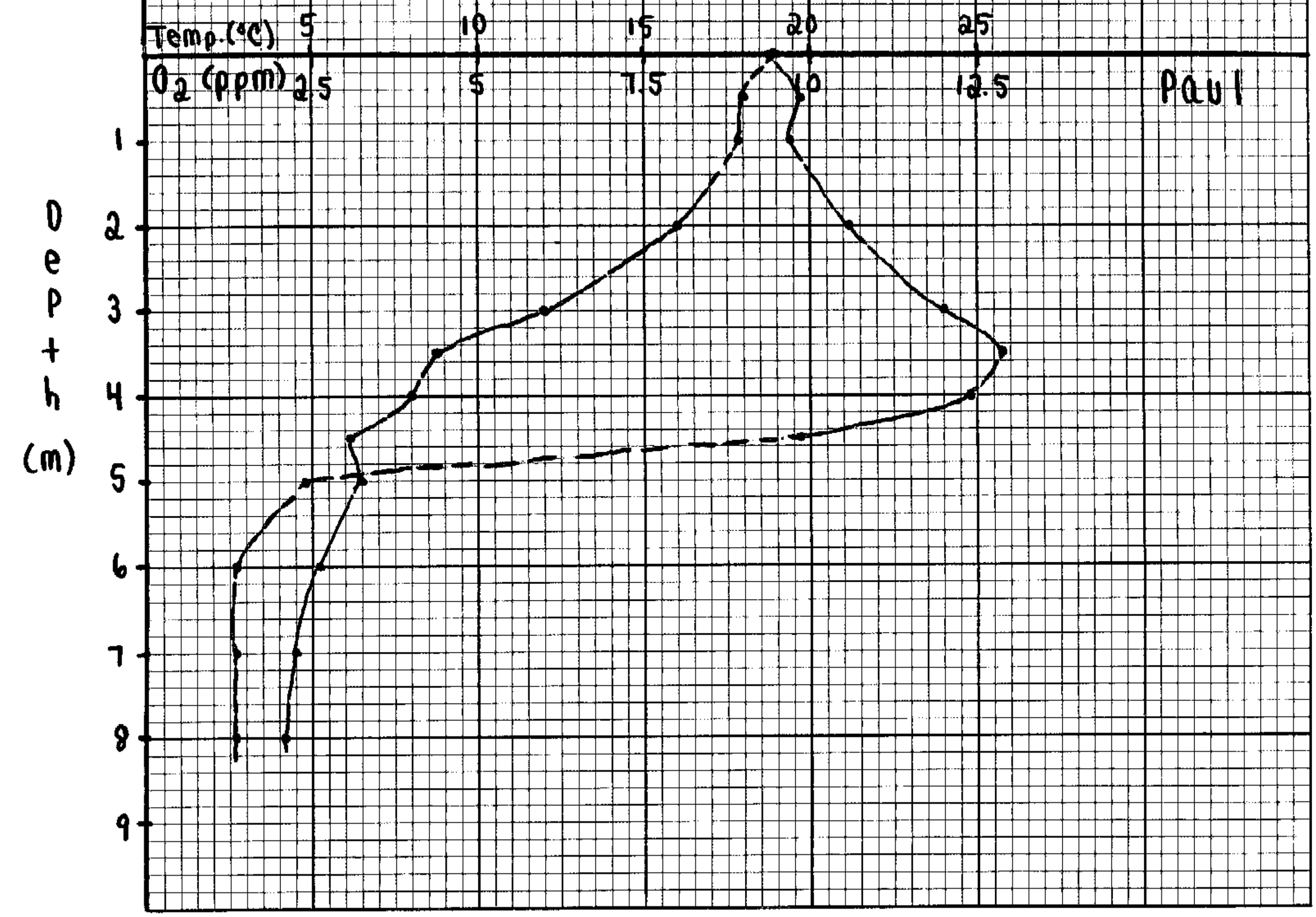
Air temperature 25° O_2 ppm 8.4

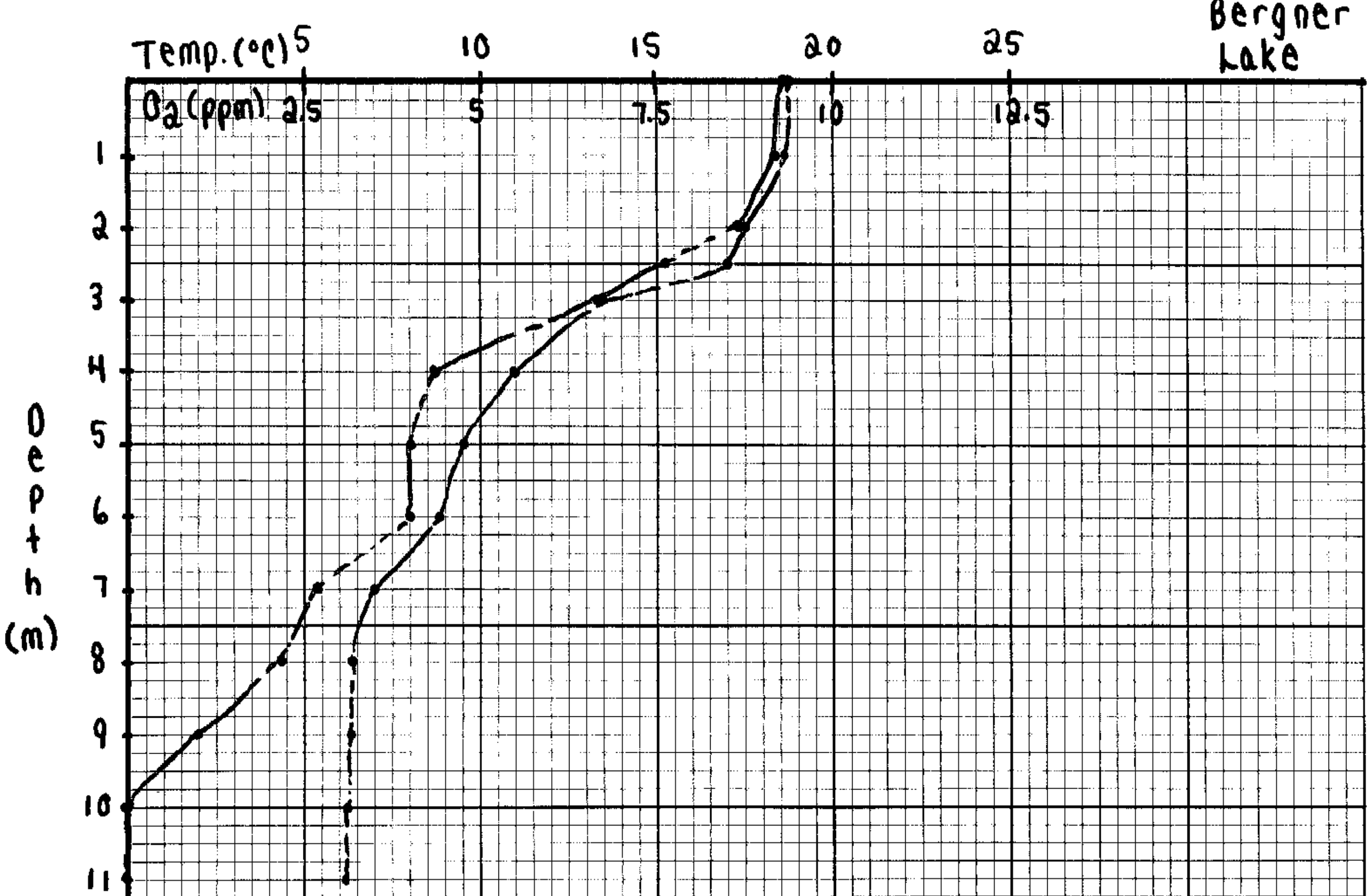
Depth m	Temperature (°C)	O_2 (ppm)
Surface	16.8	4.5
.25	16.3	4.3
.5	14.8	2.6
.75	13.6	2.5
1	11.3	2.3
1.5	7.5	1.2
2	5	0.7
3	4	0.6
4	4	—

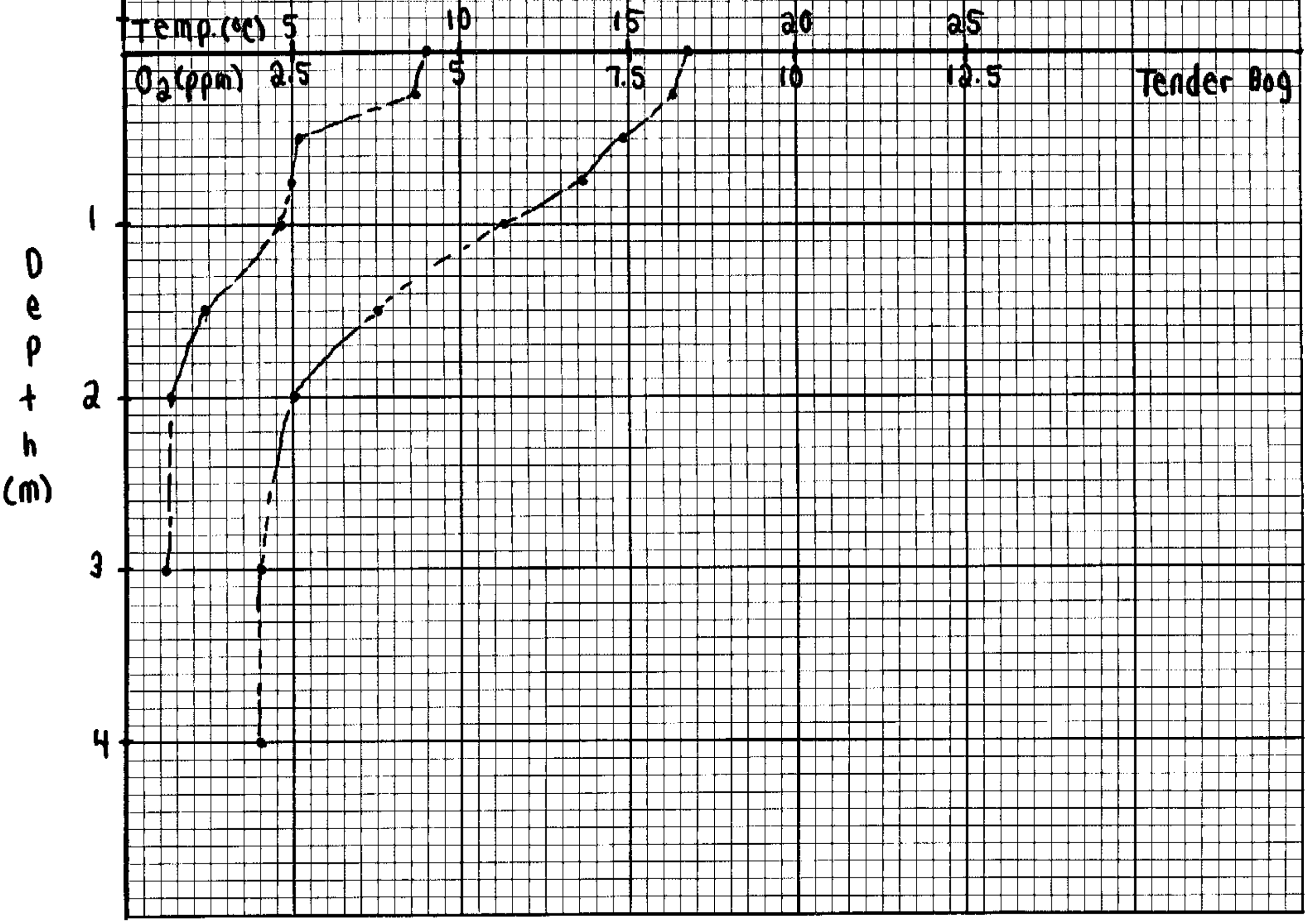

Kickapoo
Temp.(°C) 5 10 15 20 25
O_2(ppm) 2.5 5 7.5 10 12.5
Depth (m)
1
2
3


Temp.(°C) 5 10 15 20 25
O_2(ppm) 2.5 5 7.5 10 12.5
Beaver Bog
Depth (m)
1
2
3


Peter
Temp. (°C) 5 10 15 20 25
O_2 (ppm) 2.5 5 7.5 10 12.5
Depth (m)
1 2 3 4 5 6 7 8 9


Paul
Temp. (°C) 5 10 15 20 25
O_2 (ppm) 2.5 5 7.5 10 12.5
Depth (m)
1 2 3 4 5 6 7 8 9


Bergner Lake
Temp. (°C) 5 10 15 20 25
O2 (ppm) 2.5 5 7.5 10 12.5
Depth (m)
1 2 3 4 5 6 7 8 9 10 11


Tender Bog
Temp. (°C) 5 10 15 20 25
O2 (ppm) 2.5 5 7.5 10 12.5
Depth (m)
1 2 3 4

INTERPRETATION OF WATER CHEMISTRY

Kickapoo Lake

The temperature graph, because the thermocline is not very extensive and the lowest reading is only 14°C, indicates that the lake has turned over rather recently. Evidence which lends further support to this conclusion is that the lake is open, shallow, and has both visible inlets and outlets. Although the O_2 graph does not fully support this claim, it seems reasonable to believe that the bottom .5 meters were part of the bottom sediment. The considerably higher color reading found at the 2.5m mark as compared to the 1m depth suggests the same idea. Another explanation for the difference in the color readings might be attributed to the amount of plankton present. Looking at the results of the plankton tow, it is surprising that there is not more of a difference between the apparent and true color readings at 1m. That is, there was a significant amount of plankton present. Perhaps, though, the differences observed at 2.5m may be explained by the presence of vertical migrators, which were indeed found in the night tow.

The alkalinity, hardness, and specific conductance are all relatively high, therefore correlating as expected. That is, the concentration of inorganic ions would probably affect all of these in relatively the same way.

The nitrate level of Kickapoo was the lowest recorded, making it possibly "an endangered nutrient."

The rather high epilimnion/hypolimnion volume ratio, relative shallowness, and high alkalinity, conductance, and hardness suggest that Kickapoo is on the eutrophic side of things.

Beaver Bog

Beaver represents a typical bog in practically every respect. The oxygen-temperature graph of this bog indicates that it has not turned over in quite some time; the surface O_2 level of 6.8 is well below that of the air at 9.4 ppm, and it drops to 0 ppm within 1m. The thermocline is also steep, dropping from a surface temperature of 19°C to one of 4.4° in just 2 m. Its relatively low pH of 4.9 is also indicative of a bog. This particular phenomenon may be attributed to a number of sources. The main contributor of hydrogen ions is carbonic acid, formed through the equilibrium established between CO_2 and the water already in the bog. In addition, atmospheric CO_2 will equilibrate with rainwater in the same reaction ($CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^-$). Another possible factor of the low pH is H_2SO_4. This acid may form through the oxidation of sulfuric acid which is found in rainwater if the extremely soluble gas SO_2 is in the air. This is probably not a significant factor, however, since the UNDERC property is sufficiently far away from most air pollution sources, eliminating, for the most part, the possibility of SO_2. According to Cole, sulfuric acid may also form through the following reaction with pyrite (FeS_2), a compound sometimes found in anaerobic peats or bottom sediments: $4FeS_2 + 15O_2 + H_2O \rightarrow 2Fe_2(SO_4)_3 + 2H_2SO_4$. Another possible source of H_2SO_4 is found in the oxidation of H_2S to elemental sulfur, and finally to the acid. Humic acids, the breakdown products of plant lignin and cellulose, are plentiful in peats and contribute to the lowering of the pH. Finally, Sphagnum moss, observed around the perimeter of Beaver Bog, acts as an ion exchanger, donating H^+ ions as it accumulates Ca^{++}. If the calcium (salt) was $CaSO_4$, which is often found in runoff water, the H^+ ions released would form H_2SO_4.

The presence of H_2S indicates that sulfur bacteria are at work, their metabolic waste product being H_2S, as opposed to H_2O, the product of aerobic metabolism.

The alkalinity, hardness, and specific conductance are all rather low, correlating as expected. The scarcity of Ca++ accounts in a large part for the lack of microbial action in decomposition, resulting in a quick build up of sedimentation. The conductance indicates that there are relatively few free ions, and is therefore consistent with the alkalinity reading. The latter of which reflects the buffering capacity of the water, measuring the amount of OH^-, HCO_3^-, CO_3^{--}, etc., present.

The high color reading agrees well with the low Secchi disc measurement of 1.25m. Both of these results may be attributed to the presence of the humic material, causing the water to appear brownish.

All the results indicate that Beaver Bog is oligotrophic. That is, its epilimnion/hypolimnion volume ratio is very low, and its alkalinity, conductance, and hardness are also low.

Peter Lake

It is not surprising that the results of the water chemistry analysis on Peter and Paul are similar because the lakes are presently joined by a culvert, and they were once part of the same lake.

The biggest differences are found in the values of alkalinity and the Secchi disc. Much of the difference in the latter (5.1m vs 3.4m) may be attributed to the fact that different people took the readings. The increased vertical light penetration, however, may be a result of the addition of lime, which was done last year. According to Cole, Hasler found that adding such lime resulted in clearing the water.

Sulfate and nitrate are present in sufficient enough quantities that it appears they would not be considered limiting factors.

The O_2 profile indicates a euphotic zone just above the 3m line. This region represents the area from the surface to a depth at which 99% of the surface light has been filtered out. It is at this depth that the shade tolerant, or light inhibited algae grow. This is reflected in the large increase in the amount of O_2 present at 3m.

Both the O_2 and temperature readings indicate that this lake has not turned over in quite some time. That is, the O_2 graph is quite stratified, and the low temperature is 4^oC.

The color readings are the lowest of any lake studied. They reflect the absence of a significant Sphagnum mat or a conifer forest.

It is difficult to say whether Peter and Paul lakes would be considered eutrophic or oligotrophic. Most likely they are a combination of the two.

Paul Lake

An obvious oxygen bulge occurs at 3.5m. This corresponds well to the Secchi disc reading of 3.4 m, indicating that the bulge may, indeed, be attributed to a phytoplankton bloom at that depth. Such phytoplankton are inhibited by light and therefore, grow at a depth just beyond where light can penetrate.

Sulfate and nitrate appear in quantities comparable to the average found on the Property, suggesting that they are not limiting factors.

The alkalinity value of 0 mg/l is questionable since the same measurement in Peter is considerably higher ($\simeq$ 30 mg/l). Although the pH also appears low (5.5), it suggests that the alkalinity should not be 0.

The O_2 temperature profile indicates that Paul has not turned over recently. The O_2 segment is quite stratified, and the temperature goes all the way down to 4^oC. The graph resembles that of Peter, which is expected since they were once part of the same lake and are still connected by a culvert.

The Specific Conductance is in agreement with the Hardness readings since they are all a little on the low side.

Although the lower color reading in the bulge may be attributed to nothing more than experimental error, the higher reading of the hypolimnion may be due to the presence of ferrous sulfide, according to Cole, or humic materials.

The acidity appears rather high, although comparable to that found in Peter. This acidity may be attributed to the humic acid and H_2SO_4, formed in the same ways as described in the discussion on Beaver.

Bergner Lake

The spectrophotometers in the Hach kits must answer for the extremely high sulfate readings obtained in Bergner; the values were consistently high that day with respect to that compound, for all groups. It seems likely that the conductance in the hypolimnion may be attributed to similar causes.

why just that day?

The steep decline in the O_2 graph, beginning just after 2.5m, agrees well with the Secchi disc reading of 2.6m. Both of these factors indicate that light does not penetrate much below 2.5m, making it a very unlikely environment for light requiring phytoplankton.

Because the data was taken in a deep hole in the lake, the bottom of the O_2 - temperature profile must be taken with a grain of salt. That is, all other evidence suggests That the lake has turned over, especially since it is such a large lake allowing the wind to do much of the mixing.

The difference between the Apparent and True color readings at both sample depths indicates the presence of a significant amount of plankton.

Again, nitrate appears to be present at average levels, keeping it, for the time being, off "the endangered nutrients" list.

The Hardness levels and conductance agree fairly well, although the latter may be a little high considering that the alkalinity is 0 mg/l.

It does not appear that Bergner can be classified as either a eutrophic or oligotrophic lake. It is probably some combination of the two.

Tender Bog

The Sulfate level of 0 mg/l may be explained by incorrect timing procedures in the chemical analysis and/or by its reduction, eventually, to H_2S in the bog. Another possibility may be that the lake is becoming oligotrophic, and the nutrients are becoming tied up in the sediments. This trend is also suggested by the low epilimnion/hypolimnion volume ratio, as well as the low hardness, conductance, and alkalinity.

The low Calcium Hardness level may indicate a limiting factor for microbial action. In turn, this would lead to a quick sediment build-up characteristic of bogs. The Specific Conductance value follows this soft water trend. This reading suggests a lack of inorganic ions, including HCO_3^- and CO_3^{--}, which the 0 mg/l alkalinity also reflects.

The very high color reading of 190 units is most likely caused by humic material, since a large Sphagnum mat does, indeed, surround the bog. This mat also accounts in part for the low pH of 4.5, for it acts as an ion exchanger, donating H^+ ions in return for Ca^{++} ions, as already discussed. Sulfuric acid, formed in the ways described in the section on Beaver Bog, is probably another contributor of hydrogen ions.

Nitrate appears to be present in sufficient quantities not to be considered a limiting nutrient. The acidity is high, as would be expected in a bog.

PLANKTON DATA

Kickapoo Lake

Day

Phytoplankton	Organisms/liter of lake water
Anabaena	1.3×10^5
Asterionella	$\frac{1}{2} \infty$ *
Dinobryon	∞ *
Fragilaria	1.9×10^4
Taballaria	1.5×10^5
Volvox	1.2×10^5
Zooplankton	
Keratella	1.7×10^5
Lepadella	1.9×10^4

Night

Phytoplankton	Organisms/liter of lake water
Amphora	4.0×10^4
Anabaena	1.5×10^5
Asterionella	$\frac{1}{2} \infty$ *
Dinobryon	∞ *
Fragilaria	3.6×10^4
Tabellaria	1.7×10^5
Volvox	3.1×10^5
Zooplankton	
Bosmina	5.1×10^4
Chaoboridae larvae	4×10^3
Cyclops	2.6×10^5
Daphnia	1.5×10^5
Diaptomus	4.4×10^4
Kellicottia	5.1×10^4
Keratella	8.1×10^5
Lepadella	7.9×10^3

* Indicates that these organisms far outnumbered the rest and that the large population densities prohibited counting.

Beaver Bog

Day

Phytoplankton	Organisms/liter of lake water
Asterionella	2×10^3
Dinobryon	8×10^3
Zooplankton	
Bosmina	4.2×10^5
Keratella	2×10^4
Mesocyclops	9.6×10^4
Polyphemus	4×10^4

INTERPRETATION OF PLANKTON DATA

Kickapoo Lake and Beaver Bog

A number of factors influence the distribution or stratification of plankton communities. These include specific gravity, swimming ability of the organism, viscosity of the water, currents, wind, time of day and year. It is impossible to say, therefore, what percentage of the plankton actually present in these lakes have been represented here. It should be understood that it is not 100%.

The availability of the results from both the daytime plankton tow and the night time one, makes the identification of vertical migrators possible. Chaoboridae is the only insect larva of the plankton that rises during the night. It was, indeed, found in the sample taken from the nocturnal tow, and it was not found in the daytime tow.

The vertical migrators are able to withstand low levels of oxygen, enabling them to remain in the anaerobic sediments during the day.

According to Ruttner, *Diaptomus*, *Daphnia*, and *Cyclops* are all vertical migrators. This is very clearly supported by the Kickapoo data. The controlling factor in all these cases is light. For the most part, the downward movement displayed by these plankton during the day depends on negative phototaxis; the upward daytime movement on positive phototaxis.

It appears that *Amphora*, *Bosmina*, *Kellicottia*, and *Volvox* also undergo some nocturnal migration, although *Volvox* was the only one that could be confirmed through reliable sources, i.e. Ruttner.

It is impossible to analyze thoroughly the plankton data of Beaver, since a nocturnal tow was not taken. The amount of *Asterionella* and *Dinobryon* found in Beaver Bog was easily a hundred times less than that found in Kickapoo. This suggests that some necessary nutrient is present only in limited quantities and/or that these two phytoplanktons do not do well in environments as acidic as Beaver.

It appears that the population of *Bosmina* is doing better in Beaver than in Kickapoo. This could be attributed to the size of the zooplankton and the extent of the fish population present. That is, the relatively large size of the *Bosmina* makes it visible to a possible predator, the fish. Fish, however, are unable to exist in Beaver Bog due to the low pH, making it a safer environment for the *Bosmina* than in Kickapoo.

The following reveals the kind of dangers encountered when one tries to identify a lake as strictly oligotrophic or eutrophic, or tries to generalize as to what type of organisms are present in one or the other. Cole reports that Williams in 1969 generalized that *Dinobryon* and *Tabellaria* were among the phytoplankton found in oligotrophic lakes. Furthermore, he claimed that *Asterionella* and *Fragilaria* are found in eutrophic lakes. Part of the inconsistency is a result of identifying

Kickapoo Lake as eutrophic and Beaver Bog as oligotrophic. It should be emphasized that these labels are only attempting to identify trends. It is therefore interesting to note that Dinobryon and Asterionella were found in both bodies of water, while Tabellaria and Fragilaria were found only in Kickapoo.

DISCUSSION

Kickapoo Lake vs Beaver Bog

Comparing the O_2 temperature profiles of these two bodies of water, one is immediately struck by the difference in the epilimnion/hypolimnion volume ratio. While Kickapoo does not reach a 0.0 ppm O_2 reading until the depth of 3m, Beaver shows the same value occurring at only 1m. Even the surface level of O_2 in Beaver is much lower than that of Kickapoo, (6.8 ppm vs 8.8 ppm). The temperature graph of Kickapoo is much less stratified compared to that of Beaver. Whereas the temperature of the latter reaches almost 4°C at 2m, the temperature of Kickapoo does not go below 14°C even at its maximum depth of 3m. Therefore, the epilimnion/hypolimnion volume ratio of Kickapoo is larger than that of Beaver. These points are important in helping to determine if either lake has turned over recently. Looking at the graph of Beaver, it is safe to say that it has not turned over in quite some time; both its O_2 and temperature lines indicate a high degree of stratification. Arriving at a similar conclusion for Kickapoo is not so easy. While its gradual thermocline and minimum temperature of 14°C suggest that Kickapoo has turned over recently, the stratification of its O_2 profile suggests otherwise. However, considering the openness of the area and the fact that the lake has both inlets and outlets, it seems likely that Kickapoo has turned over.

An interesting point is brought out when one compares the sulfate levels of the lake and the bog. Although the sulfate reading at 1m in Kickapoo was higher than either found in the bog, the level found at the 2.5m mark was comparable to both of those in Beaver. Because all of the three lower readings were found in areas of low oxygen concentration, it is likely that the reduction of sulfate to H_2S accounts for the observations.

Indeed, the rotten egg smell of H_2S was quite prevalent in the 3m sample taken from Beaver.

In both bodies of water the correlation of alkalinity, hardness, and conductance is quite good. In the bog, the characteristic soft water trend holds true, with a 0 mg/l alkalinity , low hardness, and low conductance. Because alkalinity measures the amount of carbonate and bicarbonate present, it is also an indication of the amount of CO_2 available for photosynthesis. This discovery offers a possible explanation for the abundance of Asterionella and Dinobryon in Kickapoo and the corresponding low levels found in Beaver. That is, the alkalinity in the bog is 0 mg/l, indicating that little CO_2 is available for photosynthesis, while the levels in Kickapoo are in the 20's. In turn, the conductance, measuring the concentration of inorganic ions, also reflects the higher levels of carbonate and bicarbonate, as well as the higher levels of calcium and magnesium ions.

The scarcity of calcium has been linked with a condition common to bog lakes called dystrophy. The characteristics include stained waters which are acid and brown, low levels of electrolytes, and reduced clarity due to humus material. These symptoms are brought on by the lack of bacterial action, caused by shortages in calcium. In turn, organic matter cannot be broken down or recycled in the normal way. This certainly appears to be the condition with which Beaver Bog is faced. Both its Apparent and True color readings are much higher than those found in Kickapoo. These, for the most part are attributable to the presence of colloidal and dissolved humus material. The higher color readings at the 3m depth in Beaver, may be due to the beginning of a false bottom. As for the clarity, note that although the Secchi disc readings of the lake and bog correspond fairly well to their respective O_2 temperature profiles, the reading for Beaver is more than 0.5m less than that of Kickapoo.

The pH of Beaver is lower than that found in Kickapoo, which is expected. A number of factors contribute to the more acidic pH of the bog. These include sulfuric acid formed in the ways already discussed in the Water Chemistry section of Beaver, humic acids, the extensive Sphagnum mat which acts as an ion exchanger in donating hydrogen ions in return for calcium ions, and carbonic acid formed in the equilibrium of CO_2 and water. In Kickapoo the pH is probably due primarily to carbonic acid.

It is the fish which are first affected by a change in pH. At a pH of less than 5.5, fish begin to have problems with reproduction. And at a pH of less than 4.5, ~~no~~ most cannot fish can reproduce. It appears likely then that the fish population of Beaver is very small if existent at all. The only fish that could easily withstand such low pH's would be the mudminnow Umbra limi.

Due to the limited resources available, it is difficult to say which plankton are characteristic of what water types. A factor to be considered is the specific surface area, a ratio of the total surface area to the volume of the body, which will determine the rate of sinking. The larger it is, the greater the friction with the water and the slower the rate of sinking. Modifications for the adaptation of floating include horns, spines, and setae. Kellicottia is a good example of such adaptations. The turbulence of the water is one of the most important forces controlling flotation. The lack of significant turbulence in the bog perhaps explains why non-motile phytoplankton such as the Tabellaria and Fragilaria do not occur in large numbers in Beaver.

In conclusion, it appears that Kickapoo would be considered more eutrophic than Beaver, and Beaver would be considered more oligotrophic than Kickapoo. The large quantity of Dinobryon and Asterionella, as well as the fishpopulation found in Kickapoo, suggests that it has a higher productivity than the bog. Although Beaver does not have the depth characteristic of an oligotrophic lake, the apparent scarcity ofcalcium will slow down the bacterial action enough to tie up the nutrients in the sediments. Furthermore, the low epilimnion/hypolimnion volume ratio and the low hardness, conductance, and alkalinity values suggest an oligotrophic trend for Beaver Bog. As for Kickapoo Lake, the surrounding grasses indicate that it is on its way to becoming a marsh. Its shallowness, high epilimnion/ hypolimnion volume ratio, and high alkalinity, conductance, and hardness suggest the trend for a eutrophic environment.

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Peter Lake
6-2-81 10:30am

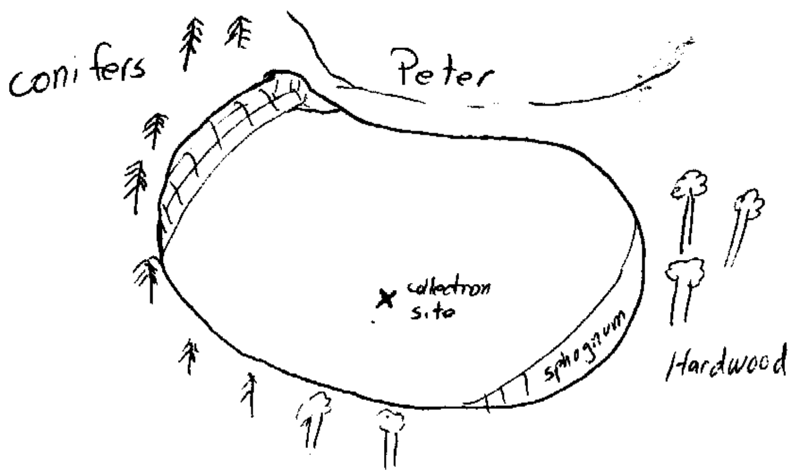
Feini, Paradox, Verhalen

Test	1 meter	3.5 meter	7 meter
acidity	50	60	60
pH	5.1	5.0	5.0
alkalinity	25	20	40
Ca	10	15	20
Mg	5	4	1
Total Hardness	15	19	21
Nitrates	.7	.8	.8
Phosphates - ortho	.08	.06	.09
- total	.04	.03	.04
Sulfates	1	3	3
Conductivity	36	37	42
H_2S	0	0	0
secchi disc		5.1 meters	
color - apparent	55	55	55
- true	55	55	55

Depth (m)	Temperature (°C)	O_2 Concentration (ppm)
air	24	8.6
surface	19.5	10.5
1	18.5	9.8
2	17.8	9.8
3	15.2	11.8
4	12.5	11.0
5	9.5	8.4
5.5	8.0	6.2
6	7.3	2.4
7	6.0	0
8	5.3	0
9	5.0	0

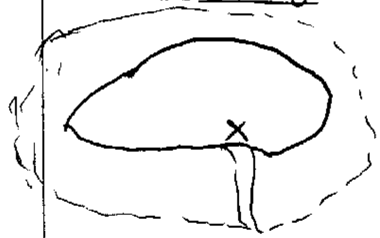
Paul Lake

Paul has a sphagnum mat that is just beginning.
The south side is a combination of conifers and hardwoods



The weather was fair with relatively no wind

Tender Bog



Tender Bog is well protected from wind by a forest of conifers. A thick sphagnum mat, populated with small, scraggly shrubs, ringed the open water.

The water sample and O_2 and temperature data were collected near the dock. The day was sunshiny.

Kickapoo Lake

Kickapoo Lake is surrounded by a marsh mat. Conifers line one side of the lake while hardwoods dominate the other side. Kickapoo has inlets from Plum and Emeline Lakes, and drains into Brown Creek.

The water sample and O_2 and temperature data were taken from the middle of the lake. The day was sunshiny and there was no wind.

Tender Bog
6-1-81 2 pm

Mary Feini
John Paradoss
Frances Verhalen

Test	1 meter	3 meter
acidity	115	115
pH	4.5	4.5
alkalinity	0	0
Ca	5	5
Mg	15	15
Total Hardness	20	20
Nitrate	.8	.9
Phosphate - ortho	.077	.210
- total	.025	.020
Sulfates	0	0
Conductivity	62	30
H_2S	0	0
Secchi disc	1.5m	
Color - apparent	190	190
- true	190	190

Depth (m)	Temperature (°C)	O_2 concentration (ppm)
air	25.0	8.4
surface	16.8	4.5
1/4	16.3	4.3
1/2	14.8	2.6
3/4	13.6	2.47
1	11.3	2.3
1 1/2	7.5	1.2
2	5	0.7
3	4	0.6
4	3	0.6

Bergner Lakes
6-5-81 8:30am

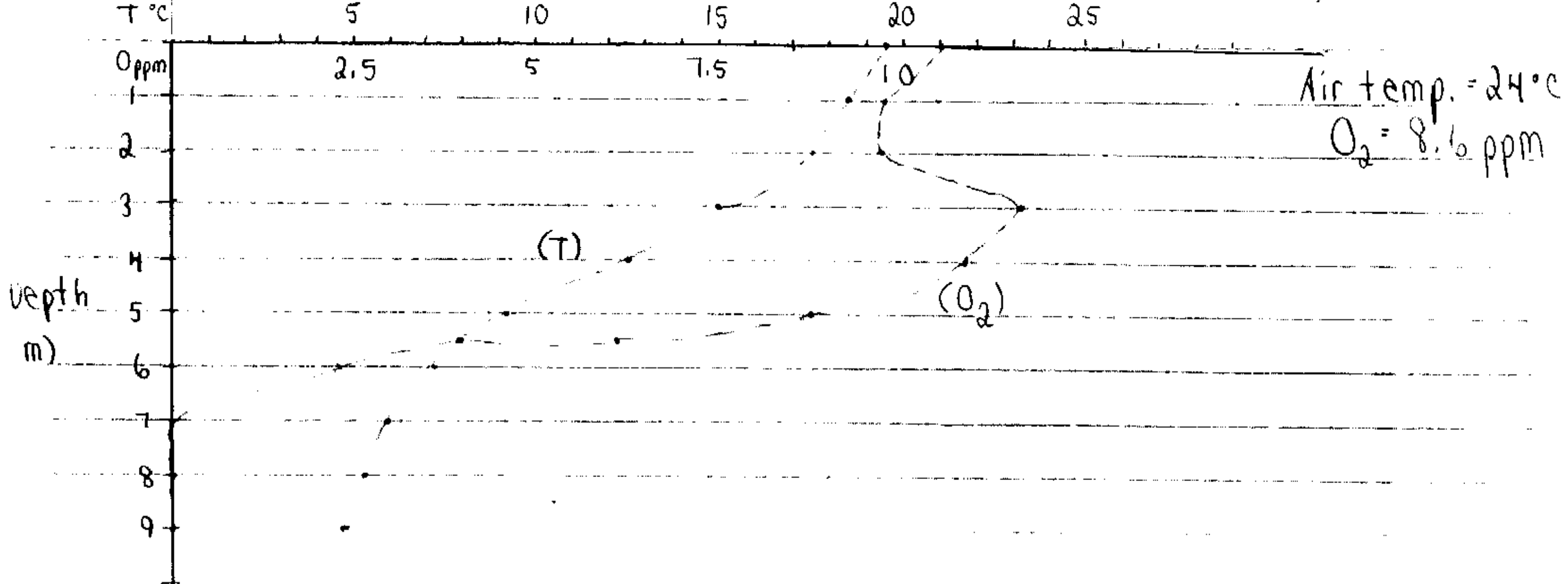
Faini, Paradox, Varhalen

Test	1 meter	7 meters
acidity - phenolphthalen	60	80
methyl orange	10	10
alkalinity	0	0
Ca	7	10
Mg	3	7.5
total hardness	10	17.5
Conductivity	33	120
pH	5.0	5.0
nitrates	0.6	0.7
sulfates	10.0	19.5
H_2S	no	no
secchi disc	2.6 meters	
color - apparent	77.5	77.5
- true	60.0	57.5

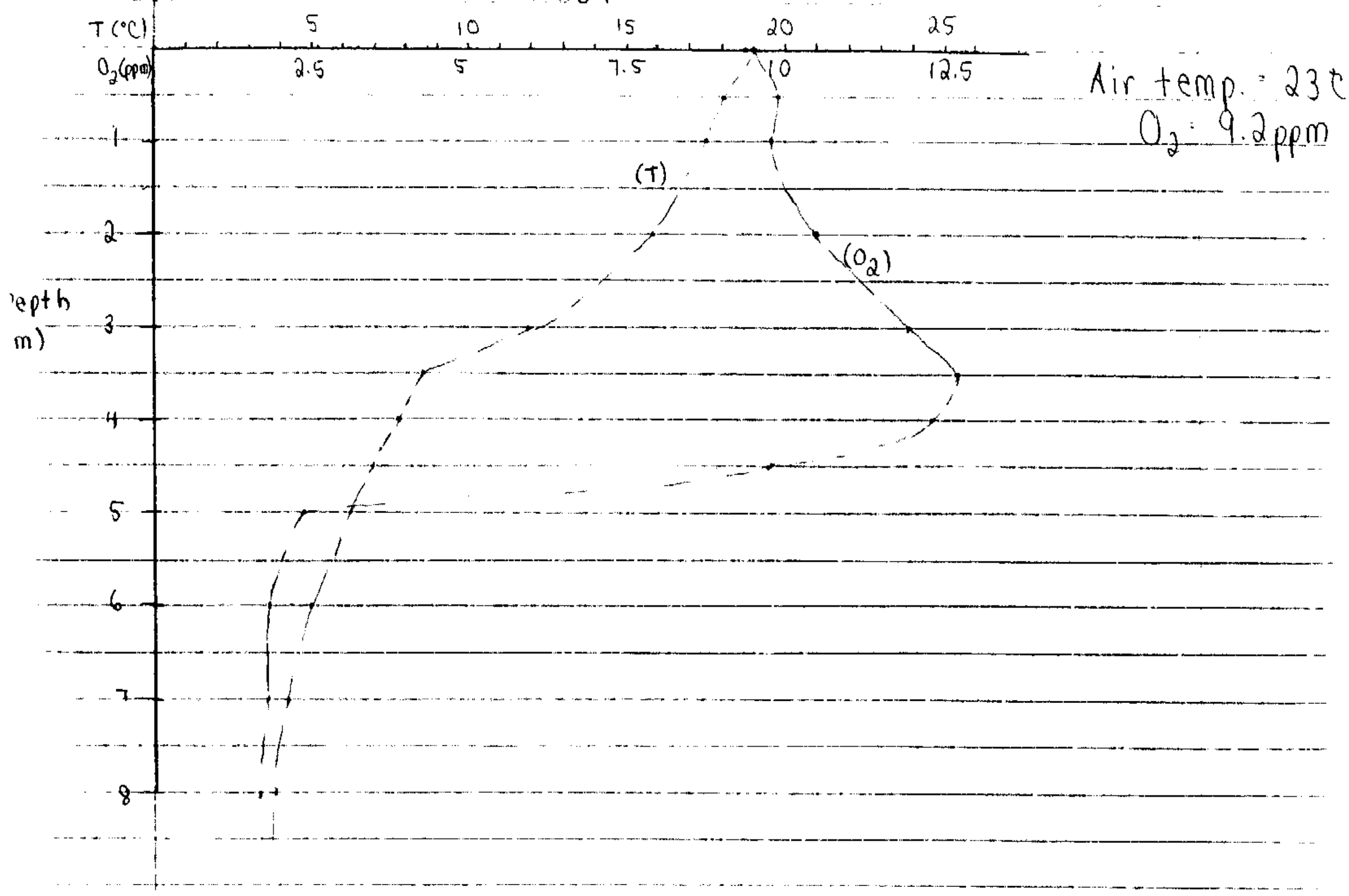
Depth (m)	Temperature (°C)	O_2 concentration (ppm)
air	19.5	9.25
surface	18.8	9.60
1.0	18.8	9.70
2.0	17.8	8.80
2.5	16.5	8.10
3.0	13.3	6.00
4.0	11.0	4.30
5.0	9.8	4.60
6.0	8.4	4.10
7.0	7.0	2.80
8.0	6.5	2.30
9.0	6.5	1.70
10.0	6.3	0.00
11.0	6.3	0.00

Faini, Paraskos, Verhalen

Peter

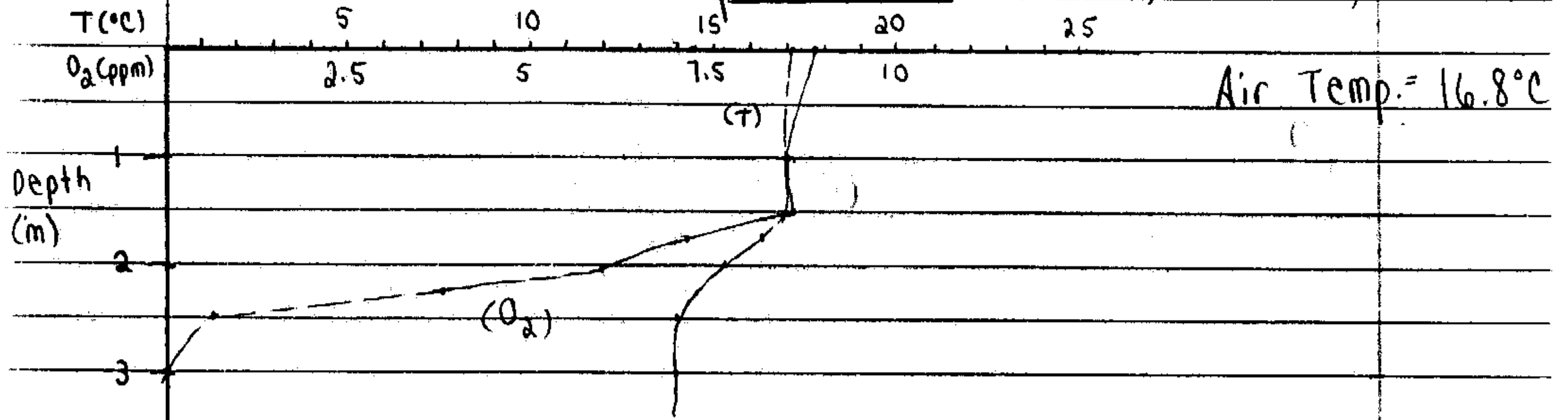


Paul

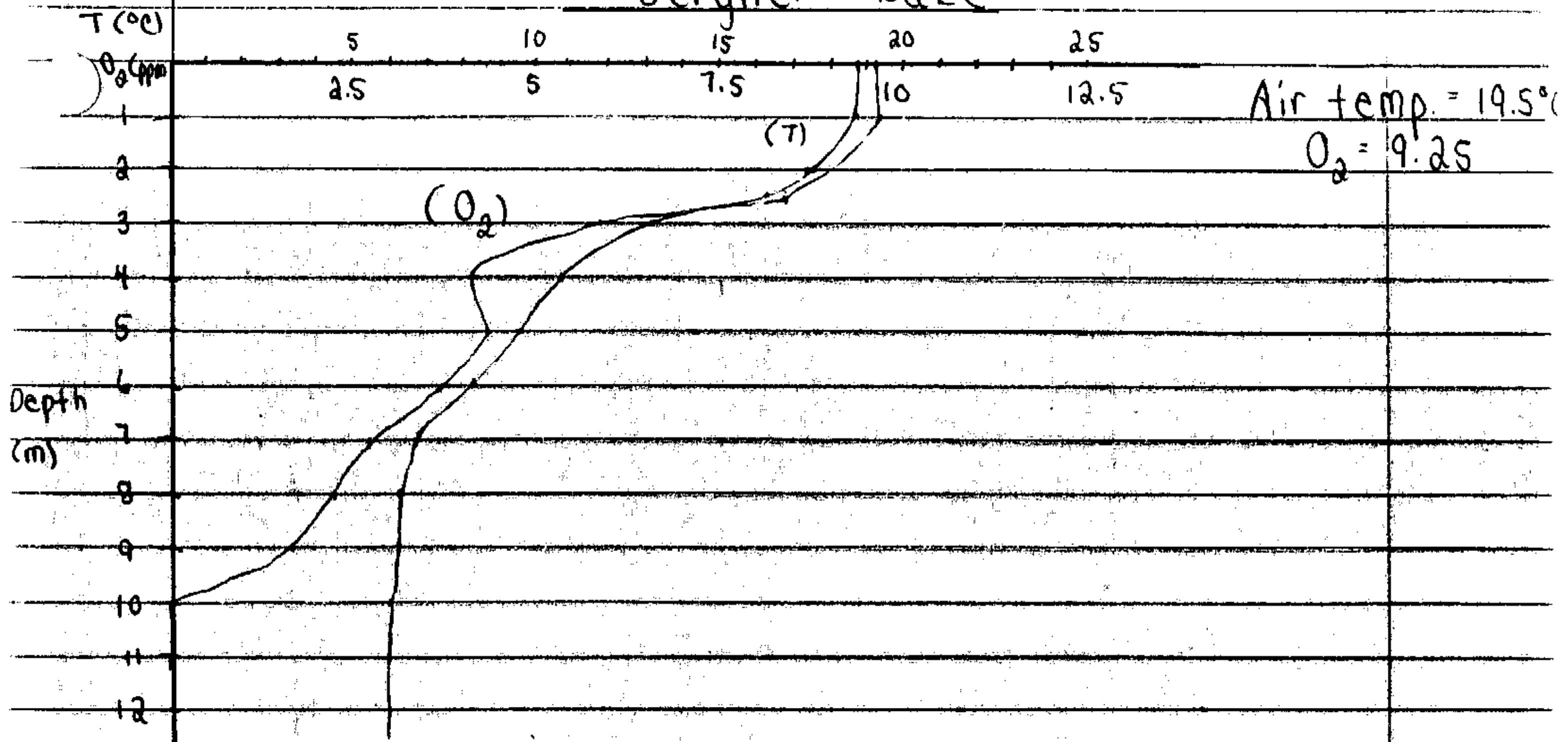


Kickapoo Lake

Faini, Verhalen, Paraskos

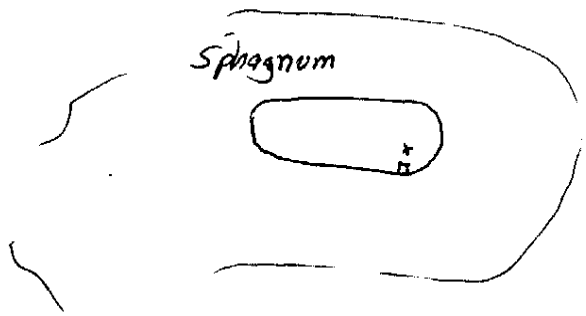


Bergner Lake



Beaver Bog

Beaver Bog is very small with only a 15 m by 50 m oval with open water

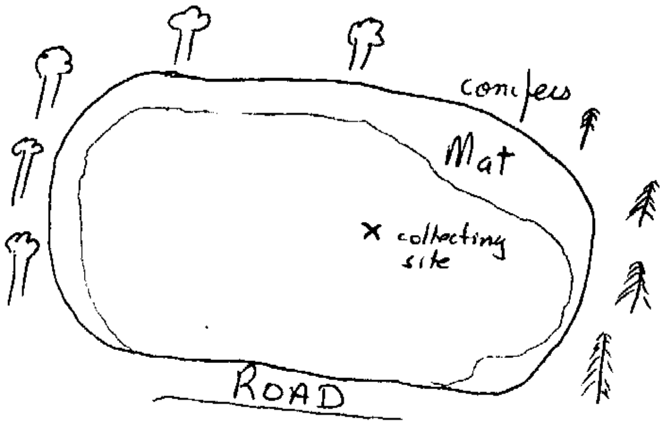


The weather was sunny and warm. The bog was well protected from any wind. There was an abundance of tadpoles swimming around.

Verhalen
Faini
Paraskos

Peter Lake

The sphagnum mat on Peter is starting to take hold
Conifers line the east and north shores while hardwoods and a road line the south and west.



The weather was fair (sunny) with a mild wind but nothing appreciable.

Paul Lake

6-2-81 10:30am

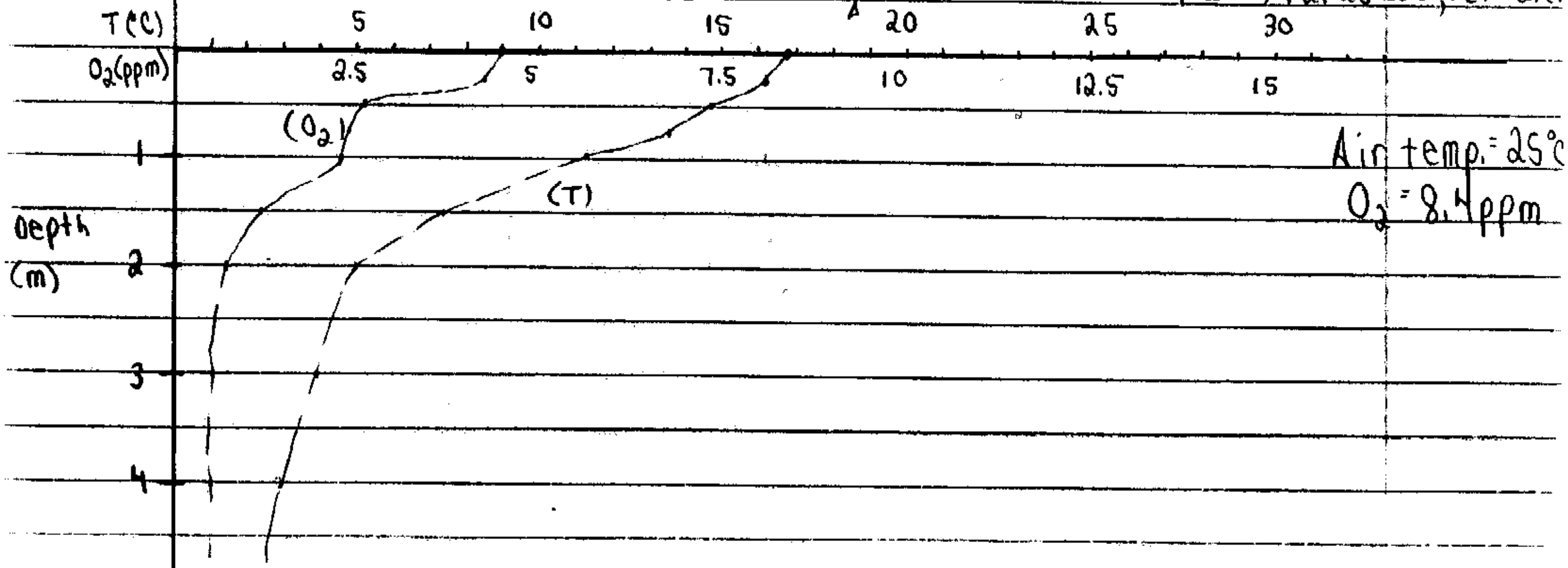
Faini, Paradoe, Verbalen

Test	1 meter	3.5 meter	7 meter
acidity	50	47	47
pH	5.5	5.5	5.5
alkalinity	0	0	0
Ca	5	7.5	7
Mg	3	1.5	5
Total Hardness	8	9	12
Nitrates	.9	.9	.8
Phosphates - ortho	.08	.07	.08
- total	.04	.08	.05
sulfates	1.5	3.0	2.5
Conductivity	17.5	18.0	28.0
H_2S	0	0	0
secchi disc	3.4 meters		
Color - apparent	65	50	80
- true	65	50	80

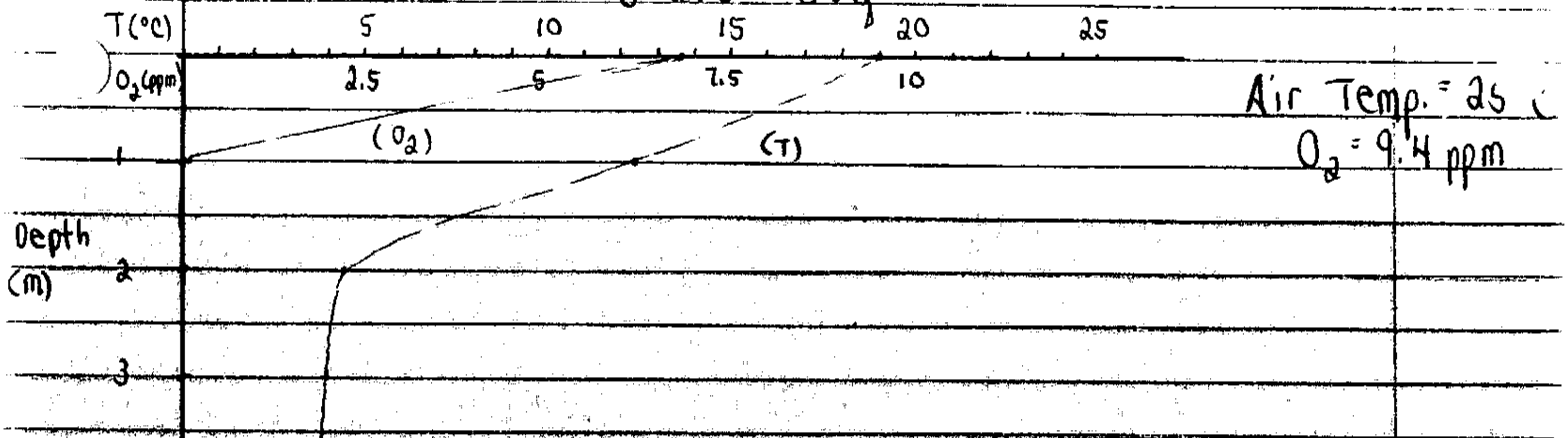
Depth (m)	Temperature (°C)	O_2 concentration (ppm)
air	23.0	9.2
surface	19.0	9.4
0.5	18.0	9.8
1.0	17.8	9.7
2.0	16.0	10.6
3.0	12.0	12.0
3.5	8.8	12.8
4.0	8.0	12.4
4.5	6.2	9.8
5.0	6.5	2.4
6.0	5.2	1.8
7.0	4.5	1.8
8.0	4.2	1.8

Faini, Paraskos, Verhaler

Tender Bog



Beaver Bog



Kickapoo Lake
6-3-81 8:30am

Feini, Caradas, Verhalen

Test	1 meter	2.5 meter
acidity	30	20
pH	5.5	5.5
alkalinity	23	29
Ca	27	30
Mg	13	20
total hardness	40	50
conductivity	45	45
nitrate	0.4	0.3
sulfate	9.5	2.5
H_2S	0	0
secchi disc	1.8 meter	
Color - apparent	80	115
- true	75	90

Depth (m)	Temperature (°C)	O_2 concentration (ppm)
air	16.8	
surface	17.1	8.8
1.00	17.0	8.6
1.50	17.0	8.7
1.75	16.2	7.2
2.00	15.2	6.0
2.25	14.5	3.8
2.50	14.0	0.7
3.00	14.0	0.0

Beaver Bog
6-4-81 10:30 am

Faini, Parashos, Verhalen

Test	1 meter	2.5 meter
Acidity - phenolphthalen	190	300
- methyl orange	10	10
pH	4.75	4.75
alkalinity	0	0
Ca	2.5	5.5
Mg	2.5	4.5
total hardness	5.0	10.0
conductivity	24	27
H_2S	0	yes
nitrates	0.8	0.7
sulfates	2.75	2.50
color - apparent	185	240
- true	165	210
secchi disc	1.5 meters	

Depth (m)	Temperature (°C)	O_2 concentration (ppm)
air	25.0	9.4
surface	19.0	6.8
1	12.5	0.0
2	4.4	0.0
3	4.0	0.0

Bergner Lake

Bergner Lake is an open lake. The shores are flat and covered with shrubs. Conifer trees surround the shrubs.

The lake is relatively shallow. However, the water samples and O_2 and temperature data were collected from a hole extending eleven meters deep.

The sun was shining. The wind was blowing and the water was choppy.