Biological Production and Nutrient Studies of LAKE CHAMPLAIN

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LAKE CHAMPLAIN BIOLOGICAL PRODUCTION and NUTRIENT STUDIES

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prepared by

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Biological Production and Nutrient Studies

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I. INTRODUCTION

1.1 Objective

The objectives of this study were to evaluate the ecological significance of certain aspects of a Lake Champlain wetland. These included an examination of the distribution, abundance and production of higher plants and algae, and also the animals, particularly the large invertebrates and the zooplankton. Concurrently, the study was directed toward the dynamics of the basic nutrients (phosphorus and nitrogen) entering, being cycled, and leaving the wetlands. It necessarily encompassed analyses of the water chemistry of the inflowing streams, water channels within the wetland, and the areas of emergent and submergent vegetation.

1.2 The Nature of this Report

With such a multi-faceted study, many notebooks have been filled with pertinent data. Not all samples taken have been analyzed as yet, nor have all available data been presented in this report. We have attempted to avoid excessive data presentation. Rather, we believe we have provided information to explain the methods utilized and the results obtained during the course of this study. As time permits, some pertinent supplementary reports will be made to provide further information on parts of the study as they are more fully completed. In addition, all data collected, including the original and the compiled and calculated, will be retained in our laboratory and will be made available if or when needed.

1.3 Duration of the Study

The study got underway June 1, 1976 and is officially completed as of

August 31, 1977. However, the study was actually begun during 1975 because of our scientific curiosity about wetlands and some of these previously collected data have been utilized in preparing this report as has information regarding inflowing tributaries, data collected since 1970. Also, we plan to continue the study beyond the contractual period.

II. DESCRIPTION OF MALLETTS CREEK WETLAND

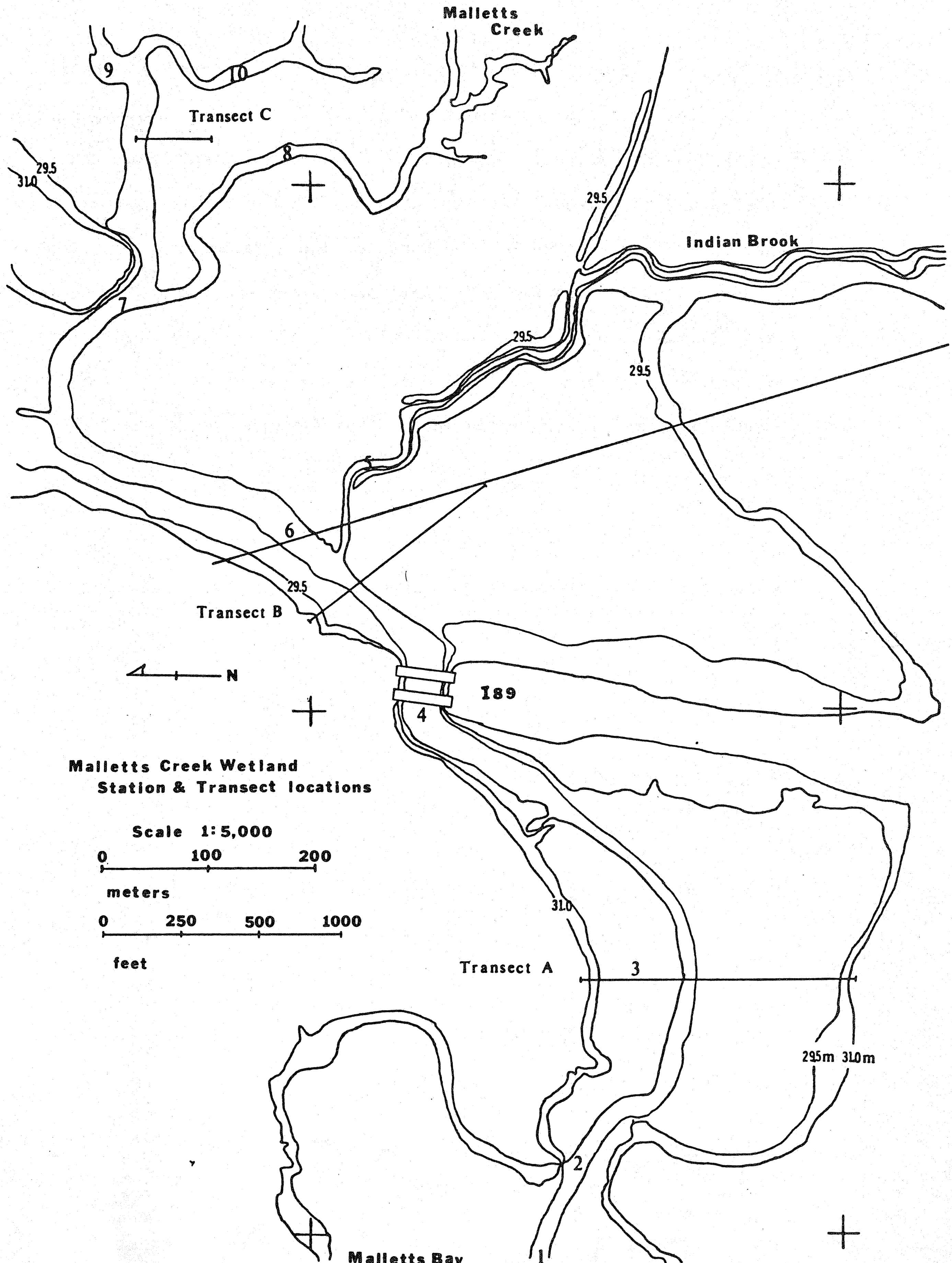
2.1 Location and area of Munson's Flat

Munson's Flat is a bowl-shaped wetland area bordering inner Malletts Bay of Lake Champlain (Figure 1). It encompasses an area of approximately 265 hectares, or 653 acres. The Flat is located in the Town of Colchester, Chittenden County, Vermont, about 10 miles north of Burlington. It occupies an area between Interstate 89 and U.S. Route 2.

2.2 Hydrographic Description of the Area

Drainage into the Flats is provided by four streams having a combined catchment area of 40.12 square miles. Allen Brook has a watershed area of 4.71 square miles, Malletts Creek has one of 18.90 square miles, the catchment area for Pond Brook is 4.37 square miles and for Indian Brook it is 12.14 square miles. Allen Brook, the most northerly tributary, drains agricultural land east of Chimney Corner in South Milton. Malletts Creek, the largest tributary, drains the woodlands and the ridge east of the Flat. Pond Brook drains the lowland area around Elm Hill and merges with Malletts Creek in the Flat. Indian Brook to the south flows through Essex Junction, crosses under Route 2 east of Elm Hill, and flows into the Flat just east of Interstate 89.

Figure 1. Malletts Creek Wetland Area.



2.3 Representation of Munson's Flat as a Lake Champlain Wetland

Actually, each wetland is unique in that it has its own morphometry, topography and hydrology. However, the species of plants, from algae to trees, found in Munson's Flat are also found in other Lake Champlain wetlands. The same is true for the benthic macroinvertebrates and zooplankton. We know of only one species of plant found elsewhere and not in Munson's Flat. Therefore we consider this wetland totally representative of the wetlands of this lake. We believe that knowledge gained from our study of Munson's Flat can be extrapolated to other Lake Champlain wetlands.

METHODS AND PRODECURES

3.1 Lake Levels and Elevation Determinations

Two U.S.G.S. staff gauges were installed at two different locations of the wetland in May, 1976. The first was attached to a telephone pole near the mouth of Indian Brook, and the second farther in the wetland, also attached to a tree. They were arranged so that the second gauge was exactly one foot lower than the first. Lake levels were recorded from these gauges on each field trip. The two values always matched almost exactly. During the winter of 1976-1977 one of the trees holding a gauge fell over, and early in the summer of 1977 the water level fell below the bottom of the other gauge.

The recorded lake levels were then compared with the mean daily lake level values given for the Burlington, Vermont, gauging station. A linear regression (r=0.992) indicated a maximum deviation of 1.45 inches (3.68 cm) (level = 96.768 + .9449 staff reading).

3.2 Direct Measurement of Water Inflow Through the Influence Stream Channels

3.2.1 General Comments

Information on water discharged into the Flats is required in order to assess the nutrient loadings into the wetland. These four streams are not gauged; therefore it was necessary to make direct measurements ourselves. The four streams were gauged where they crossed Route 7, very near the outer periphery of the wetland. The data will be used to compare with the results of a mathematical model presented in Section 3.3.

3.2.2. Method of Measuring the Discharge

The channel geometry was measured on each field visit because of the shifting bottom sediments at some of the stations. A calibrated line was stretched across the stream, and a series of quadrilateral areas were measured. Stream velocity for each trapezoid was measured at several points with a Gurley Current Meter. Stream discharges were then calculated. Some problems were encountered that should modify the results. Late in the fall of 1976, a beaver dam was constructed below the Malletts Creek location, inundating the station, and this, of course, modified the results. A farmer above the Allen Brook station was doing some earth moving late in 1976, and since that watershed is small, there may be some influence on the discharge measurements.

3.3 A Model for Calculating Mean Daily Discharges of Influence Streams

3.3.1 Logic Behind the Model

In Working Document #1 (Henson, 1977) a procedure is described where the mean daily discharges of a sector of the Lamoille River are compared with those discharges of Stone Bridge Brook, a small stream about 20 km distant from Munson Flat. Stone Bridge Brook is intermediate in size to the four tributaries of Munson's Flat, so its discharge could be used to estimate the discharge of the four streams by prorating their respective areas. Unfortunately, the gauging of Stone Bridge Brook was discontinued in 1974, necessitating a method to estimate Stone Bridge's flow as an intermediate.

3.3.2 Relationship of Lamoille River Sector with Stone Bridge Brook

Selection of 29 dates between 1971 and 1974 was made, dates for which data were obtained on any of the five subject streams in another study (Henson and Potash, 1976). The mean daily discharge of the Lamoille sector (Q_L) and Stone Bridge Brook (Q_S) were plotted, using data published in the

Water Supply Papers of the U.S.G.S. showing excellent correlation when Q_L flow was 1500 cfs or less. The equation

$$Ln\ Q_s = 0.53848 + 0.002619\ Q_L \qquad (1)$$

yielded calculated values for Q_s that averaged 3.2% above the data of the U.S.G.S., for flow of Q_L of less than 1500 cfs. Also, a low Chi-square value t (p=.60) in the test for goodness of fit further substantiates that equation (1) is valid for estimating the mean daily discharges of Stone Bridge Brook when Q_L is less than 1500 cfs.

When Q_L exceeds 1500 cfs, simple correlation breaks down, and two sets of correlations appear, a higher and a lower set. These two sets are approximated by

$$Q_s' = 136.77861 - 0.010770807\ Q_L \qquad (2)$$

and

$$Q_s'' = 18.71985 - 0.0005865\ Q_L \qquad (3)$$

Despite the fairly large scatter for equation (3), when Q_L exceeds 1500 cfs the mean daily discharge estimate for Q_s can be approximated by solving for both of these equations and taking the average.

3.3.3 Applying this Model for Discharge Values for the Influent Streams

Since the drainage area of Stone Bridge Brook is intermediate in size to the other four streams, the discharge of the four influent streams can be estimated by prorating their areas as follows:

		Q_s
Malletts Creek	Q_s x 2.2367	18.90
Indian Brook	Q_s x 1.4367	12.14
Stone Bridge Brook	1.0000	
Allen Brook	Q_s x 0.5574	4.71
Pond Brook	Q_s x 0.5172	4.37

The daily discharges for Malletts Creek have been calculated along with the calculated values for Stone Bridge Brook for March through October, 1976.

3.3.4 Estimating Total Water Input from Malletts Creek Discharge

It is sometimes necessary to have the value for the total water inflow into the Flats. Since Malletts Creek discharge data have been calculated, those data can be used to supply the desired information. The four streams that drain into the Flats constitute most of the influx, and their combined drainage area amounts to 40.12 sq. miles. Malletts Creek has a drainage area of 18.90 sq. mi., or 0.47109 of the entire drainage. Also, since the total inflow is governed by area, Malletts Creek represents 0.47109 of the inflow. Thus

$$Q_t = \frac{Q_m}{0.47109} = 2.12274\ Q_m \qquad (4)$$

3.4 Water Quality Monitoring Stations Established for this Study

3.4.1 Stations on the Influent Tributaries

Water samples were collected from the influent streams at almost weekly intervals throughout the Spring and Summer of 1976, periodically through the Fall of 1976, and through the remainder of the study period. The water samples were collected at the time of discharge measurements, but additional samples were obtained when hydrological conditions indicated a need for additional data. In all instances the stations were located where the stream crossed Route 7.

3.4.2 The Channel Stations

Ten channel stations were established in the Flats for monitoring general water quality conditions of the standing waters in the wetland. It was assumed that the general flow out of the wetland would be concentrated in channel areas even though the interchannel terrain was in fact inundated. Referring to Figure 1, Station 1 is located outside the wetland proper, and in the peripheral area of inner Malletts Bay. This station was designed to serve as a control to contrast wetland water quality with Malletts Bay quality. However, since an extensive delta has been built in that area, we probably have well mixed control water with wetland water. The analyses will indicate at the least, the trends of the differences in the character of the water "in" and "out" of the wetlands.

The true entrance to these wetlands is through what we refer to as the "portal"; two rock outcrops that restrict exchange between the two habitats. This is Station No. 2. Wind conditions and seiche activity allow maximum exchange of water at this station.

Station 3 lies along Transect A (re. Section 3.6) in mid-channel and was designed to provide continuity with Transect A, as well as to monitor the extent of mixing of wetland waters with Malletts Bay water.

Station 4 is situated in a pool of the channel at a 90^{o} meander of the channel just west of Interstate 89. This relatively unimportant station was established to provide continuity of conditions inland. The location of Station 4 was a compromise between establishing it at Transect B or at a station out of Indian Brook's influence. Its location provides a good inter mixture of the influences of Indian Brook and of the influences of influxes from Malletts Bay.

Station 5 is just above the mouth of Indian Brook, but is in the channel. During low lake levels the discharge from the brook is contained within the channel.

Station 6 is situated below power lines that traverse the area. This reflects conditions above the influence of Indian Brook, although we have many times noticed surface flow moving into the wetland at this station caused by discharge from Indian Brook.

Station 7 is situated in mid-channel south of the rock-ledge margin of an island in the Flats. The water here is influenced by the drainage of Malletts Creek, modified by Pond Brook and Allen Brook.

Station 8 was located about 250 m up the Malletts Bay channel, and during the low lake level periods it does reflect Malletts Creek conditions. However, during the higher lake levels the station has water communication with Stations 9 and 5.

Station 9 reflects the conditions of the northeast quadrant of the Flats, and receives the drainage from Allen Brook. Allen Brook disappears in the wetland, and is unexplored.

Station 10 is situated on an uncharted channel located below a beaver pond. During high waters this station is in water connection with Station 8, but it is now considered to represent drainage from the eastern sector of the Flats.

3.5 Methods used for Chemical Analyses

3.5.1 Dissolved oxygen measurements were made using a Yellow Springs oxygen meter Model 51. Calibration was carried out prior to each day's use and the instrument was checked regularly, using the modified Winkler titrimetric method as a control. Measurements were made approximately six inches below the surface. In addition, when depth permitted, measurements were made at mid-depth and slightly above the bottom.

3.5.2 Measurements of pH were made by using a Fisher Accumet Model

210 meter.

3.5.3 Alkalinity was measured titrimetrically. Titration was carried out using 0.02 N sulfuric acid, using methyl purple as an indicator.

3.5.4 Specific conductance was measured using a Solu Bridge conductivity meter.

3.5.5 Biochemical oxygen demand was calculated using the standard procedure. A large sample was taken, shaken well and placed in two sets of B.O.D. bottles (300 ml). The dissolved oxygen concentration in one set of duplicates was determined immediately; the other set of bottles was incubated in the dark for five days at 20°C. At that time the dissolved oxygen concentration was determined titrimetrically. The difference between the original and final concentrations indicated the biochemical oxygen demand.

3.5.6 The total phosphate-phosphorus concentration was determined by using the method described by Gales et al. (1966).

3.5.7 Ortho-phosphate or reactive phosphate-phosphorus was carried out by sulfuric acid and potassium persulfate digestion, followed by colorimetric determination using stannous chloride and ammonium molydate standards (Strickland and Parsons, 1965). An optical density standard calibration curve was calculated for use with a Bausch and Lomb Spec-20 Colorimeter, and phosphate readings were determined from the standard curve.

3.5.8 Organic nitrogen was determined by digesting 100 ml of the sample in sulfuric acid and mercuric sulfate. This was allowed to evaporate over low heat until a yellow solution was obtained. The volume was returned to 100 ml and subjected to Kjeldahl digestion.

3.5.8 Cation concentrations for calcium, magnesium, sodium and potassium were obtained by using a Perkin-Elmer Atomic Absorption spectrophotometer.

3.6 The Transects

3.6.1 General Statements

Three transects were established in the wetland for the purpose of mapping the vegetation along a strip from the shore to the channel and for helping to locate positions when the area was revisited (Figure 1). Transect A is located west of Interstate 89 and extends on a bearing of 192° from the north shore to the south shore. The location was determined by the fact that it transected representative stands of bur reed (*Sparganium*) south of the channel and horsetail (*Equisetum*) and bullrush (*Scirpus*) north of the channel. Transect B is located between the Interstate and Indian Brook and is on a bearing of 152°. Transect C is deep in the wetland, beginning along a stand of silver maple trees on a bearing of 180°.

The transects were established by driving pairs of eight-foot stakes into the ground one meter apart and every 25 meters along the bearing. The transects were visited approximately every ten days during the 1976 season, and monthly during 1977. These transects were located in areas considered representative of the major dominant species within the vegetational zones.

3.6.2 Procedures

Eye bolts were screwed into the tops of the stakes along one side of each transect. A ¼-inch nylon rope, with a harness snap attached to one end, was calibrated to read each meter, and was more than 25 meters (100+ ft.) long. When the transect was visited, the calibrated line was snapped onto the first stake on shore and stretched to reach a stake about 25 meters distance.

The transect team then started at the zero point at the first stake and proceeded to record each species of plant that was under the rope. Therefore, a listing was compiled indicating the species found between 0 and 1 m, 1m and 2m, etc. When the members of the team did not know the species of a plant, a specimen would be collected from the general area, labelled, and returned to the laboratory for identification.

3.7 Quantitative Quadrat Sampling

3.7.1 Description of the Quadrat Sampler

The quadrat sampler was constructed by using four lengths of 3/8" (95mm) dowling and four blocks of wood approximately 4½" x 4½" x 4" (11.4 x 11.4 x 10.2 cm), and with 3/8" (95mm) holes drilled in two faces 90° apart. When assembled, the device has inside dimensions of 17.5" x 17.7" (44.5 cm x 45 cm), and subtracting the four corners of the blocks, the total area amounts to 2.1 sq. ft. (1,977.75 cm^2). A factor of 5.06 converts the data in units per square meter. When a quadrat sample is taken, the device is assembled on the spot, enclosing the area for enumeration.

3.7.2 Procedures

The investigators took three "random" quadrat surveys in the emergent, floating, and submergent zones along each transect. If the emergent zone was extensive, then three quadrats were taken nearer shore, and another three farther away from the shore.

When the device was assembled, each species, and the number of each species was counted to provide a complete census in the quadrat. Three specimens of each species of representative size, including the roots, were collected. If three specimens were not found in the quadrat, a collection was made of what was needed from the immediate adjacent area.

3.8 Laboratory Procedures for Handling the Plant Specimens

3.8.1 Identification and Logistics

Each plant was given a code number in the field, the number being recorded in the Field Book. The code number was the date, species number, and location code. For example, B(N)-1-Q136m-3'-6/14/76/2 indicates that this specimen was collected from quadrat #1 in the emergent zone in 3" of water 136 m from the zero point on June 14, 1976 and species 2 is *Scirpus fluviatilis*. The plants were identified using a variety of keys. For a number of the plants, identification had to be delayed until the reproductive parts developed. Most of the species have been preserved as herbarium mounts.

3.8.2 Mensurations

The specimens were air dried and then the roots, stem, leaves, and reproductive parts were separated. Each part was then weighed and measured for length. These bits of data were recorded on a form. Table 1 is an example of the form used and shows how the data are entered.

3.8.3 Processing for Chemical Analyses

Each part of the plant then was ground through a grinding mill through a #20 mesh screen and stored in glass jars or envelopes awaiting analyses.

3.9 The Invertebrate Populations

3.9.1 Qualitative Sampling for the Fauna

On a number of occasions qualitative samples by dip nets were taken in a variety of different areas of the wetland to become familiar with the fauna, and to ascertain if anything unusual might turn up.

TABLE 1

BIOMETRICS AND CHEMISTRY OF PLANT MATERIAL

Name of organism *Scirpus fluviatilis* (River Bullrush) Location B(H)-1-[illegible]1-36m-3"

Date 14 vi 76. Cruise 76009. Page 12. Species Code 6/14/76/2

		Specimen (cm) #1	Specimen (cm) #2	Specimen (cm) #3	Specimen (cm) AVG	Dry Weight (grams) #1	Dry Weight (grams) #2	Dry Weight (grams) #3	Dry Weight (grams) AVG
Length: (cm)	Stem	35	42	41	39.33	2.16	1.46	1.06	1.56
	Leaves	98	91	95	94.67	2.87	1.96	1.91	2.25
	Flower	-	-	-	-	-	-	-	-
	Root	15	15	17	15.67	7.47	5.51	2.38	5.12
	Totals:					12.50	8.93	5.35	8.[illegible]3
	Means:								

AVERAGE CHEMICAL COMPOSITION

	% Phosphorus #1	% Phosphorus #2	% Phosphorus #3	% Phosphorus AVG	% Nitrogen #1	% Nitrogen #2	% Nitrogen #3	% Nitrogen AVG	% Silicon #1	% Silicon #2	% Silicon #3	% Silicon AVG
Stem	.24	.28	.29	.270								
Leaves	.22	.24	.24	.233								
Flower												
Roots	.22	.14	.13	.163								
weighted mean % in whole plant	.223	.185	.201	.203								
Weight in whole plant	.0279	.0165	.0108	.0184								

3.9.2 The Invertebrate Sampling Box

In an attempt to quantify biomass, a special sampler was constructed. This device consisted of four sides of a box open at the top and bottom. The bottom ends were beveled, and the inside was fitted with sheet metal finished flush with the inside of the box.

In using, the box was lowered to position at the sampling site and the metal flange was pressed into the bottom material. The water inside the container was pumped out by means of a bilge pump, and the pumped water strained through a "benthos bucket" to capture any of the animals loose in the water. Using hands and a rake, the vegetation was removed and returned where the animals were sorted and processed.

3.9.3 Bur Reed Basket Samplers

Simulated substrate samplers were utilized to assess the characters of the fauna in the different zones of the wetland. The samplers consisted of 600 grams of bur reed stems cut to uniform size, and cleaned of all organisms that might be attached. These were placed and secured in a wire chicken barbeque basket, weighted down with a few small rocks in the bottom. These were placed, in replicate pairs, in the emergent zone, floating-submerged zone and in the channel. The samplers remained in position for 1 month each time. After a month the baskets were carefully retrieved and placed in a plastic bag. In the laboratory, the bur reed stems were carefully examined and all animals were removed and preserved. These animals were subsequently sorted, identified, and enumerated.

3.10 Phytoplankton Populations

3.10.1 Collecting the Samples

The phytoplankton was collected by using a #20 plankton net. The net was placed on the bottom and raised slowly. The depth of the water was recorded, and the sample preserved in the field with formalin. Knowing the water depth and the diameter of the net, an estimate can be made of the volume of water that went through the net.

3.10.2 Counting the Phytoplankton

The phytoplankton populations were evaluated following a method described by Prescott. A dropper was calibrated so that when held vertically 20 drops made up 1 ml, with each drop being equal to 0.05 ml. The plankton sample was brought up to a known volume. The sample was mixed, and one drop of sample dropped onto a microscope slide, and this was covered with a coverslip of known size. The field of an Olympus phase microscope was calibrated so that the diameter under each magnification was known. The slide was adjusted so that the initial field of view was near, but not too near, the edge of the coverslip. The species of plankton in the field were tallied, and then the slide was moved along, so that, in effect, a micro-transect was counted. Knowing the width of this transect (= diameter of the field) and thickness of the water under the coverslip, a semi-quantitative evaluation can be made. One, two, more, or partial transects were counted until 100 specimens were tallied. For sparse samples, only the first 50 organisms were tallied.

3.11 Zooplankton Populations

3.11.1 Collecting the Samples

Samples were taken in Malletts Creek at Transects A and B, from the center of the channel and near its edges, and at the surface and bottom. On 22 September, 1976, a Juday plankton trap with a 35μ mesh nitex net was used. On 6 October, 1976, samples were taken with a Birge style plankton net (#20 mesh), lowered in the water and retrieved by hand.

Samples were preserved in 6% formalin immediately after collection. In the laboratory the Juday samples were concentrated to 100 ml, and three 5 ml aliquots were taken from each, using a wide-bore pipette. Each aliquot was analyzed for species and numbers present. The Birge net samples were analyzed on a qualitative basis only.

4.1 Nutrient Input from the Tributary Streams

Nutrient input was calculated by determining the daily mean discharge for the tributary streams, as described under Methods, 3.3. Nutrient input was determined from past calculations of the relationship of loading to discharge. Nutrient input was calculated by comparing concentrations measured with input as plotted on previously calculated curves.

4.1.1 Total Phosphorus Loadings

For total phosphorus loading in Malletts Creek see Table 2. It can be observed that the highest values were obtained during the months of March, April and May in 1976 coinciding with the period of maximum runoff and precipitation. In late May there was a dramatic drop in the loading values and the loading values continued in the same order of magnitude from June through early August except for occasional rain. The wetland reacts very rapidly to any significant precipitation. August's loading was influenced considerably during the period from the 11th to the 18th as a result of activity by Hurricane Belle. There was a very slight decrease in loading from this period until early October when slow daily increases were noted. Table 3 indicates the mean monthly total phosphorus loading for the wetland as a whole and for its four individual tributaries.

TABLE 2

Calculated loadings of total phosphate-phosphorus carried by Malletts Creek; March through October, 1976. Values in kg/day.

Day	March	April	May	June	July	August	September	October
1	20.1	14.0	8.8	2.3	1.6	22.5	2.0	2.0
2	7.0	9.7	4.5	2.6	1.8	22.3	1.8	2.1
3	5.4	18.7	23.6	1.9	1.7	9.25	1.5	2.8
4	4.8	20.9	25.2	1.6	1.6	2.9	1.6	0.92
5	13.8	22.4	10.7	1.4	1.4	1.8	2.1	1.1
6	23.7	22.8	6.1	1.3	1.15	1.5	0.96	1.3
7	23.7	23.0	3.2	1.0	0.96	2.6	0.86	1.4
8	10.7	18.4	28.7	2.1	1.1	2.8	0.87	2.4
9	6.0	13.4	11.0	2.0	5.8	0.82	1.2	31.5
10	3.8	9.1	5.6	1.6	2.8	23.0	0.92	19.3
11	3.3	7.6	4.1	1.3	1.2	12.5	23.4	30.8
12	3.4	9.8	22.5	0.61	1.4	19.0	19.7	20.7
13	2.8	5.9	22.5	1.3	1.2	14.8	2.9	7.0
14	3.9	4.9	24.0	0.98	1.2	24.6	3.0	4.8
15	3.6	4.6	23.4	1.1	1.4	23.6	1.6	3.7
16	2.7	6.1	26.6	0.90	1.3	20.9	1.4	4.2
17	2.4	23.5	9.7	3.3	0.89	23.7	1.5	2.9
18	1.9	22.1	1.9	2.2	0.86	12.4	1.3	2.3
19	2.5	23.4	24.4	1.5	1.15	4.5	1.1	2.2
20	23.2	23.3	18.4	1.2	0.92	2.3	0.78	2.3
21	12.5	9.6	20.5	0.87	0.90	2.1	1.1	30.8
22	14.3	5.0	23.5	2.1	0.98	1.6	1.2	31.9
23	19.5	3.8	23.7	1.3	0.90	1.3	1.8	24.9
24	22.3	4.2	23.9	1.4	0.96	1.4	1.5	6.1
25	22.3	3.4	17.5	0.84	0.73	1.3	1.5	4.7
26	20.6	2.7	11.1	1.1	1.2	1.1	1.9	5.6
27	15.9	11.2	13.1	2.6	8.8	0.87	23.6	4.9
28	13.8	22.7	5.5	2.3	23.4	3.1	23.1	3.5
29	17.6	24.6	3.8	1.8	6.1	1.8	7.6	4.4
30	20.0	17.0	2.7	1.5	3.0	4.2	3.0	2.8
31	18.7	-	2.3	-	1.8	2.0	-	2.4
Total:	366.2	407.8	452.5	48.0	80.2	268.54	135.74	265.32
Daily Mean:	11.81	13.59	14.60	1.60	2.59	8.66	4.52	8.56

TABLE 3

Total phosphorus (kg) loadings from the individual tributaries and the total load entering the wetland

Month	Malletts	Indian	Pond	Allen	Total
March	366.2	84.5	55.6	89.8	596.1
April	407.8	94.1	61.9	100.0	663.8
May	452.5	104.4	68.7	111.0	736.6
June	48.0	11.1	7.3	11.8	78.2
July	80.2	18.5	12.2	19.7	130.6
August	268.5	62.0	40.8	65.9	437.2
September	135.7	31.3	20.6	33.3	220.9
October	265.3	61.2	40.3	65.1	431.9

Again the general pattern observed is one of high loading data for the spring period, low additions of data phosphorus in June and July, an increase in August, again coinciding with the hurricane, and again a slight increase in September and October. Figure 2 describes graphically the seasonal pattern of total phosphate-phosphorus loading with an explanation for the major changes of direction from increase to decrease or decrease to increase in loadings.

4.1.2 Reactive Phosphorus Loadings

Tributaries were sampled every week throughout the summer of 1976 and dissolved reactive phosphorus load was calculated. Table 4 illustrates the reactive phosphorus load of six such dates. The total data have not yet been utilized to calculate the total reactive phosphorus load, as was done for the total phosphate load. This will be presented in the supplementary report. The figures cited in Table 4, for several dates in June and July, 1976, are representative of the data obtained throughout the study period.

4.1.3 Nitrogen Loadings

To date, calculations of nitrate-nitrogen and total Kjeldahl nitrogen have not been carried out, although some analyses have been done. Data are available from these samples analyzed during the course of the study and will be presented as a supplementary report.

4.2 Physical and Chemical Characteristics of the Wetland Water

4.2.1 Water Levels

1976 was a high water year. The lake level started out above 100 feet, dropped to 97.3 feet by July 1, and to 97.0 feet by August 10. This is a very slight drop of only three-tenths of a foot in over a month. At the

Figure 2. Seasonal fluctuations in the total phosphorus loading of Malletts Creek wetland.

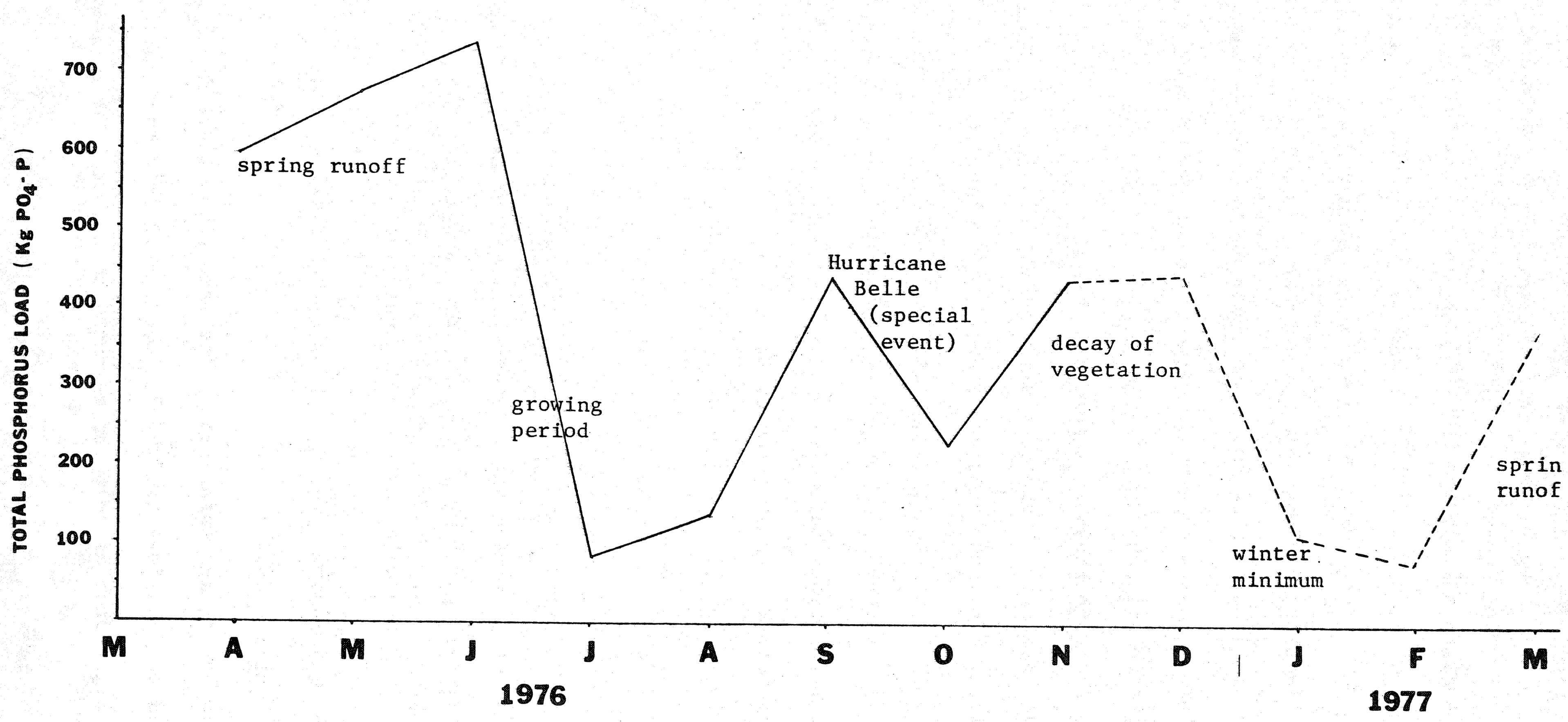


TABLE 4

Reactive phosphorus load in the four tributaries on six sampling dates during 1976.

MALLETTS CREEK

Date	Discharge (c.f.s.)	PO_4-P (μg/l)	Load (Kg/day)
4vi	11.71	35.50	1.016
16vi	0.85	31.10	0.065
23vi	0.57	36.50	0.051
1vii	14.71	40.88	1.470
8vii	2.30	47.97	0.269
22vii	0.01	17.56	0.0004

INDIAN BROOK

Date	Discharge (c.f.s.)	PO_4-P (μg/l)	Load (Kg/day)
4vi	6.8	29.35	.48827
16vi	2.79	12.49	.08525
23vi	2.68	20.61	.13513
1vii	19.94	27.195	1.32666
8vii	4.00	22.30	.21823
22vii	4.57	8.78	.09816

ALLEN BROOK

Date	Discharge (c.f.s.)	PO_4-P (μg/l)	Load (Kg/day)
4vi	2.07	225.	1.13946
16vi	1.04	39.53	.10058
23vi	1.24	44.59	.13527
1vii	1.76	49.32	.21236
8vii	4.96	87.8	1.06542
22vii	0.82	23.64	.04742

POND BROOK

Date	Discharge (c.f.s.)	PO_4-P (μg/l)	Load (Kg/day)
4vi	2.71	28.87	.19141
16vi	0.219	26.689	.01430
23vi	0.45	26.70	.00305
1vii	3.56	27.70	.24125
8vii	4.00	22.30	.21823
22vii	0.33	20.27	.01636

time of Hurricane Belle, during mid-August, there was an increase in the water level to 98.35 feet. The level then dropped to 97.3 feet by September 8th. It rose slightly until about August 11th and then dropped after that date. 1975 was a low water year as was 1977. In Spring 1977 the high occurred in April and was of the magnitude of 100 feet. However, before we were very far into June the gauges in the wetland were above water, hence readings could not be taken directly. As a result, we relied on the data from the Burlington gauge for water level readings.

4.2.2 Water Temperature

In general, temperatures tend to be higher in the emergent zones as opposed to the submergent-floating zones, because of shallow water. Temperatures were also quite high, relatively speaking, near the shore zones. The overall pattern tends to follow the seasonal pattern. In spring and fall when the tributaries tend to follow more closely the lower atmospheric temperatures, waters entering from the tributaries into the wetland will be at slightly lower temperatures than the water within the wetland itself. During the summer months tributary waters can and do warm up as high as the open water areas within the wetland and as a result no significant changes are noted. Stations near the lake (Stations 1,2 and sometimes 3) are influenced by wind-blown waters from inner Malletts Bay and the temperatures at these stations reflect the lower temperature of the open bay waters.

4.2.3 Dissolved Oxygen

In submergent zones at depths of 0.8 to 0.9 meters, a dissolved oxygen gradient would frequently be noted during the summer. Dissolved oxygen values range from 5.0 ppm or 62.6% of saturation at the surface to 1.5 ppm or 17.4% of saturation near the bottom in water slightly less than 1 meter in depth (see Table 5). These measurements were observed on July 15, 1976, when the lake level was 97.3' (29.66 m). At other times the dissolved oxygen values at the bottom were extremely low approaching and reaching complete deoxygenation. At the same time, one occasionally observed dissolved oxygen measurements close to 100% saturation in the surface waters, obviously the result of photosynthetic activity.

4.2.4 pH

The pH values obtained almost always ranged between 7.0 and 8.0. Only on rare occasions did the pH drop, and then only very slightly, below neutrality.

4.2.5 Alkalinity

Alkalinity values in the tributaries and in the wetlands were considerably higher than those found within the adjacent bay or in the open lake. Within the tributaries the ranges of alkalinity concentrations fell between 55 to 100 ppm. Similar readings were obtained at stations within the wetlands. In the adjacent area in inner Malletts Bay, readings were in the order of magnitude of 32 to 37 ppm. At times there was a noticeable decrease at the lower stations, Stations 1 and 2, probably the result of a mixing of bay water entering into the wetlands through the narrow portal.

4.2.6 Specific Conductance

Specific conductance, or conductivity, has been found to be higher in the tributaries and in the wetlands than in the adjacent bay areas. Values for tributaries average between 250 and 350 μmhos the majority of the time while in the bay readings of 110 to 135 μmhos are usual values. There is very little variation within the wetlands either within or between emergent or floating zones or between stations. Again, on occasion when the wind is

TABLE 5

Physical and chemical characteristics observed along two transects on July 15, 1976. S = surface, B = near the bottom.

Station		Depth m	Temp °C	pH	Cond. µmhos.	D.O. ppm	% Sat. D.O.	T.A. mg/l	Total PO_4-P µg/l
<u>Transect A</u>									
1. Shore- Swamp Forest		0.21	25.0	6.90	315	2.2	27.1	99.75	29.4
2. Emergent	S		27.0	7.11	305	6.0	76.3	95.5	38.8
Equisetum	B	0.6	25.0	7.08	300	6.0	73.9	93.4	110.1
Bull rush	S		26.0	7.30	305	4.8	60.1	96.5	83.0
	B	0.7	23.0	7.0	310	1.5	17.9	92.7	98.9
3. Floating	S		25.0	7.28	295	4.4	54.3	101.3	54.7
	B	0.9	21.5	7.25	325	1.5	17.4	92.2	44.7
4. Channel	S		23.5	7.18	320	4.3	51.7	85.2	30.6
	B	2.5	20.5	7.16	360	4.5	51.4	39.7	48.3
5. Floating	S		27.5	7.60	245	7.0	89.6	92.7	61.8
	B	0.8	22.0	7.03	320	2.5	29.3	86.0	71.6
6. Emergent	S		26.0	6.85	280	5.0	62.6	88.8	77.7
Bur reed	B	0.5	22.5	6.65	270	2.5	29.6	91.4	94.8
7. Shore- Meadow	S		24.5	6.62	250	2.5	30.6	72.4	106.5
	B	0.5	20.5	6.60	250	1.0	11.4	94.7	85.9
<u>Transect C</u>									
1. Swamp Forest		0.2	20.0	7.0	250	5.5	62.2	96.5	50.6
2. Floating	S		23.0	7.43	240	8.5	101.4	103.0	30.0
	B	0.9	20.0	7.09	240	3.5	39.6	97.4	73.6
3. Channel									
	S		22.0	7.11	410	2.5	29.3	129.8	58.9
	B	0.8	20.0	7.08	300	2.0	22.6	129.0	70.6

blowing bay water into the wetlands some decrease at the lower stations was noted.

4.2.7 Biochemical Oxygen Demands

Readings tended to be only slightly higher in plant zones than was found in the tributary channels within the wetlands, although B.O.D. values never reached significantly high levels (Table 6).

4.2.8 Organic Nitrogen

Analyses for organic nitrogen are still in the processing stage and data are not yet available. When analyses are completed the results will be included in a supplementary report.

4.2.9 Total Phosphorus

Variations in total phosphorus were found to occur along the transects when samples were taken and analyzed. The highest readings were found in the emergent zone and lowest readings in water located in the floating-submergent zones and in the channels. Examples of samples taken from two different years, 1976 and 1977, are included in Table 7 and we believe the variations that can be observed are a reflection of the differing water levels, the water level being significantly higher in 1976 than 1977.

4.2.10 Reactive Phosphorus

Stations 1 through 10 in the wetlands have been examined on a number of occasions. In Table 8 data are cited from four sampling dates ranging from June 16 through September 17, 1976. It can be noted that the concentration in the tributaries is generally significantly higher than those in the wetland waters. There is also a seasonal decrease there tending to be a drop from June through September.

TABLE 6

Summary of trends of biochemical oxygen demand of the four influent tributaries, the ten channel stations, and in three zones of vegetation. Average values in mg/1, 5-day B.O.D. Refer to Figure 1.

Pond Brook	1.43
Indian Brook	1.72
Allen Brook	2.03
Malletts Creek	1.48
Station 10	2.30
Station 9	2.48
Station 8	1.86
Station 7	2.63
Station 6	2.22
Station 5	2.34
Station 4	2.88
Station 3	2.85
Station 2	2.18
Station 1	1.59
Shore zone	2.40
Emergent zone	3.01
Submergent zone	1.80

TABLE 7

Total phosphorus concentration observed along transects on two sampling dates. Values in μg/l PO_4-P.

Station	15vii76	9vi77
Transect A		
Shore	96.2	157.75
Emergent *Equisetum*	74.5	135.38
Emergent River bullrush	90.9	75.34
Floating	66.7	44.15
Channel	39.4	62.98
Transect B		
Emergent	41.2	201.31
Floating	17.0	102.70
Channel	35.5	----
Transect C		
Swanp forest	50.6	148.33
Floating	51.8	91.24
Channel	64.8	73.9

TABLE 8

Reactive phosphorus concentrations in the four tributaries and 10 wetland stations from June 16 to September 17, 1976. Values in µg/l PO_4-P.

Station	16vi76	8vii76	18viii76	17ix76
Indian Brook	12.49	22.3	24.3	---
Pond Brook	26.7	33.1	11.5	---
Malletts Creek	31.1	48.0	34.5	---
Allen Brook	39.5	87.8	41.0	---
1	7.9	2.8	2.0	4.0
2	12.3	4.2	6.2	3.6
3	14.0	39.7	7.9	6.6
4	13.2	5.5	8.9	5.5
5	16.9	8.8	9.1	4.4
6	13.7	8.4	8.7	4.6
7	12.9	7.8	8.7	3.3
8	18.5	11.2	11.7	4.2
9	12.2	7.7	6.6	6.0
10	25.7	6.8	6.9	3.2

4.2.11 Cations

Concentrations of calcium and magnesium are rather constant for the tributaries and the wetland stations, although significantly lower in the inner Malletts Bay area. Calcium tends to range from 26 to 30 mg per liter in both the tributaries entering the wetlands and at the wetland stations while the bay area tends to be reasonably constant at about 12 ppm. Magnesium ranges from about 7 to 14 ppm in both the tributaries and the wetlands while in the bay area the concentration tends to remain relatively constant at approximately 3 ppm. Potassium also remains relatively constant varying from approximately 1 to 3 ppm in the tributaries and in the wetlands and about 1 ppm in the adjacent bay area. Sodium seems to be the only one of the four cations which shows a greater variation ranging from 6 to 27 ppm in the four tributaries varying from about 6 to 16 ppm at different stations within the wetlands. At the same time measurements in the adjacent bay area are the order of 4 ppm.

4.3 Horizontal Distribution of the Vegetation

There is a typical variation in the species of plants that are found, variation appearing with depth. One can identify a shore zone, an emergent zone which is typically shallow, a submergent-floating zone and also the mainstream channels. In addition, the swamp forest areas are obvious because of the shallow nature and the tree growth, the trees being predominantly silver maple and white ash.

4.3.1 Morphometry Determined from Line Transects

In taking depth measurements along the transects some rather significant observations were made. One would reason a priori that there would be a gentle slope from the terrestrial zone into shallow water and that the bottom would tend to continue to slope gently out toward the main channel. However, what was observed at Transect A and B particularly was that there was a very significant steep shore zone at elevations of the most frequently occurring water levels, ranging from 97.4' to 95.8' in elevation (29.7 to 29.2 m). This rapid drop was noted within 10' (3 m) of the horizontal distance from the water's edge immediately following the sharp drop in the short horizontal distance. The bottom remained almost horizontal for at least 328' (100 m) from the shoreline toward the main channel (Figure 3). At about this point there is a slow increase in depth to the edge of the channel at approximately 95' (29 m) at about 492' (150 m) from shore. When the water level dropped to the lower reading of 95' (29 m) the emergent zone became dry with a shallow zone of water appearing at the edge of the channel.

4.3.2 Transects

Numerous observations were made on the horizontal distribution of plant species along Transects A, B and C during the course of the summer. For the purposes of this report, however, a presentation will be made of the southern part of Transect A with results indicated from three observation dates, those being June 29, 1976, August 11, 1976, and June 9, 1977 (Figures 4, 5 and 6). Nineteen seventy-six, as has been mentioned, was a high water year and there is definitely a tendency for the floating-submergent zones to be expanded at higher water levels and to be contracted as the water levels drop, the areas gradually being taken over by emergent vegetation. As an example, the river bullrush exhibited an intermittent pattern in 1976 being found near the shoreline and being found along some considerable portion of the transect near the channel. In 1977, the river bullrush was only near the channel. There was an obvious decrease in water level and

Figure 3. Morphometry of Transect A illustrating steep shoreline and horizontal emergent zone extending to channel.

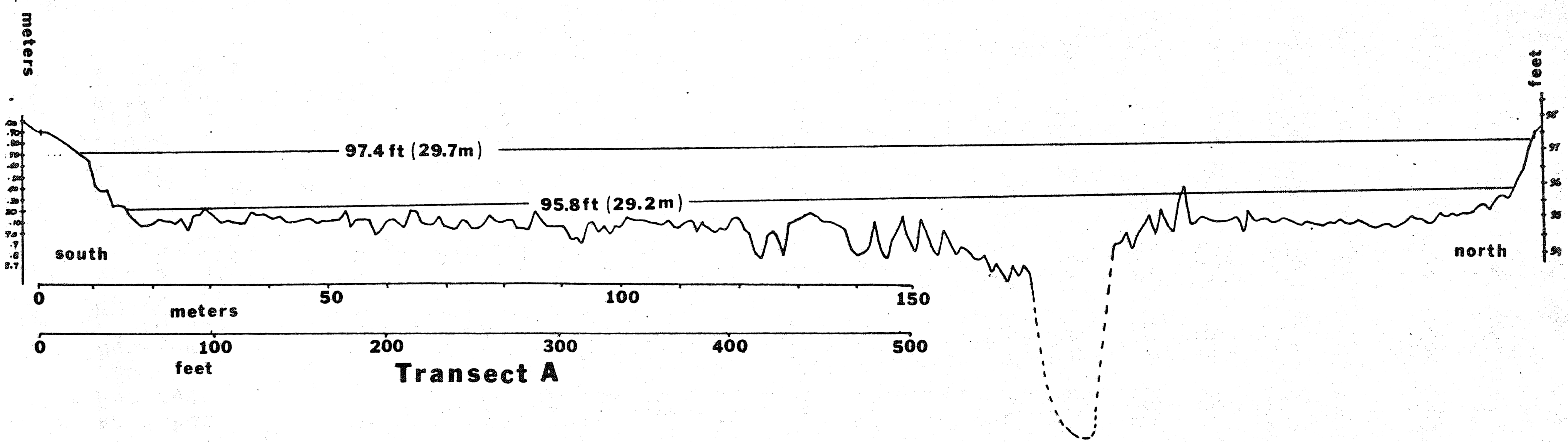


Figure 4. The distribution of aquatic flora along Transect A-South on June 29, 1976. Lake level 97.40' (29.69m).

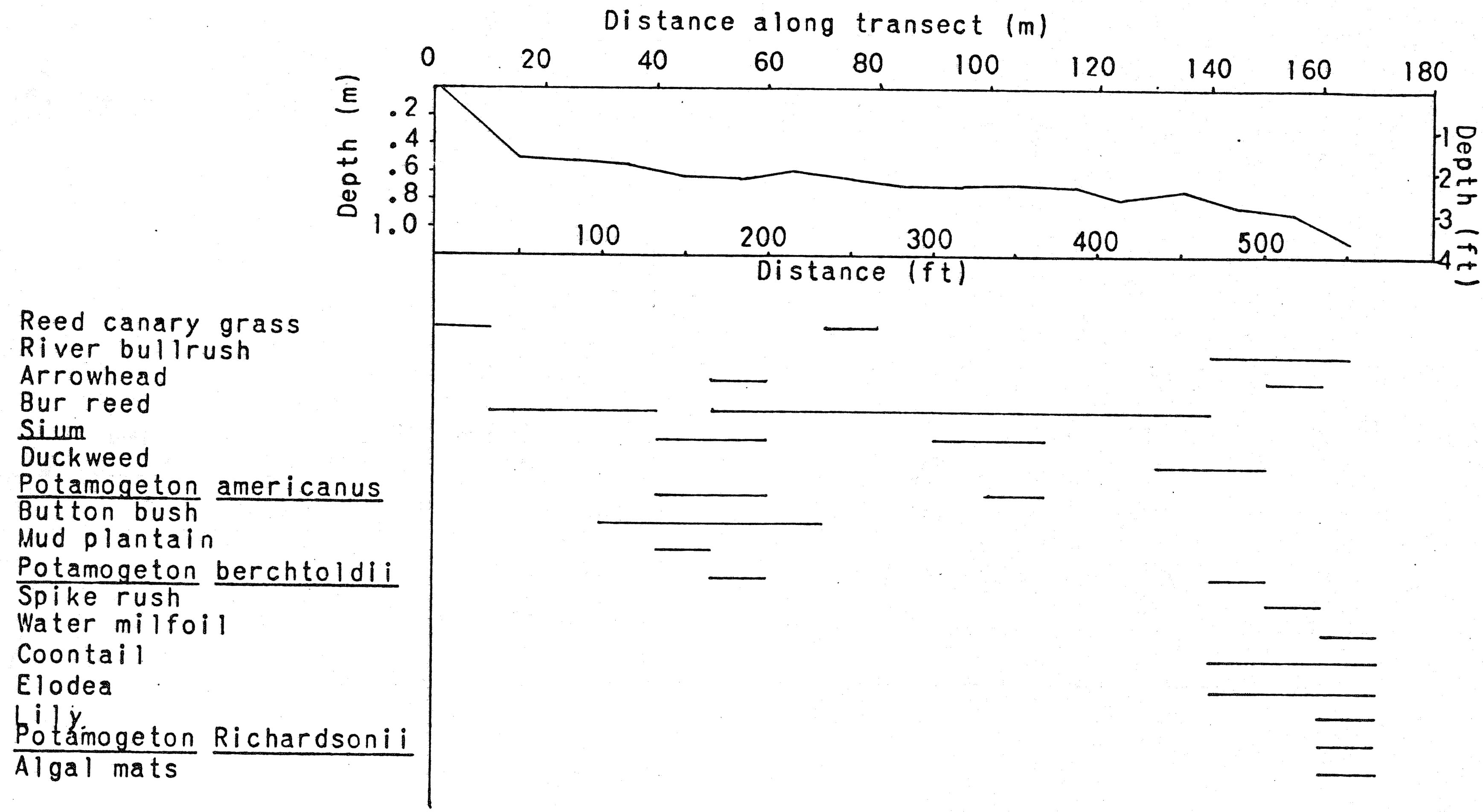


Figure 5. The distribution of aquatic flora along Transect A-South on August 11, 1976. Lake level 97.50' (29.72m).

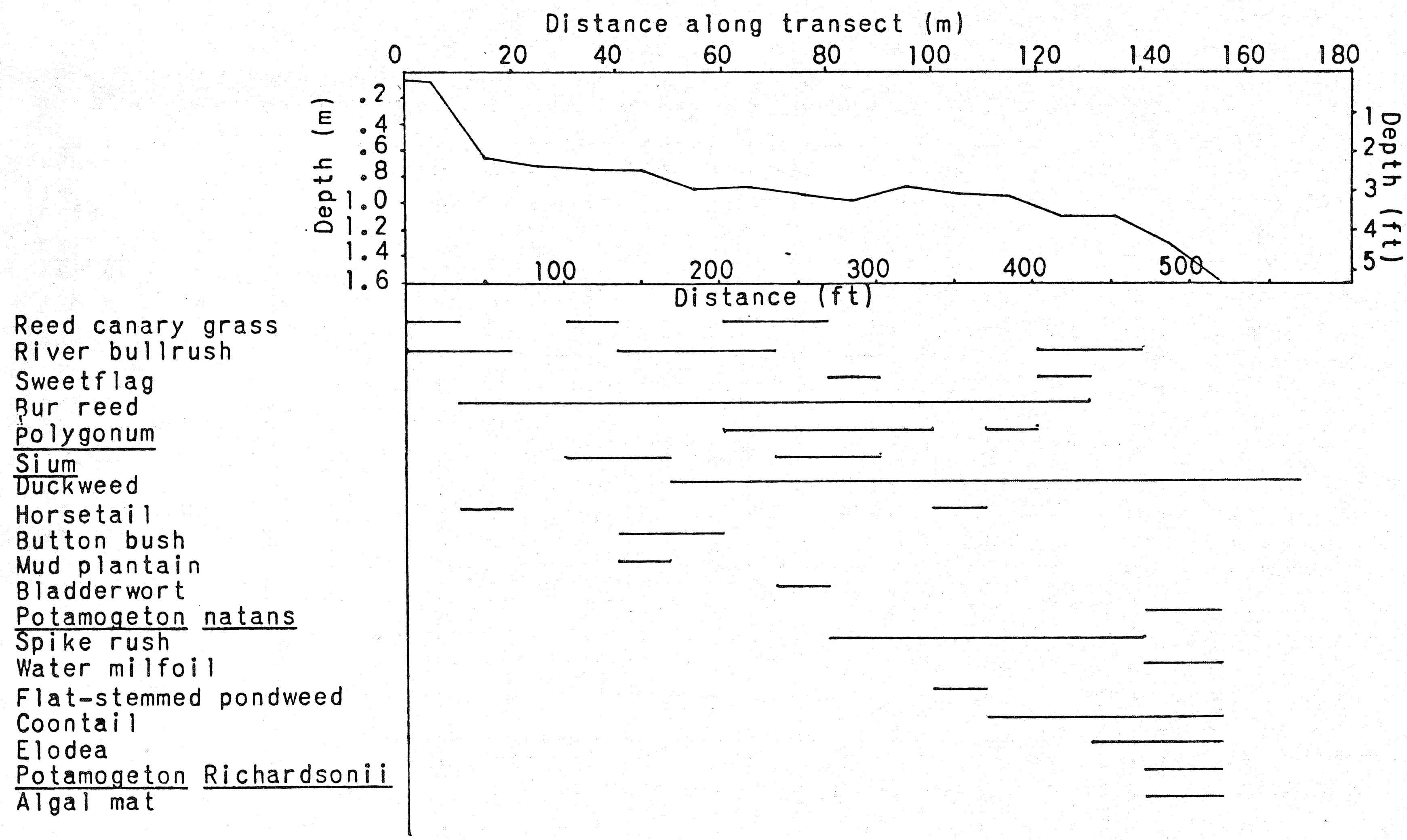
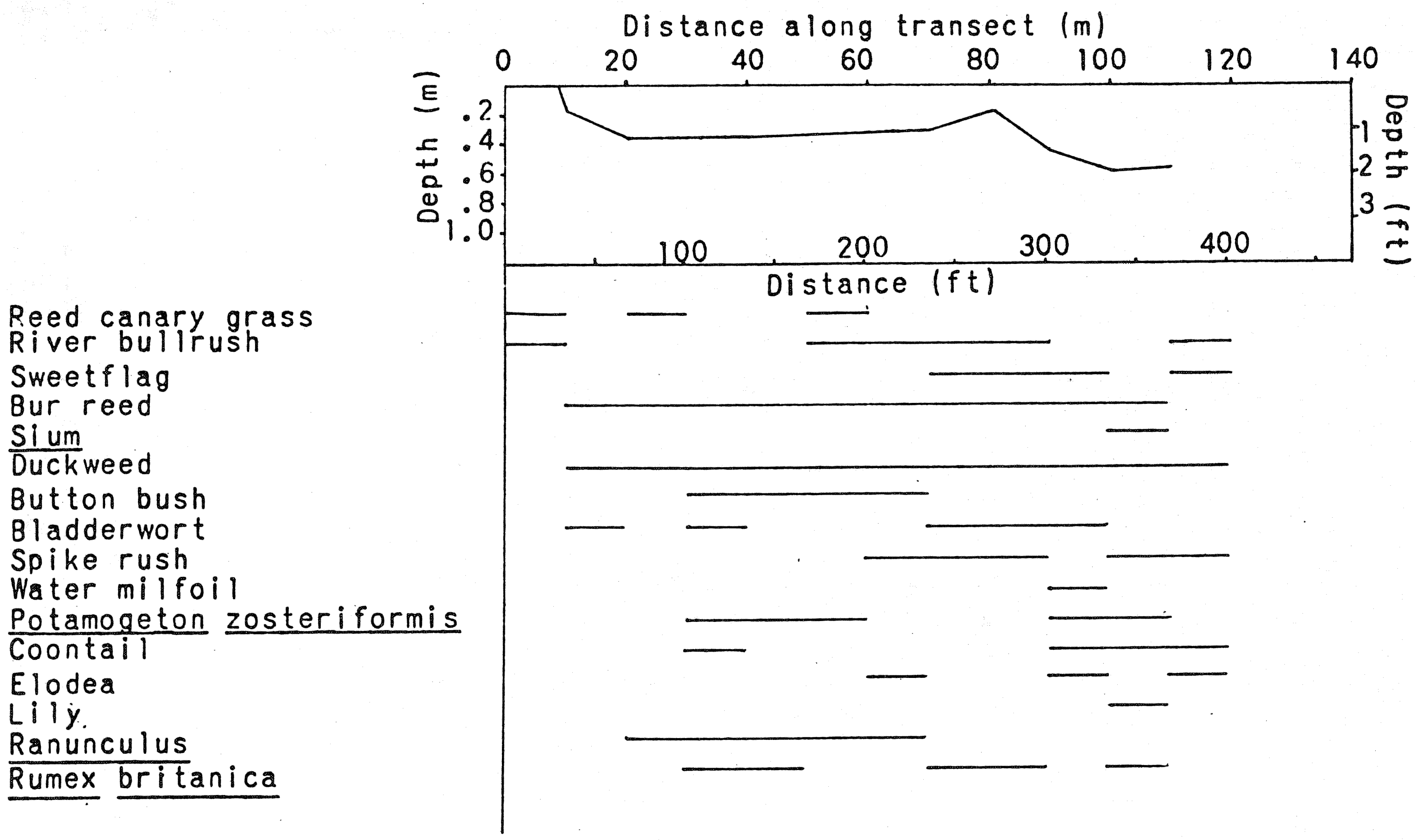


Figure 6. The distribution of aquatic flora along Transect A-South June 9, 1977. Lake level 96.35' (29.37m).



in the depth of the water covering the bottom near the shore. In Figures 4 and 5, demonstrating patterns which were exhibited during 1976, there is an obvious tendency toward zonation of the various species found. In Figure 6, showing the 1977 study, the water was shallower and the zonation much less obvious. One can observe that intermittent patterns are predominant from near the shore to the region of the main channel. When one observes specific plant species it can be seen that some plants tend to show an intermittent distribution from the shore to the channel. A few will extend over a considerable distance from near shore toward the channel while others are found only in the deeper water near the main channel.

4.3.3 General Distribution of the Plants

To date distributions have been limited to the transects and to the quadrats and have not been extended to other areas of the wetlands. It is hoped that we can obtain general plant distribution information from other contractors and that general distribution information can be included in a supplementary report.

4.4 Quantitative Distribution of the Flora

4.4.1 Numerical Determination of Abundance

We have collected a significant amount of information from quadrats along the transects during the period of study. For purposes of presentation here a single example will be given of three sets or three quadrats taken along Transect A-South on June 19, 1976. The first zone from which three quadrats were taken ranged from 13.1 to 59.1 feet (4 to 18 m) from flora. The second zone ranged from 98.4 to 196.8 feet (30 to 60 m) and the third zone ranged from 362.5 to 459.3 feet (80 to 140 m) from the shoreline. Within the first zone six species of plants were observed within the three quadrat sampled. The mean number of plants found was 172.05/m^2 (Table 9). The dominant plant was Phalaris (reed canary grass). In zone 2 six species of plants were also observed within the three quadrats. However, there was no water parsnip or sweet flag as was present in the zone closest to the shore. However, button bush and Potomageton berchtoldi were found to be present. However, the mean number decreased from 172 to slightly over 89/m^2 and the dominant plant was Sparganium (bur reed). In zone 3, the zone furthest from the shore, five spcies of plants were observed. Sweet flag and water parsnip reappeared. Also, horsetail and cinquefoil were present for the first time. However, lost from the plant assemblage was arrowwood, button bush, bur reed and Potomageton berchtoldi. At this distance and depth the mean number of plants per quadrat decreased to 17/m^2 with the dominant plant being reed canary grass.

4.4.2 Gravimetric Determination of Biomass

Biomass was determined for the plants in the same quadrats as was described in the previous section (4.4.1). Again, as can be observed in Table 9, there is a decrease in biomass, just as there was in number of plants per unit area. The decrease was very significant, dropping from almost 1600 gm/m^2 in zone 1 to 171 gm/m^2 in zone 2 and 131 gm/m^2 in zone 3.

4.4.3 Year-to-Year Changes in the Vegetation

During 1976 and 1977, counts were made along the transects, actual counts being totalled of each species within 1 m intervals along the transect from the shoreline to the main channel. Two examples are cited

TABLE 9

Quadrat Analysis Along Transect A on June 29, 1977.

	Plant Species	Mean No./M^2	Biomass (g/M^2)	Phosphorus Content (g/M^2)
Zone 1	*Phalaris*	134.93	1423.5	2.34
	Sagittaria	6.75	9.6	0.04
	Sparganium	16.87	143.2	0.45
	Sium	1.69	9.0	.02
	Potamogeton natans	1.69	13.0	.03
	Acorus calamus	10.12	----	----
	Total	172.05	1593.3	2.88
Zone 2	*Phalaris*	45.54	5.86	0.009
	Sagittaria	1.69	0.74	0.002
	Sparganium	33.73	146.73	0.464
	Potamogeton berchtoldii	3.37	13.92	----
	Potamogeton natans	1.67	4.36	0.009
	Cephalanthus	----	----	
	Total	89.37	171.61	0.484
Zone 3	*Acorus calamus*	5.06	40.63	----
	Sium	5.06	2.07	0.005
	Equisetum	3.37	2.66	----
	Cinquefoil	3.37	86.06	----
	Potamogeton natans	0.37	0.407	0.0005
	Total	17.23	131.8	----

here to indicate the typical pattern observed (see Tables 10 and 11). For Transect A observations made on June 29, 1976 are compared with observations on June 9, 1977. The transect is divided into two regions, the first ranging from the shore toward the channel for 59 m and the second ranging from 60 to 119 m. For example, as can be seen in Table 10, Lemna was observed in two of the 59 one-meter intervals in 1976 while it was present in 48 to 59 in 1977. The data change in one-meter intervals was calculated. For Transect C (Table 11) are observed June 21, 1976 and June 20, 1977 the two zones which were examined at ten-meter intervals ranged first from the shoreline to 35 m and the second from 36 m to 76 m from the shore. In this case, 14 species showed an increase in the one-meter intervals found.

4.5 Phosphorus Content of the Plant Material

4.5.1 Average Content of the Dominant Species

Table 9 also indicates the phosphorus concentration in each of the species found in the three zones in which quadrats were taken along Transect A. In zone 1, the greatest phosphorus concentration was found, it being 2.88 gm/m^2. In zone 2 there was a very significant decrease to 0.484 gm/m^2 while in zone 3 insufficient measurements have been made to determine this. In zone 1 the dominant species, reed canary grass, made up 2.34 gm of the total or 81% of the total 2.88 gm/m^2. In zone 2 bur reed made up .464 or 96% of the .484/m^2 phosphorus concentration.

4.5.2 Total Phosphorus Concentration of the Vegetation

To date we have insufficient data to extrapolate from the measurements we've made in square meter quadrats or from transect analyses to the wetlands area as a whole. We hope that we can receive some help in terms of

TABLE 10

Changes of occurrence of flora in Transect A(S) between 29vi76 and 9vi77. Numbers represent positive occurrence in a 1-meter length of the transect; percentage values give the total percentage.

	0-59m		60-119		Total	Percentage of meters		
	1976	1977	1976	1977	Change	1976	1977	Change
Lemna	2	48	0	55	+ 101	1.67	85.83	+ 84.16
Potomogeton zosteriformis	0	30	0	26	+ 56	0.0	46.67	+ 46.67
Rumex Britannica	0	26	0	30	+ 56	0.0	46.67	+ 46.67
Utricularia minor	1	18	0	31	± 48	0.83	40.83	+ 40.00
Ranunculus flabellaris	0	32	0	14	+ 46	0.0	38.33	+ 38.33
Ceratophyllum demersum	0	14	0	31	+ 45	0.0	37.50	+ 37.50
Scirpus fluviatilis	5	23	0	26	+ 44	4.17	40.83	+ 36.66
Anacharis canadensis	0	6	0	32	+ 38	0.0	31.67	+ 31.67
Eleocharis robbinsi	0	1	10	44	+ 35	14.35	37.50	+ 23.15
Acorus calamus	5	2	1	27	+ 23	5.00	24.17	+ 19.17
Lily	0	0	0	11	+ 11	0.0	9.17	+ 9.17
Cephalanthus occidentalis	25	32	12	15	+ 10	30.83	39.17	+ 8.34
Polygonum amphibium	2	2	0	7	+ 7	1.67	8.89	+ 7.22
Equisetum sp.	6	11	3	4	+ 6	7.50	12.50	+ 5.00
Myriophyllum sp.	0	0	0	5	+ 5	0.0	4.17	+ 4.17
Sparganium sp.	36	45	56	50	+ 3	76.67	79.17	+ 2.50
Phalaris arudinacea	12	27	13	0	+ 2	20.83	22.50	+ 1.67
Potomogeton natans	2	0	1	0	- 3	2.50	0.0	- 2.50
Heteranthra sp.	12	0	0	1	- 11	10.00	0.83	- 9.17
Sagittaria rigida	17	6	5	3	- 14	18.33	7.50	- 10.83
Sium suave	22	9	16	13	- 16	31.67	18.33	- 13.34
Potomogeton Berchtoldi	12	0	8	0	- 20	16.67	0.0	- 16.67
Potomogeton americanus	15	0	14	0	- 29	24.17	0.0	- 24.17

Lake Levels
29vi76 97.40' (29.69m)
9vi77 96.35' (29.37m)

TABLE 11

Changes in occurrence of flora in Transect C between 21vi76 and 20vi77. Numbers represent positive occurrence in a 1-meter length of the transect; percentage values indicate the total percent.

	0-35m		36-76m		Total	Percentage of meters		Change
	1976	1977	1976	1977	Change	1976	1977	%
Lemna	6	26	14	22	+ 28	26.3	63.2	+ 36.9
Sium suave	0	19	0	0	+ 19	0	25.0	+ 25.0
Ceratophyllum demersum	0	4	10	22	+ 16	13.2	34.2	+ 21.0
Rumex Britannica	0	1	0	14	+ 15	0	19.7	+ 19.7
Sparganium	1	10	0	3	+ 12	1.30	17.1	+ 15.8
Scirpus fluviatilis	1	0	2	16	+ 13	3.9	21.0	+ 17.1
Anacharis canadensis	0	4	12	22	+ 14	15.8	34.2	+ 18.4
Algal mat	0	5	1	4	+ 8	1.30	11.8	+ 10.5
Moss	0	6	0	0	+ 6	0	7.9	+ 7.9
Potamogeton zosteriformis	0	4	10	10	+ 4	13.2	18.4	+ 5.2
Utricularia minor	0	0	6	9	+ 3	7.9	11.8	+ 3.9
Acorus calamus	1	3	0	0	+ 2	1.3	3.9	+ 2.6
Cephalanthus occidentalis	7	7	16	18	+ 2	30.3	32.9	+ 2.6
Silver Maple	2	3	0	0	+ 1	2.6	3.9	+ 1.3
Potamogeton natans	0	0	9	8	- 1	11.8	10.5	- 1.3
Phalaris arvdinacea	14	12	0	0	- 2	18.4	15.8	- 2.6
Potamogeton Richardsonii	0	1	3	0	- 2	3.9	1.3	- 2.6
Potamogeton epihydrous	2	0	0	0	- 2	2.6	0	- 2.6
Ranunculus flabellaris	21	21	3	0	- 3	31.6	27.6	- 3.9
Myriophyllum	0	0	10	4	- 6	13.2	5.3	- 7.8
Sagittaris rigida	25	25	17	0	- 17	55.3	32.9	- 22.4
Potamogeton berchtoldii	4	0	15	0	- 19	25.0	0	- 25.0
Equisetum	31	20	14	0	- 25	59.2	26.3	- 32.9
Veronica	9	0	16	0	- 25	32.9	0	- 32.9
Heteranthra	15	10	14	0	- 29	38.2	0	- 38.2
Polygonum amphibium	24	0	19	0	- 43	56.6	0	- 56.6

Lake Levels
21vi76 97.55' (29.73m)
20vi77 95.90' (29.23m)

identification of percentage areas of submergent-emergent vegetation within the Munson's Flat or Malletts Creek wetlands as a whole and from this information, then, we would be able to prepare a supplementary report.

4.6 Invertebrate Populations

Certain patterns become clear when one examines the make-up of macroinvertebrates in the emergent zones with those of the floating-submergent zone (Tables 12 and 13).

First, the floating-submergent zone is considerably more productive. In fall of 1976, almost nine times as many were in the submergent zone. In June of 1977, almost three times as many were found in the submergent zone. The great majority of these organisms were isopod and amphipod crustacea. Their greater density appears to be a function of the greater water depth associated with submerged and floating plants. Since they make up a significant part of the diet of smaller fish, their abundance becomes very meaningful.

A greater proportion of the taxa found in the floating-submergent zone tend to be detritus feeders, while a greater proportion of emergent zone occupants are primary consumers. Tables 12 and 13 indicate the very sharp differences.

The food habits of the dominant swamp forest inhabitants appear to have changed from 1976 to 1977, probably a result of the vastly different water levels. In 1976 this area remained submerged. In 1977, the swamp forest became more typically a terrestrial environment, because of the lower water level.

In the main stream channel, while detritovores remained dominant both

TABLE 12

Benthic macroinvertebrate findings in chicken baskets placed on September 15, 1976 and removed October 19, 1976.

	Floating Submergent Zone	Emergent Zone	Swamp Forest	Malletts Creek Channel
Number of taxa found	24	25	16	18
Number of individuals collected/basket	901	106	61	286
Number of amphipod and isopod crustaceans	485	14	38	251
Primary consumers	29.7%	56.6%	21.4%	2.8%
Secondary consumers	13.3%	28.3%	24.3%	9.1%
Detritovores	57.0%	15.1%	54.3%	88.1%

TABLE 13

Benthic macroinvertebrates collected from chicken baskets placed June 15, 1977, and removed July 19, 1977.

	Floating Submergent Zone	Emergent Zone	Swamp Forest	Malletts Creek Channel
Number of taxa found	45	38	23	32
Number of individuals collected/basket	949	329	62	578
Number of amphipod and isopod Crustacea	281	3	1	270
Primary consumers	63.5%	75.9%	66.1%	35.2%
Secondary consumers	6.5%	19.2%	11.3%	17.5%
Detritovores	30.0%	4.9%	22.6%	47.3%

years, they made up a greater percentage of the species in 1976 than in 1977, again most likely a result of changing water levels.

As examples, the dominant animals in the emergent zone were leeches, midge larvae and snails. In the floating-submergent zone the dominant forms were the amphipod and isopod crustacea, immature dragonflies and damselflies, flatworms and some species of snails.

The feeding patterns tend to indicate that a small percent of organisms follow the usual plant-herbivore-carnivore food chain. Rather, energy and nutrients appear to be stored by plants, which die and are slowly decomposed by bacterial activity. During this time, many species feed on the plant remains (detritus). In some cases, detritovores compose the largest percentage of feeders. Since the bottom of the wetland area is covered with detritus, it is assumed that phosphorus accumulates in this form in the wetlands.

4.7 Phytoplankton Analyses

Munson's Flat exhibits a considerable diversity of phytoplankton. Diatoms are predominant, in number of species and in number of cells observed in samples. Of the diatoms, the most common genus is *Fragilaria*, with *Synedra* and *Navicula* being found with reasonable frequency. The greatest diversity was observed at Station #9 (Fig. 1) and near the shore zone of Transect A-North (Table 14).

Up to eight genera of green algae were identified, with *Mougeotia* being by far the most common genus. *Oedogonium* was fairly common, with *Microspora* present with some regularity. There were few blue-green algae, with *Anabaena* and *Oscillatoria* being the only genera found at each sampling date.

TABLE 14

Total Number of Species of Phytoplankton Found During the Period from June 14, 1977 through August 31, 1977.

	Station # 1	Transect A - North Sh.	Em.	Sub.	Chan.	Station # 9
CHLOROPHYTA Green Algae	6	6	8	7	6	8
CYANOPHYTA Blue-green algae	4	6	2	2	3	5
CHRYSOPHYTA Yellow-green algae	3	3	5	3	4	5
BACILLARIOPHYCEAE Diatoms	15	21	17	12	15	21
EUGLENOPHYTA Euglenoids	1	1	1	1	1	1
PYRRHOPHYTA Yellow-brown algae	1	1	0	0	0	0
Total Number of Species	30	38	33	25	29	40

Along Transect A - North, Sh. = Shore zone, Em. = Emergent zone, Sub. = Submerged and floating zone, and Chan. = the main channel of Malletts Creek.

TABLE 15

Numbers of Species of Phytoplankton Found at Each of the Stations and Their Relative Abundance.

	Station # 1	Transect A - North Sh.	Em.	Sub.	Chan.	Station # 9
CHLOROPHYTA						
No. species identified	6	6	8	7	6	8
Abundant	1	1	1	0	1	2
Occasional	0	1	2	2	1	1
Rare	5	4	5	5	4	5
CYANOPHYTA						
No. species	4	6	2	2	3	5
Abundant	0	1	1	0	0	2
Occasional	1	1	1	2	1	0
Rare	4	4	0	0	2	3
EUGLENOPHYTA						
(Unidentified spp.)	1	1	1	1	0	1
Abundant						
Occasional	1		1			
Rare		1		1		1
Absent					X	
PYRRHOPHYTA						
No. species	1	1				
Rare	1	1				
Absent			X	X	X	X
BACILLARIOPHYCEAE						
No. species	15	21	17	12	15	21
Abundant	3	3	3	2	2	3
Occasional	2	3	2	2	4	2
Rare	10	15	12	8	9	15

Along Transect A - North, x Sh. = Shore zone, Em. = Emergent zone, Sub. = Submerged and floating zone, and Chan. = the main channel of Malletts Creek.

There was a tendency toward a reduction in general at the sampling points along Transect A-North, from the shore zone through the emergent zone to the submergent-floating zone, with a slight increase in the main channel of Malletts Creek.

In summary, few genera occurred in abundance (Table 15), and the total phytoplankton assemblage was not impressive. The process of converting total counts to numbers per unit volume has not been completed and will be included in a supplementary report. The generalization which can be drawn with reasonable confidence is that the phytoplankton do not play a significant role in primary production in the wetland, compared to the contribution made by the higher aquatic plants.

4.8 Zooplankton Investigations

The Juday trap samples (Table 16) were sparse at the time of this sampling, that is, well into autumn. The only cladoceran appearing at all transects was *Ceriodaphnia reticulata*. The nauplii, or very young stages were greatest in abundance but did not compose much of the biomass, because of their small size.

The Birge net samples (Table 17) reflect a somewhat different picture. Having passed through aquatic vegetation, as opposed to the Juday trap method, 21 taxa were collected compared to only 11 found in the Juday samples.

It is evident from Table 16 that the greatest species diversity was along the sides of the channel, in the weedy margins, as opposed to mid-channel, there being an average of 7.5 taxa in the center channel compared with an average of 14 taxa at the side of the channel. For example, of the

TABLE 16

Juday Trap Samples of Zooplankton Collected in Malletts Creek, September 22, 1976.

		Transect A		Transect B			Transect C	
	Center, Bottom	Center, Top	South, Top	Center, Top	Center, Bottom	Center, Top	Center, Bottom	South, Top
Cladocera								
Ceriodaphnia reticula		0.63	0.63	N				
Chydorus sphaericus				O	1.90		0.63	35.56
Eurycercus lamellatus				T				1.90
								1.27
Copepoda				P				
				R				
Nauplii	38.73	43.18	11.43	E	19.05	45.72	28.57	31.11
Cyclopooida sp.				S				
copepodid	6.98			E		1.90	1.27	5.08
Diaptomus sp.	0.63			R				
Cyclops bicusbidatus	1.27			V	0.63			
Cyclops vernalis				E	0.63			
Eucyclops agilis				D				2.54
Ostracoda								
Unidentified	5.08				6.98			0.63

TABLE 17

Species Composition and Distribution of Zooplankton in Malletts Creek from Birge Net Tows, October 6, 1976.

	Transect A			Transect B		
	Center, Top	South, Top	North, Top	Center, Top	South, Top	North, Top
Cladocera						
Alona affinis		X	X		X	X
Alona guttata	X			X	X	
Camptocercus rectivastris		X				X
Ceriodaphnia reticulata	X	X	X	X	X	X
Chydorus sphaericus	X	X	X	X	X	X
Eurycercus lamellatus		X	X		X	
Pleuroxus denticulatus	X	X	X		X	
Simocephalus serrulatis		X	X			X
Copopoda						
Cyclops bicusbidatus		X	X			X
Cyclops vernalis			X			
Eucyclops agilis		X	X		X	X
Eucyclops speratus			X			
Macrocyclops albidus		X	X		X	X
Macrocyclops alter			X			
Harpacta coida			X	X	X	X
Copepodids	X	X	X	X	X	
Copedoda nauplii	X	X	X	X	X	X
Ostracoda						
Unidentified	X	X	X	X	X	X

cladocerans, *Alona affinis*, *Camptocercus*, *Eurycercus* and *Simocephalus* were found only near the edges. The sampling method and replication is incomplete and definite results can only be tentatively accepted.

DISCUSSION AND RECOMMENDATIONS

5.1 Occasional high water levels (above 98.4 feet = 29.99 m) in early spring appear to have no harmful effects on a wetland such as Munson's Flat. In contrast, the snow-melt and spring high runoffs carry peak loads of nutrients into the wetland, much transported by particulate matter in the stream, at a time when there is minimal plant growth in the waters to utilize the nutrients. At the same time, during this time of the year, the water discharged into the flat is spread horizontally over the slightly higher elevations of the wetland, and much of the particulate matter is allowed to settle out over terrain that in late summer during low lake levels becomes part of the terrestrial ecosystem. Those nutrients that are channeled directly to the main lake are therefore reduced in amount.

5.2 However, maintenance of high water levels throughout the growing season have a detrimental effect on many of the emergent plants. As an example, wild rice flourished during 1975 and 1977, lower water years, but was hardly noticeable during 1976, a high water year throughout.

5.3 For best growing conditions, water level should be maintained at about 98.4 ft. (30 m) from late May through June and should not go below 97.4 ft. (29.7 m). From July through the remainder of the growing season, the water level should not be reduced below 95.8 ft. (29.2 m) with 95.1 ft. (29 m) as an absolute minimum. This level permits lateral movement of water through the emergent zone, thus providing needed nutrients, and also maintains an ample submergent-floating zone within the wetland. It is the submergent zone which supports the greatest densities of macroinvertebrates, thereby providing an adequate supply of food for fish.

5.4 A decrease in water level to 95.8 ft. (29.2 m) will result in the following negative effects.

5.4.1 There will be an increase in abundance of shore margin plants, such as reed canary grass, water parsnip, arrowhead, mud plantain and nightshade. These would move toward the channels in the shallower water and tend to crowd the floating and submergent vegetation.

5.4.2 There will be increased competition between the emergent and submergent species, the result being that the emergents will win out. While total plant production would increase, production of macroinvertebrates would decrease when the submergent zone is fenced in between an expanding emergent vegetation on the one side, and a deep channel on the other, preventing expansion.

5.4.3 On the other hand, if the submergent zone is not restricted on the seaward side by a deep channel, but instead is provided with an area of shallow water, the submerged vegetation would have a place in which to move, and thereby would not be so restricted.

5.5 Since a high percentage of the invertebrates are detritus feeders, their depletion will result in an accumulation of dead plant material. With this lowered consumption, the rate of filling of the submergent zones will be increased.

5.6 An increased channelization will result as emergent areas become dry. This will diminish significantly the ability of the wetland to trap nutrients. Instead, they will be transported directly into the lake. In isolated bay areas, this could result in a more rapid rate of eutrophication.

5.7 Lake levels maintained below 95.1 ft. (29 m) during the winter will serve to kill off much of the aquatic vegetation and cause a disruption of the ecosystem causing increased decomposition in the spring and summer, and releasing a greater amount of nutrients into the lake.

5.8 The effects discussed under section 5.4 are not serious when these summer low lake levels take place during infrequent years. Wetland habitats are able to respond to summer low lake conditions and can repair themselves the following year.

5.9 In summary, we believe that there are upper and lower water levels which should be established. Except for early spring runoff, the water level should be no higher than 98.4 ft. (30 m) in early summer, with 97.4 ft. (29.7 m) as a maximum through June. We believe there should also be a minimum level maintained within the wetland. Mid- and late summer minima should not go beyond 95.8 ft. (29.2 m), with 95.1 ft. (29 m) as an absolute minimum. We believe that such regulation will maintain a rigorous, highly productive wetland which will support the fish and wildlife which are so desirable. It will also minimize the rate of evolutionary change of the wetland.

6. BIBLIOGRAPHY

Allen, S. E. (Editor), 1974. Chemical Analyses of Ecological Materials. John Wiley & Sons, New York. 565 pp.

American Public Health Association, 1971. Standard Methods for the examination of water and wastewater. 13th Ed., Wash. D.C. 874 pp.

Bell, R. T., 1971. Handbook of the Malacostraca of Vermont and neighboring regions (Crayfish, sowbugs and their relatives). Privately publ., Dept. of Zoology, University of Vermont, Burlington. 65 pp.

Borror, D. J. and D. M. DeLong, 1964. An introduction to the study of insects. Holt, Rinehart and Winston, New York. 819 pp.

Bourelly, Pierre, 1966. Les algues d'eau douce. Initiation à la systématique. Tome 1: Les algues vertes. N. Boubée & Cie, Paris. 508 pp.

Downer, R. N., 1971. Extreme mean daily annual water levels of Lake Champlain. Vt. Water Res. Res. Rep. 3, 18 pp. with 1 pg. arrata.

Environmental Protection Agency, 1974. EPA National Eutrophication Survey; Report on Lake Champlain, New York and Vermont, EPA Regions I and II. Working Paper No. 154. Pacific Northwest Environmental Res. Lab., Corvallis, Oregon.

Fassett, N. C., 1960. A manual of aquatic plants. Univ. Wisc. Press, Madison. 405 pp.

Fogg, G. E., 1975. Algal cultures and phytoplankton ecology. Univ. Wis. Press, Madison, 2nd Ed. 175 pp.

Gales, M. E., Jr., E. C. Julian, and R. C. Kroner, 1966. Method for quantitative determination of total phosphorus in water. Jour. Amer. Waterworks Assoc., 58:1363-1368.

Golterman, H. L. and R. S. Clymo, 1971. Methods for chemical analysis of fresh waters. Internat. Biol. Prog., Handbook No. 8. Blackwell Sci. Publ., Oxford. 166 pp.

Harman, W. N. and C. O. Berg, 1971. The freshwater snails of central New York. Cornell Univ. Agr. Exp. Sta., Search, Entomology Vol. 1 (2), 68 pp.

Henson, E. B., 1977. A method for calculating the mean daily discharge from small unmeasured Champlain tributaries utilizing information from a large monitored river: A Lamoille River sector as related to discharge into the Malletts Creek wetland. Int. Working Document #1, unpubl. typescr., 10 pp.

________, 1977. Procedure used for calculating total phosphate-phosphorus loadings into the Malletts Creek wetland. Int. Work Doc. #2, unpubl. typescr., 7 pp.

________. Ecology of a Lake Champlain wetland. Verh. int. Ver. Limnol., Vol. 20, in press.

Henson, E. B. and M. Potash, 1976. Materials budgets of Lake Champlain. Completion Rept. to Office of Water Res., U.S. Dept. Int., Proj. No. A-014-VT, 62 pp., mimeo.

Johannsen, O. A., 1937. Aquatic Diptera. Cornell Univ. Agr. Exp. Sta. Memoirs, Part III Chironomidae, Memoir 205, 84 pp., 18 plates, and Part IV. Chironomidae, Memoir 210, 52 pp.

Kantor, J. D., 1976. A zooplankton survey of a marsh wetland of Lake Champlain. Unpubl. Typsch., 8 pp.

Kenk, R., 1944. Freshwater triclads of Michigan. Univ. Mich. Press, Ann Arbor, 59 pp.

Linde, A. F., T. Janisch, and D. Smith, 1976. Cattail--The significance of its growth, phenology, and carbohydrate storage to its control and management. Wisc. Dept. Nat. Res., Tech. Bul. No. 94:27 pp.

Muenscher, W. C., 1928. Aquatic vegetation of the Lake Champlain Watershed. In: A Biological Survey of the Champlain Watershed, N. Y. State Conserv. Dept., Suppl. to 19th An. Rep., pp. 164-185.

________, 1944. Aquatic plants of the United States. Comstock Publ., Ithaca, N. Y., 374 pp.

Mullen, Anne and Diane Noel, 1976. A study of the chemical properties of a transect in Munson Flat. Unpubl. Typescr., 20 pp.

Ogden, E. C., 1974. Potomogeton in New York. N. Y. State Mus. and Sci. Serv., Bul. No. 423, Univ. State of N.Y., 20 pp.

Pennak, R. W., 1953. Freshwater invertebrates of the United States. Ronald Press, N.Y., 769 pp.

Prescott, G. W., 1937. Notes on the algae of Gatun Lake, Panama Canal. Amer. Micros. Soc. 55:501-509.

________, 1951. Algae of the western Great Lakes Area. Comstock Inst. of Sci., Bloomfield Hills, Mich., 946 pp.

Ranney, T. A. and R. J. Bartlet, 1972. Rapid field determination of nitrate in natural waters. Comm. in Soil and Plant Analysis, 3(3):183-186.

Schwoerbel, J., 1970. Methods of hydrobiology. Pergamon Press, Elmsford, N.Y., 200 pp.

Smith, G. M., 1950. Freshwater algae of the United States. McGraw-Hill, N.Y., 719 pp.

Stearns, J. G., 1970. Key to aquatic Gastropoda of Vermont. Undergrad. Res. Diss., Univ. Vermont, Burlington, 15 pp.

Strickland, J. D. H. and T. R. Parsons, 1965. A manual of sea water analysis. Fish. Res. Bd. Canada, Bul. 25, 203 pp.

Usinger, R. L., 1956. Aquatic insects of California. Univ. Cal. Press, Los Angeles, 508 pp.

Vermont Dept. of Water Resources, 1974. Field and laboratory methods manual, Montpelier, Vt., 196 pp. (Mimeo).

Ward, H. B. and G. C. Whipple, 1963. Freshwater Biology. Ed., W. T. Edmondson, John Wiley and Sons, N.Y., 1248 pp.

Weber, C. I., 1971. A guide to the common diatoms at water pollution surveillance system stations. U. S. E. P. A. Res. Center, Cincinnati, Ohio, 101 pp.

Westlake, D. F., 1960. Water-weed and water management. Jour. Inst. of Public Health Engineers LIX(3):148-165.

Williams, W. D., 1970. A revision of North American Epigean species of Asellus (Crustacea: Isopoda). Smithsonian Contr. to Zoo., No. 49. Smith. Inst. Press, Wash., D.C., 80 pp.

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