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A limnological investigation in the lower Saskatchewan River drainage basin prior to operation of a forestry complex at The Pas, Manitoba.

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ABSTRACT

In July, 1967, the first of a series of pre-pollutional surveys on the Saskatchewan River and adjoining areas was initiated. The need for such surveys was stimulated by the proposal to construct and operate a pulp and paper mill at The Pas, Manitoba. Standards of water quality, quantity and quality of benthos and nature of bottom sediments will be established under present environmental conditions. Necessary baseline data will be provided in this manner to determine and assess changes in these factors if such occur after operations have begun.

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as Cedar Lake, the river banks are covered by willows (Salix) which are, in many areas, the only means to determine the position of the submerged banks. On limestone outcrops on Cedar Lake are stands of conifers such as white spruce (Picea glauca), balsam fir (Abies balsamea), and jackpine (Pinus banksiana) mixed with poplar (Populus) and birch (Betula) (Anon., 1960; Anon., 1961).

Hydrology

The headwaters of the North and South Saskatchewan rivers rise near the British Columbia border in the province of Alberta. The two streams join near Prince Albert and the main tributary of the Saskatchewan River crosses into Manitoba at the 54th parallel. Flow is generally in a southeast direction through The Pas to Cedar Lake. The river ultimately enters Lake Winnipeg at Grand Rapids.

The mean discharge of the Saskatchewan River for a 47-year period, from 1913 to 1964, was 23,400 c.f.s. A maximum of 105,000 c.f.s. was recorded on June 11, 1948 and a minima of 1,790 c.f.s. in February, 1930 and on January 19, 1942 (Anon., 1961).

METHODS AND MATERIALS

Location of Sampling Stations

To ensure adequate sampling on the length of the Saskatchewan River between The Pas and Cedar Lake, 15 stations were established at 5-mile intervals (Figure 2). Thirteen stations

were located on two transects in Cedar Lake and one each at Cross Lake and Grand Rapids. Ten stations at 8-mile intervals were established on Lake Winnipeg between Grand Rapids and Birdsnest Point (Figure 3).

Field Collections

At each of the 15 stations on the Saskatchewan River, field data such as depth, dissolved oxygen, water temperature, alkalinity, CO₂, pH and type of bottom materials were recorded.

At stations Δ-1, Δ-3, Δ-4, Δ-6, Δ-7, Δ-8, Δ-9, Δ-11, Δ-12, Δ-13, Δ-14 on the Saskatchewan River and A-2 and A-6 on Cedar Lake, 2 litre water samples were collected with a standard 1,200 c.c. Kemmerer water sampler. These samples were submitted to the Provincial Environmental Health Laboratory for an analysis which included true colour, turbidity, pH, total solids, suspended solids and dissolved solids. From stations Δ-2, Δ-5, Δ-10, and Δ-15 in the Saskatchewan River, A-1, A-4, A-8, B-1, and B-5 on Cedar Lake and one each from Cross Lake and Grand Rapids, similar water samples were submitted to the Health Laboratory for more complete analysis. This included colour, turbidity, pH, calcium, magnesium, sodium, total hardness, alkalinity, bicarbonate, chloride, sulphate, specific conductivity, suspended solids and dissolved solids.

Samples of bottom sediments were taken with a 9-inch Ekman dredge from 8 stations on the Saskatchewan River. These samples were submitted to the Soils Testing Laboratory, Department

Nematoda, Conchostraca and Hirudinea. The Chironomidae were made up of Chironomus sp., Chironomus attenuatus, Chironomus staegeri, Chironomus anthracinus, Cryptochironomus fulvus, Procladius sp., Procladius culiciformis, Calopsectra sp. and various pupae. The genera, Pisidium and Musculium were represented in the Sphaeriidae, and the Gastropoda were made up of the genera Valvata, Amnicola and Helisoma. The genus Caenestheriella made up the Conchostraca, Gammarus, the Amphipoda and Erpobdella punctata the Hirudinea.

Depths and types of bottom materials at the stations sampled on Lake Winnipeg are given in Table VII. Table VIII summarizes the discharge rates, in c.f.s., on the Saskatchewan River and lake levels for Cedar Lake at Easterville for the period of sampling from July 7 to July 14, 1967.

Table IX presents the results of analysis of particle size distribution and organic matter content of the bottom sediments at stations on the Saskatchewan River.

OBSERVATIONS

Limnological Data

From stations on the Saskatchewan River, alkalinity values were from 128 to 152 mg./l. as determined in the field and from 125 to 138 mg./l. as determined by the Health Laboratory (Table II). The slightly lower values obtained by the Health Laboratory were dependent on the length of time samples spent in

transit. Values for the Cedar Lake samples varied from 130 to 153 mg./l. (Table III). Concentrations for calcium were from 41.6 to 44.8 mg./l.; for magnesium, from 11.1 to 13.6 mg./l.; for sodium, from 13.8 to 15.5 mg./l.; for chloride, from 9 to 14 mg./l.; for sulphate, from 42 to 52 mg./l. and for bicarbonate, from 152 to 168 mg./l. These are comparable with results obtained by Reed (1962) for the North Saskatchewan River.

Turbidity values were relatively high at stations on the Saskatchewan River near The Pas, Manitoba. Values decreased toward Cedar Lake as more of the materials in suspension settle out in the region of the delta (Table II). Total dissolved solids are similar at all stations on the Saskatchewan River (Table II). Values for total solids decrease in samples close to Cedar Lake, indicating that the major contribution to total solids are those in suspension (Table II). Dissolved oxygen values were adequate at all stations on the Saskatchewan River and pH values were relatively constant. Oxygen saturations from stations on Cedar Lake were 90% or better, and similar to those recorded by Webb (1965) for mid-summer conditions.

Secchi disc readings were similar to those obtained by Webb (1965) for Cedar Lake. A maximum of 8 feet was recorded at one station, in spite of an extensive zooplankton bloom (consisting of Daphnia and Cyclops).

The quantity of electrolytes present in Cedar Lake is demonstrated by the values obtained for sodium, calcium, magnesium, sulphate, bicarbonate, alkalinity and total dissolved

solids (Table III). Bicarbonate values were higher than those recorded by Webb (1965) but lower than records for either the North or South Saskatchewan River (Reed, 1962). Total dissolved solids ranged from 212 to 248 mg./l. and were comparable with figures obtained by Webb (1965) and Reed (1962) and, as thus, are characteristic of eutrophic lakes.

The results of bottom sediment analysis, presented in Table IX, are intended to serve primarily as a baseline in assessing the effects of the pulp mill operations at The Pas, Manitoba. The present analysis would suggest that the bottom fauna between stations 2 and 8 would be sparse (Table IX). Sediments with a high sand content normally support scanty benthic populations. The organic content of the sediments rises at Station 11 which marks the beginning of the delta of the Saskatchewan River. As the results of benthic sampling indicate a larger and more diverse benthos is supported under these conditions.

Benthos-Saskatchewan River and Cedar Lake

The majority of the benthos from stations on the Saskatchewan River was composed of Sphaeriidae and Oligochaeta (Table IV). It is difficult to ascertain if this is characteristic of the river as a whole since most of the benthos was collected from a few stations close to Cedar Lake (Table IV). Since the sampling methods employed proved inefficient, it may be necessary, in subsequent years, to employ artificial substrate samplers.

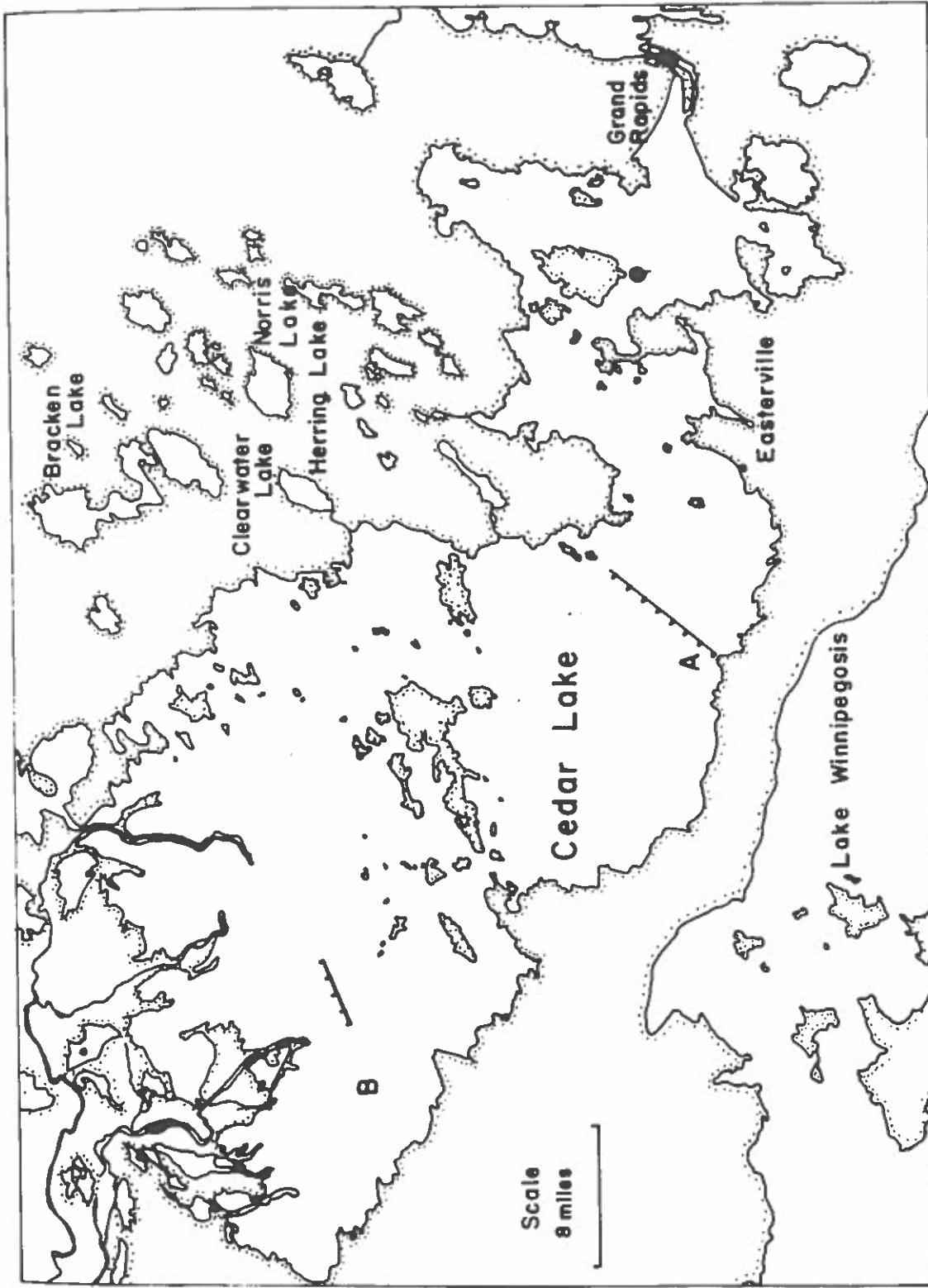


Figure 1. Transects and sampling stations on Cedar Lake during the summer of 1967.

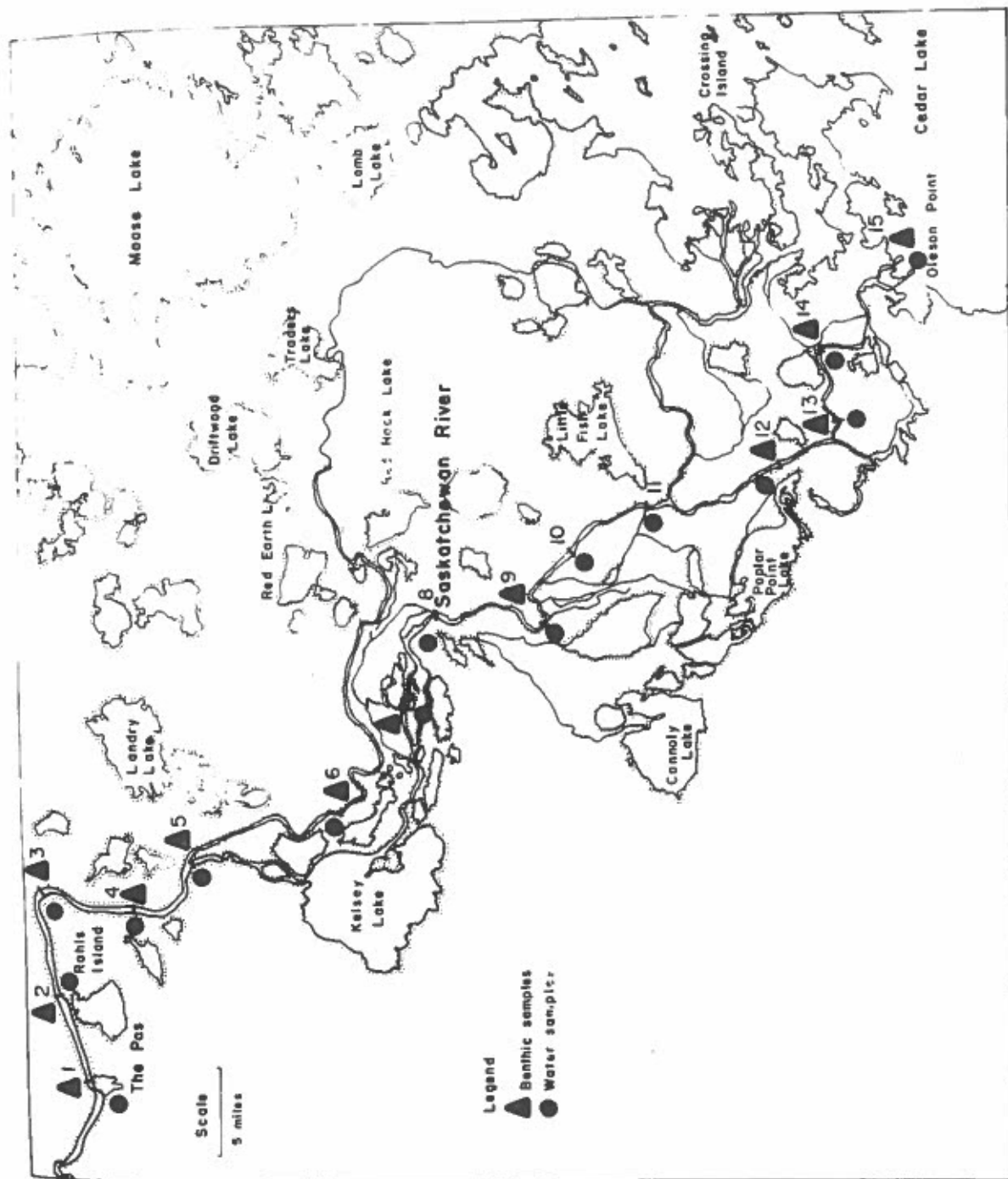


Figure 2. Sampling stations on the Saskatchewan River - July 1967

date

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Table I. Limnological data for stations sampled on the Saskatchewan River and Cedar Lake, July, 1967.

Station	Depth in Feet			D.O. mg./l.	Secchi	O ₂ % Sat.	Temp. C°	Alka- linity mg./l.	CO ₂ mg./l.	pH
	1/3	1/2	2/3							
Δ - 1	22	27	-	8.5	-	90	18.6	138	7.04	8.0
Δ - 2	18	-	14	8.1	-	91	18.3	152	1.76	8.0
Δ - 3	15	-	-	9.1	-	96	18.6	128	1.76	8.0
Δ - 5	22	-	-	8.4	-	86	17.2	140	8.8	7.8
Δ - 7	-	-	-	8.8	-	93	-	144	5.28	8.3
Δ - 9	-	-	-	8.9	-	93	18.3	128	14.08	7.2
Δ - 11	-	29	-	9.4	-	98	18.0	138	7.04	8.0
Δ - 13	14	20	9	7.8	-	78	16.6	150	8.8	8.1
A - 1		20		9.0	2	92	18.3	126	7.04	7.5
A - 2		37½		9.4	4½	95	"	138	7.04	8.1
A - 3		29		9.1	6	94	"	136	5.28	8.1
A - 4		40		9.0	7½	92	"	-	3.52	7.9
A - 5		39		9.5	8½	96	"	138	3.52	8.2
A - 6		38		9.3	5½	94	"	136	3.52	8.2
A - 7		35		9.4	5	95	"	136	5.28	8.1
A - 8		26		9.1	5½	93	-	134	5.28	8.2
B - 1		-		9.0	-	92	-	142	3.52	8.0
B - 5		19		9.1	-	96	-	136	1.76	8.0

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Table II. Chemical analysis of water samples taken at stations on the Saskatchewan River July, 1967, as reported by the Provincial Environmental Health Laboratory.

Stations	True Colour	Turbidity Units	pH	Ca mg./l.	Mg mg./l.	Sodium mg./l.	Total Hardness CaCO ₃	Alkalinity CaCO ₃	Bicarbonate mg./l.	CO ₃ Carbonate mg./l.	Cl ⁻ mg./l.	Sulphate mg./l.	Specific Conductivity OHMS	Total Solids mg./l.	Suspended Solids mg./l.	Dissolved Solids mg./l.
Δ-1	15	50	7.7	-	-	-	-	-	-	-	-	-	-	350	122	228
Δ-2	20	20	7.57	43.2	13.6	14.5	164	131	160	nil	9	50	330	299	82	217
Δ-3	15	25	7.77	-	-	-	-	-	-	-	-	-	-	325	109	216
Δ-4	15	35	7.56	-	-	-	-	-	-	-	-	-	-	327	117	218
Δ-5	15	20	7.89	41.6	12.6	13.8	156	125	152	nil	10	44	325	316	91	225
Δ-6	20	40	8.0	-	-	-	-	-	-	-	-	-	-	298	86	212
Δ-7	10	20	7.85	-	-	-	-	-	-	-	-	-	-	288	68	220
Δ-8	15	25	7.9	-	-	-	-	-	-	-	-	-	-	344	133	211
Δ-9	20	25	7.94	-	-	-	-	-	-	-	-	-	-	294	70	224
Δ-10	20	25	7.90	44.8	11.1	15.5	158	131	160	nil	10	52	340	368	134	234
Δ-11	15	30	7.68	-	-	-	-	-	-	-	-	-	-	317	98	219
Δ-12	20	35	7.78	-	-	-	-	-	-	-	-	-	-	353	121	232
Δ-13	10	10	7.8	-	-	-	-	-	-	-	-	-	-	290	69	221
Δ-14	20	35	7.7	-	-	-	-	-	-	-	-	-	-	262	21	241
Δ-15	15	9	7.6	41.6	12.6	14.2	156	138	168	nil	14	42	325	239	14	225

CO₃ ~~CO₃~~ ~~Cl~~ ~~Cond~~ ~~TS~~ ~~TDS~~

all

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Table III. Chemical analysis of water samples taken at stations on Cedar Lake, Cross Lake and Grand Rapids, July, 1967, as reported by the Provincial Environmental Health Laboratory.

Concentrations mg./l.	Sampling Stations - Cedar Lake								Cross Lake	Grand Rapids
	A-1	A-2	A-4	A-6	A-8	B-1	B-5			
True Colour	5	5	5	5	10	5	5	5	5	5
Turbidity (Units)	9	6	6	4	4	4	95	4	25	4
pH	8.15	8.1	7.97	8.01	7.92	7.65	7.5	7.9	7.79	7.9
Ca	41.6	-	43.2	-	43.2	40.8	32.0	48	46.4	48
Mg	12.2	-	11.7	-	11.7	11.7	18.9	13.1	13.1	13.1
Na	12.5	-	12.0	-	13.2	12	13.5	13.8	13.2	13.8
Total Hardness	154	-	156	-	156	150	158	174	170	174
CaCO ₃										
Alkalinity <i>alk</i>	134	-	136	-	131	130	133	153	148	153
Bicarbonate <i>HCO₃</i>	156	-	166	-	160	159	162	187	180	187
Carbonate <i>CO₃</i>	3.6	-	nil	-	nil	nil	nil	nil	nil	nil
Chloride <i>Cl</i>	17	-	20	-	23	12	18.5	19	14	19
Sulphate <i>SO₄</i>	36.2	-	42	-	45.1	37.8	46.1	41	44.2	41
Specific Conductivity <i>Cond</i>	325	-	325	-	320	313	380	350	345	350
Total Solids	239	310	227	220	231	218	352	250	303	250
Suspended Solids	21	79	7	6	9	6	39	2	72	2
Dissolved Solids	218	231	220	214	222	212	213	248	231	248

(-) - not done

Table VIII. Discharge rates on the Saskatchewan River and water levels on Cedar Lake at Easterville from July 7 to July 14, 1967.

Date	Saskatchewan River	Cedar Lake - Easterville
July 7	c.f.s. 37,500	841.07
" 8	37,200	841.23
" 9	37,000	841.18
" 10	36,500	841.37
" 11	35,800	841.67
" 12	36,300	841.53
" 13	36,400	841.37
" 14	36,600	841.35

Table IX. Particle size distribution and organic matter content of bottom sediments at stations on the Saskatchewan River, July, 1967.

Stations	Sand %	Silt %	Clay %	Organic Matter %
2	97.71	0.31	1.98	0.14
4	96.33	0.76	2.91	0.15
8	1.58	53.40	45.02	1.86
11	0.94	64.01	35.05	2.10
12	8.86	64.54	26.60	2.27
13	32.85	45.76	21.39	2.81
14	51.10	31.35	17.55	2.38
15	59.99	25.21	14.80	2.62