BAYFIELD RIVER DRAINAGE BASIN STUDY

Surface Water Hydrology, Quality and Biology

April, 1980

Ontario

Ministry
of the
Environment

BAYFIELD RIVER
DRAINAGE BASIN STUDY

Surface Water Hydrology,
Quality and Biology

Water Resources Assessment Unit
Technical Support Section
Southwestern Region

Ministry of the Environment April, I980

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SUMMARY

Historical data for water quality, streamflow and fish kills have been drawn together in this report to provide a documentation of the surface water resources in the Bayfield River.

The water quality data show improvements as a result of the upgrading of sewage facilities in Clinton and Seaforth in the early 1970's. In recent years, however, water quality has declined at Seaforth on an annual and seasonal (May to September) basis. The seasonal decline can be attributed to diffuse sources, principally poor agricultural practices or manure spills, since the only point source at East Huron Produce Limited (Dublin) is remote and does not usually discharge for any extended period in the summer. At Clinton, water quality is degraded but has remained stable in recent years. Considerable improvement in water quality is evident between Varna and Clinton as a result of inputs from Trick's Creek and the Bannockburn River. The annual average and seasonal average total phosphorus concentrations have consistently equalled or slightly exceeded the Ministry of the Environment criterion of 0.03 mg/L. Incorporation of phosphorus into plant tissues during the active growing season is also a factor in the apparent improvement in water quality between Varna and Clinton.

The streamflow data indicate that a "no-flow" condition exists from the headwaters to downstream from Seaforth during extremely dry periods.

The fish kill inventory further stresses the impact of manure spills and other poor farming practices on the Bayfield River. One fish kill was related to a municipal lagoon discharge.

The 1978 survey data include surface water chemistry, bacteriology, streamflow measurements, aquatic plant observations and bottom fauna collections. The chemical and bacteriological data reflect the impact from the Clinton sewage treatment plant, the Seaforth lagoons and diffuse sources. Bacterial levels were elevated throughout the

Basin, particularly during the June survey. At the end of July, about 0.03 cubic metres per second (m^3/sec) (one cubic foot per second (cfs)) of flow disappeared downstream from Clinton. The streambed was dry at the first two concession roads.

The Bayfield River system has profuse *Cladophora* (filamentous green alga) growths. These growths are aesthetically displeasing, foul the stream bed and cause serious dissolved oxygen fluctuations through the photosynthesis-respiration process. In addition, very low dissolved oxygen conditions result in the stream when decomposition occurs.

Collections of bottom-dwelling stream life which reflect water quality were hampered by a lack of streamflow from the headwaters to Clinton. Only forms capable of tolerating somewhat degraded conditions were found upstream from Clinton. At Highway #4, in Clinton, the benthic community was diverse with some intolerant forms being present. The stream was dry downstream from Clinton to the confluence with Trick's Creek. A diverse, pollution intolerant community, indicative of good water quality, was present in Trick's Creek. The Bannockburn River and the lower Bayfield River harboured mostly less sensitive forms, however, intolerant taxa were well represented.

RECOMMENDATIONS

1. The sewage treatment plant at Clinton should be provided with phosphorus removal facilities. An effort should be made to reduce the free ammonia concentration in the effluent so that the Ministry's criterion of 0.02 mg/L un-ionized ammonia is achieved after mixing with the streamflow.

2. The lagoon system at Seaforth should be converted to a no-discharge facility from May 1 to October 31. To reduce the possibility of ammonia toxicity during discharges in low flow periods, aeration of the entire lagoon system or post-aeration should be provided to permit a continuous discharge from

November 1 to April 30.

3. The lagoon systems servicing the Huron Centennial School and the Huronview Home for the Aged should only be discharged during the period April 15 to 30 and November 1 to 30.

4. A survey of wells in the vicinity of the Bayfield River, downstream from Clinton, should be completed to ensure that groundwater quality is not being adversely affected by the infiltration of Clinton's sewage plant effluent into the water table.

5. Additional treatment and phosphorus removal should be afforded to the waste water from the East Huron Produce Limited (Dublin). Effluent Objectives are -

BOD_5	- 30 mg/L
Suspended solids	- 30 mg/L
Total phosphorus	- 1 mg/L

A discharge from the facultative lagoons at this industry should be carefully regulated and staged during the periods April 15 to 30 and November 1 to 30.

6. Efforts should be made to improve sections of the river that have been degraded by ensuring proper planning within the watershed and implementing programs to encourage reforestation, proper farming practices and stream enhancement measures.

7. Agricultural practices such as those outlined below should be implemented to reduce organics, nutrients, solids and bacteriological loadings to the Bayfield River. Farmers should take advantage of manure storage and erosion control subsidies available through the Farm Productivity Incentive Program of the Ministry of Agriculture and Food and other programs through the Ausable-Bayfield Conservation Authority to foster soil conservation and water quality improvements.

a) Fertilizer should be applied at rates recommended by the Ontario Ministry of Agriculture and Food and should be based on soil tests.

b) Runoff from feed lots and silage storage areas should be controlled before reaching streams. Manure and other liquid wastes should be applied to the ground when it is not frozen or saturated and should be well incorporated into the soil to ensure that wastes do not gain direct entry to the watercourse.

c) Livestock access to streams in the basin should be restricted so that direct inputs of animal wastes are reduced and so that erosion of stream banks is reduced.

d) Adequate stream buffers along open channels should be provided to reduce erosion and to retard overland runoff.

e) Agricultural drainage practices should be conducted in a manner to minimize soil losses including the following: use of varying slopes along open drains depending upon soil characteristics (e.g. more gradual slopes required for lighter soils), proper tile outlets, minimal disruption of vegetative cover and/or reseeding of ditch banks following cleanout operations. Grassed waterways should be utilized wherever possible.

f) Where soil conditions permit (i.e. lighter soils), erosion losses should be reduced by leaving corn stubble and other crop residues on the land over fall and winter periods (i.e., spring ploughing) and minimum tillage practices should be followed.

INTRODUCTION

The Bayfield River originates in the Townships of Logan and Hibbert in Perth County and flows through Huron County to discharge into Lake Huron at the Village of Bayfield. The majority of the watershed is intensively farmed. Beef and dairy livestock operations are present as well as some cash-crop farms. The urban areas include the Village of Bayfield, the Town of Clinton, the Town of Seaforth and several smaller communities such as the Hamlet of Dublin.

RECREATIONAL USES

The mouth of the Bayfield River is an important harbour area for recreational craft, especially sailboats. Three marinas are located at the mouth of the river and boating activity is increasing in this area.

Several tent and trailer parks are established on the lower Bayfield River in the vicinity of Bayfield. The Ausable-Bayfield Conservation Authority maintains two park areas along the Bayfield River; a general day use park at Clinton and the Bannockburn Wildlife Area, located at the confluence of the Bayfield and Bannockburn Rivers. The wildlife area is forested and the topography of the river valley is aesthetically pleasing. Hiking is a popular activity in this area. Nature trails have been established and the Ausable-Bayfield Conservation Authority feels there is a need to expand hiking trails in this area and along the lower Bayfield River.

The Bayfield River also provides limited angling opportunities for rainbow trout and salmon during their spring and fall upstream migrations. Areas downstream from Clinton and especially near the mouth of the river receive the most fishing pressure. Trick's Creek has a resident population of brook trout. The main Bayfield River and the Bannockburn River support warm water sport fisheries (e.g. smallmouth bass, northern pike).

WASTE TREATMENT

There are six sewage treatment systems that discharge to the Bayfield River either continuously or seasonally, (Figure 1). The Town of Clinton operates an I800 cubic metre per day (m^3/d) (0.4 million gallon per day (mgd)) continuously discharging treatment plant with chlorination and filtration but no phosphorus removal. By-passing of raw or partially treated sewage during periods of rainfall and snow melt is a frequent occurrence. A summary of 1978-79 effluent data is attached (Table A1 of Appendix A). The data indicate that high concentrations of ammonia and total phosphorus are frequently discharged to the river.

The Ministry of the Environment operates a 12-hectare (30-acre) lagoon system for the Town of Seaforth. The spring and fall discharges are to a small tributary that flows to the Bayfield River. Chemical for phosphorus reduction is added prior to each discharge. Effluent data for 1978 and 1979 are attached (Table A2). The data indicate that a reasonably good effluent is being discharged in late April - early May and during late October.

The Huron Centennial School (Brucefield) has a 0.4 hectare (one-acre) lagoon which discharges in the spring and fall to a tributary of the Bannockburn River. The most recent sample (part of Table A4) was collected in 1976 and indicates that, with the exception of elevated suspended solids, the lagoon was of good quality.

The Huronview Home for the Aged (Clinton) has a one-hectare (2.5-acre) lagoon which discharges in the spring and fall to the Bayfield River. No recent analytical data are available.

The Ministry of the Environment operates the sewage treatment plant at Vanastra (1400 m^3/d - 0.3 mgd) which has secondary treatment, phosphorus removal, chlorination and a discharge to Grant Creek, a tributary of the Bayfield River.

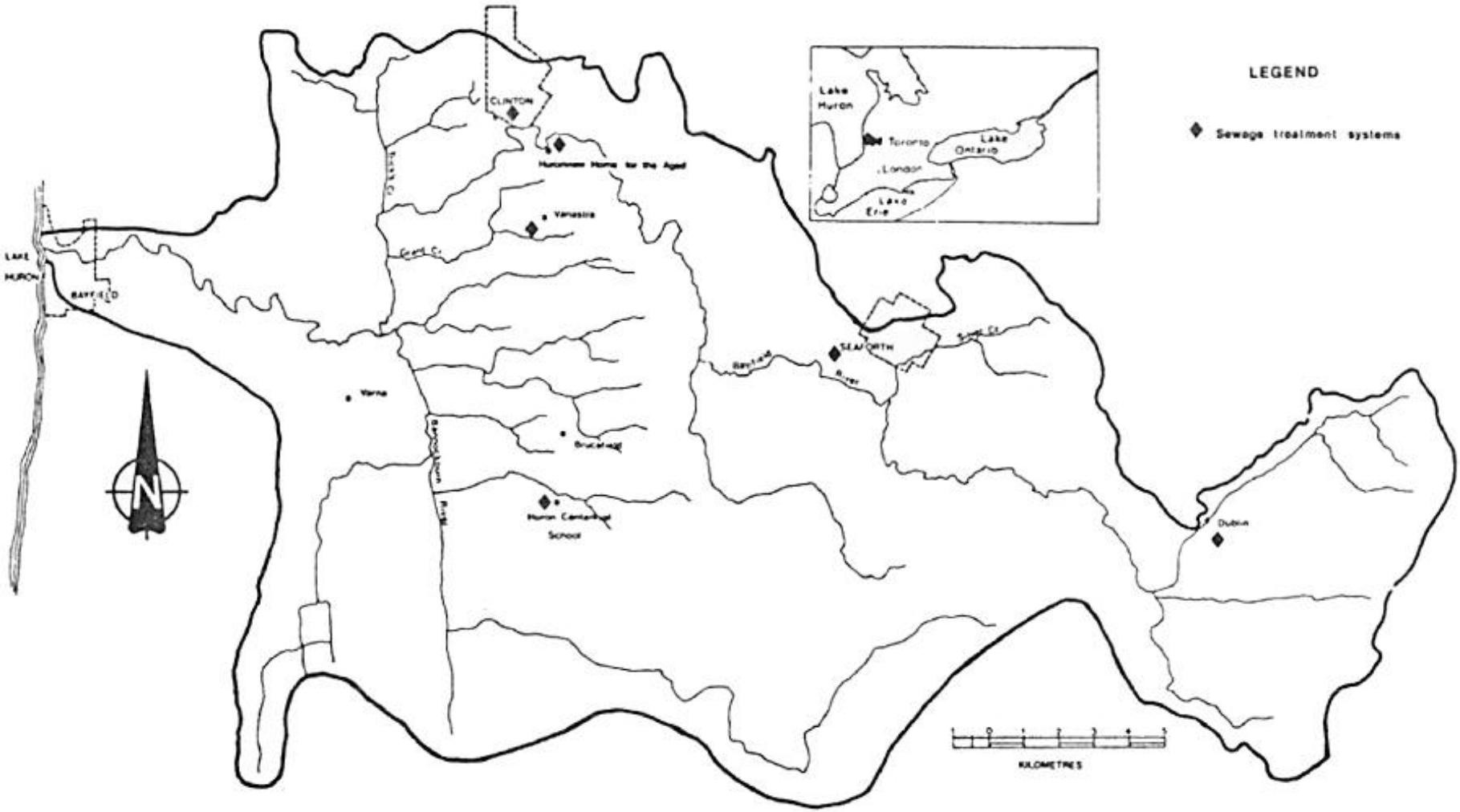

Figure 1. Sewage treatment systems in the Bayfield River watershed.

Effluent data from 1979 are attached (Table A3) and indicate that an excellent effluent is being discharged most of the time. Occasional bacterial counts have been elevated.

East Huron Produce Limited (Dublin) has used a 2-cell, 3.2-hectare (8-acre) lagoon system since the early 1960's to treat waste water from a poultry processing operation The effluent data from recent discharges are attached (Table A4) and indicate the lagoon quality is quite poor.

METHODOLOGY FOR DATA DOCUMENTATION

LONG-TERM MONITORING

Water Quality

A total of 10 long-term monitoring stations have been active at various times in the Bayfield River Watershed (Figure 2) since 1964. Samples were collected monthly by staff of either the Ministry of the Environment or the Ausable-Bayfield Conservation Authority and transported to the Ministry of the Environment's laboratory for analyses. Field measurements were made for dissolved oxygen and temperature.

Water Quantity

Staff of the Ministry of the Environment measured streamflow at Seaforth (02FF101) from 1967 and 1974 and on Silver Creek (02FFI00) from 1966 to 1974 using either Pygmy-Gurley or Ott Current meters. Continuous measurement of streamflow is carried out by the Water Survey of Canada north of Varna (02FF007).

FISH KILLS

Numerous fish kills have been reported in the watershed and investigations were launched for each. Visual documentation and the collection of water samples for analyses were used to determine the sources of the problems. Field measurements of dissolved oxygen and temperature were usually taken.

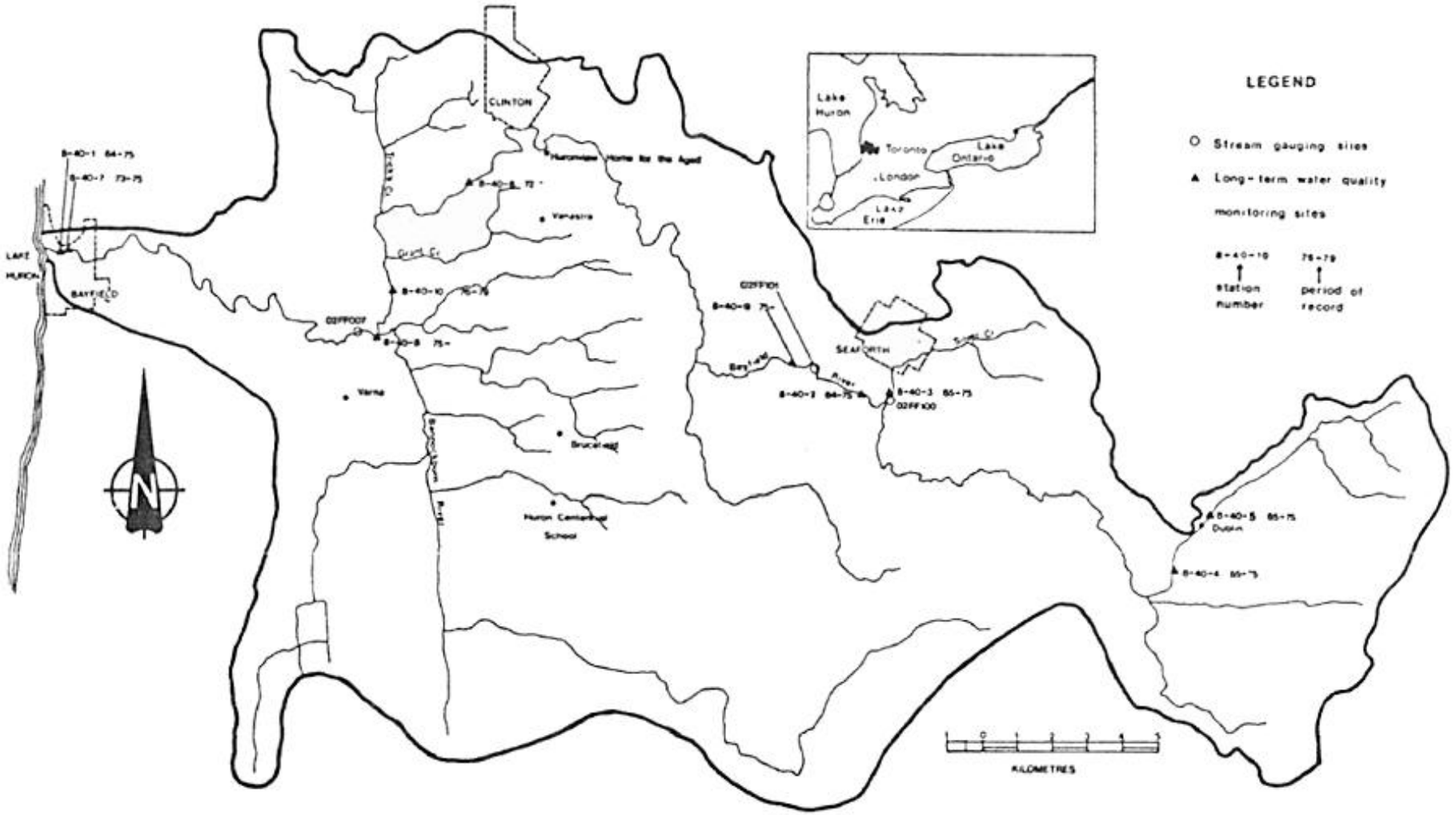

Figure 2. Long-term water quality and stream gauging sites.

SURVEYS

Seaforth

From May 2-4, 1978 an intensive survey of the Bayfield River was undertaken to document the impact of the Seaforth lagoon discharge on the river. Dissolved oxygen and temperature were measured every three hours at 13 stations (Figure 3) using a YSI meter, and continuous measurements were made at three stations using EIL meters. Every six hours, samples were collected for subsequent transport to the Ministry of the Environment's laboratory in London for chemical analyses. Two samples were collected during the survey for bacteriological tests and were transported on ice to the Ministry's laboratory.

The streamflow was measured twice using a Pygmy-Gurley current meter at seven stations in the vicinity of Seaforth.

Clinton

An intensive survey was planned for July 31 August 2, 1978; however, there was no streamflow at two stations immediately downstream from Clinton. Flow measurements were made at four stations further downstream as well as upstream from the Town.

Basin-Wide

Two sets of water quality samples were collected (June 15 and July 31) at 23 locations (Figure 3) to document the river quality in the basin during the summer.

Biology

During August of 1978, collections of bottom fauna were made at nine stations in the Bayfield River watershed (Figure 4). Only qualitative sampling was conducted. Two timed ten-minute qualitative samples taken at each station, produced a total of 52 taxa (Table C4 of Appendix C).

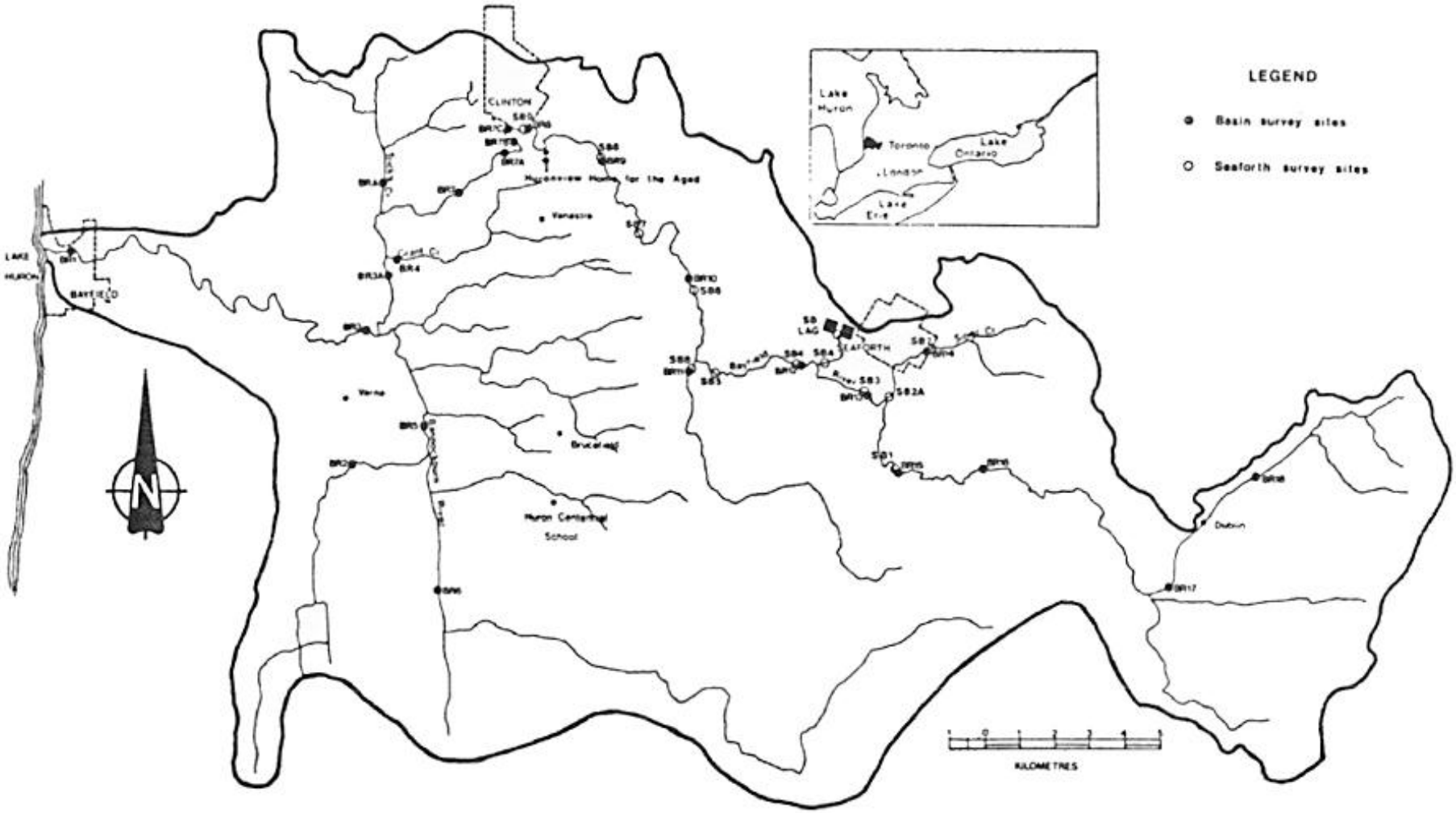

Figure 3. Water quality and stream gauging sites for 1978 surveys.

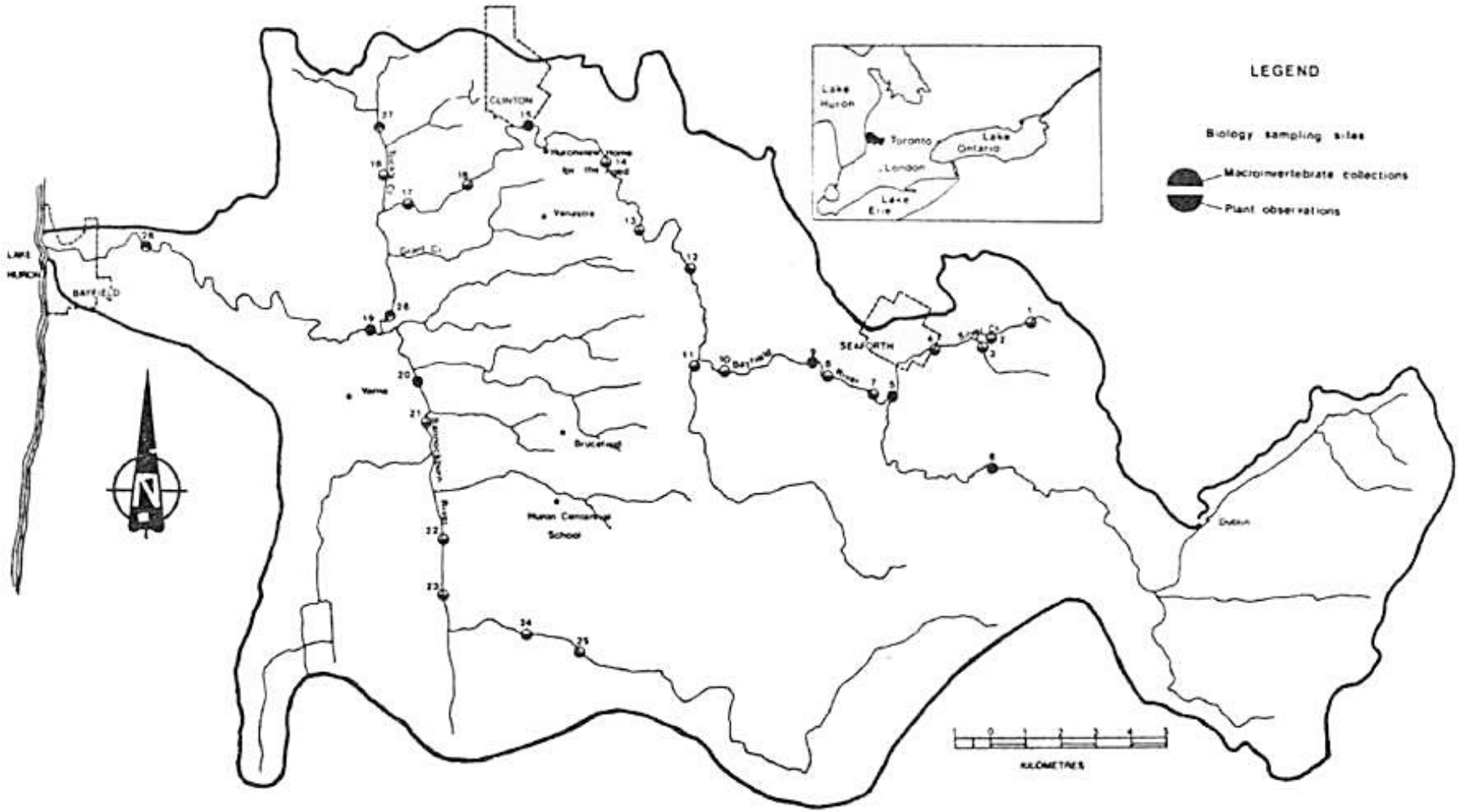

Figure 4. Aquatic plant growth observation sites and benthic community sampling sites, 1978.

Growth of the filamentous green alga, *Cladophora*, in the Bayfield River Basin was documented during the week of June 4, 1978.

RESULTS

HYDROLOGY

Federal Data

An historical record of streamflow is available from the records of the Water Survey of Canada for a gauge north of Varna (02FF007) for the period October, 1966 to the present. The drainage area upstream from the gauge is 46,600 hectares (I80 square miles). Mean monthly and minimum monthly average flow data have been calculated from the records (Table D1 of Appendix D) and indicate the lowest monthly flow with a ten-year return period is about 4 cfs and occurs in September. The minimum daily discharge recorded was 1.1 cfs in 1977. These flows have been pro-rated to Seaforth and Clinton to demonstrate the flow regime at these urban centres (Tables D2 and D3).

Long-Term Ministry Data

Periodic measurements have been made on the Bayfield River downstream from Seaforth by the Ministry of the Environment (gauging site No. 02FF101). The data (Table D4) indicate that a "no flow" situation has occurred on several occasions, particularly in the period July to October. These data conflict with the pro-rated flows from Varna (Table D2); however, the summer flows at Varna are increased by tributaries such as the Bannockburn River and Trick's Creek, both of which have good base flow. The flow is also augmented from two continuously discharging treatment plants (Clinton and Vanastra). The minimum streamflow at Seaforth is therefore assumed to be zero from late June to October.

Streamflow measurements were also made on Silver Creek just upstream from the confluence with the Bayfield River. The data (Table D5) indicate the presence of very low streamflow in the summer months.

Survey Data

There were two surveys of the Bayfield River during which streamflow measurements (Figure 3) were made. The Seaforth survey (May 2-4, 1978) had two measurements at six stations (Table D6). The data indicate a dilution ratio of slightly greater than 1:1 of streamflow to lagoon effluent The second survey (July 31) was effectively cancelled due to the lack of streamflow downstream from Clinton. The limited flow data collected (Table D6) indicate that approximately 0.03 m^3/sec (1 cfs) disappeared into the streambed about 2 kilometers downstream from Clinton's sewage treatment plant.

WATER QUALITY

Long-term Data

There are data from 10 long-term water quality monitoring stations that have been or still are active in the Bayfield River watershed (Figure 2). The data indicate the trends in water quality since 1964.

Stations 8-40-4 and 8-40-5 were operated from 1965 to the early 1970's and the data indicate poor water quality existed at both stations (Tables B1 and B2 of Appendix B). $BOD_{5,}$ total phosphorus and suspended solids concentrations were elevated and minimum dissolved oxygen concentrations were occasionally less than the Ministry of the Environment's Objective of 4 mg/L. Total coliform levels were declining in the later sampling years but the fecal coliform and fecal streptococci counts were increasing.

Station 8-40-3 was located on Silver Creek near the confluence with the Bayfield River. Silver Creek was the receiving stream for effluent from the former Seaforth sewage treatment plant until the Seaforth lagoons were constructed in 1973. The water quality (Table B3) prior to this time was quite poor with minimum dissolved oxygen concentrations of 2 mg/L recorded and BOD_5 and total phosphorus concentrations as high as 22 and 5.6 mg/L respectively. An improvement in water quality in 1974 and 1975 was evident, however, the water quality was still degraded. Numbers of fecal coliform and fecal streptococcus bacteria levels were steadily increasing when the station was discontinued.

Station 8-40-2 was operated from 1964 to 1975 and was located on the Bayfield River at Seaforth. The water quality (Table B4) at this station also showed limited improvement in 1974 with the movement of the sewage effluent discharge away from Silver Creek. Occasional slugs of pollutants in 1974 were found, as evidenced by the occurrence of maximum $BOD_{5,}$ total phosphorus and free ammonia concentrations of 40, 0.40 and 13.0 mg/L respectively.

The annual average for suspended solids showed a general increase over the period of record. The seasonal (May to September) data indicate that some high concentrations of suspended solids (e.g. 70 mg/L) occurred. The fecal coliform and fecal streptococcal levels were increasing at this station as well. The annual average and minimum concentrations of dissolved oxygen steadily decreased over the period of record.

Station 8-40-9 was established in 1975 to monitor the discharge from the Seaforth lagoon. These data (Table B5) reflect a decline in water quality over the period 1975 to 1979 with increasing concentrations of essentially all parameters on an annual and seasonal average basis. Since the lagoons are not discharged in the summer, the decline in water quality is attributed to diffuse sources of contamination.

Station 8-40-6 was started in 1972 to monitor the effect of the Clinton sewage treatment plant. Improvement in water quality (Table B6) can be seen since a major sewage plant expansion was completed in 1974. Concentrations of total phosphorus

are consistently above the Ministry of the Environment's criterion (0.03 mg/L) and summer averages exceed 0.1 mg/L. Annual and seasonal averages of suspended solids tend to be improving.

Station 8-40-10 was operated from 1976 to 1979 to document the effect of the sewage treatment plant at Vanastra on the Bayfield River. Even though Clinton's sewage treatment plant would be suspected to affect conditions at this station, an improvement in total phosphorus, soluble phosphorus and free ammonia from Station 8-10-6 is evident (Table B7).

Station 8-40-8 has been operational since 1975 at the Federal Stream Gauge 02FF007 near Varna. The water quality (Table B8) was good and was similar to Station 8-4010.

Stations 8-40-7 and 8-40-1 were located at the mouth of the Bayfield River. The water quality (Tables B9 and B10) was reasonably good and remained steady, with the only change being an increase in the annual average for suspended solids in 1974 and 1975 at Station 8-40-1. The annual geometric mean for bacteria also appears to have increased in recent years.

Survey Data

Basin Monitoring

Two sets of water quality data were collected during the summer of 1978 to document variations in quality within the basin (Figure 3). The first set of samples was collected on June 15. The data (Table C1 of Appendix C) indicate that with some exceptions the water quality was reasonably good at the time of sampling. At several stations in the upper watershed (Stations BR12 to BR17) there were elevated concentrations of specific parameters. For example, the total phosphorus concentration was elevated at Stations BR13 and BR17 to 0.105 and 0.114 mg/L, respectively.

The only other location in the watershed with increased total phosphorus was Station BR7 downstream from Clinton. High BOD_5 concentrations were recorded at stations BR12, BR13 and BR17 and the largest concentration of free ammonia was 1.26 mg/L at Station BR15. Bacterial levels were high throughout the watershed.

The second basin-wide sampling occurred on July 31 (Table C2). Three additional samples were collected downstream from the sewage treatment plant at Clinton (Stations BR7A, BR7B and BR7C). These latter stations reflected the effect of the treatment plant discharge with elevated concentrations of BOD_5, total phosphorus, soluble phosphorus and total Kjeldahl nitrogen. Once again, the total phosphorus was high in the upper watershed (Stations BR12, BRI3 and BR16). The pH was considerably higher than during the previous sampling, as evidenced by a maximum reading of 9.04 at Station BR7A.

Seaforth Survey

An intensive 48-hour survey of the Bayfield River was conducted in the vicinity of Seaforth from May 2 to 4, 1978 to document the impact of Seaforth's lagoon discharge (Figure 3).

The data (Table C3) indicate an increase in BOD_5, total phosphorus and free ammonia concentrations downstream from the discharge. The concentration of free ammonia in the effluent and at Station SB4 converts to 0.04 mg/L and 0.014 mg/L un-ionized ammonia, respectively. After mixing, the Ministry of the Environment's Objective of 0.02 mg/L is therefore achieved. The BOD_5 and total phosphorus remained elevated above the background level for the rest of the survey reach. One point that should be noted is the increase in total phosphorus and bacterial parameters in Silver Creek (Stations SB2 and SB2A). There are storm sewer discharges from Seaforth and Egmondville into Silver Creek in this reach. At the present time, the community of Egmondville does not have sanitary sewers.

BIOLOGY

BOTTOM FAUNA

Results of biological sampling in the Bayfield River Basin are presented in Table C4. Station locations and a map of the watershed are illustrated in Figure 4.

Silver Creek

Station 5 was situated on Silver Creek near its junction with the Bayfield River. The stream had been channelized and the bottom consisted of cobble, sand, and gravel which was heavily silted. Flows were low and nuisance growths of blue-green algae and filamentous green algae were common. In pooled areas of the stream, rocks removed from the bottom were black and emitted a hydrogen sulphide odour, indicating anaerobic conditions were present in the sediments.

Thirteen taxa were collected at this station, mainly from a riffle area. The organisms collected consisted of mainly of forms capable of tolerating somewhat degraded conditions.

Bayfield River

Station 6 located approximately 5 kilometers upstream from the Town of Seaforth was characterized by warm water (27°C), low flow, and a cobble-clay substrate. Aquatic plant growths such as pondweeds (*Potamogeton spp*.), bulrush *(Scirpus validus*), and water lilies (*Nuphar advena* and *Nymphaea tuberosa*) were common. Collections of bottom fauna were facultative (relatively pollution tolerant) in nature and basically consisted of snails, beetle larvae, bugs and true flies.

Station 9 was located downstream from the municipal lagoon discharge at Seaforth. Samples could not be obtained upstream from the lagoons as the river was completely dry on August 15, 1978. Downstream from the discharge, the river was pooled and had minimal flow. Filamentous green algae was covering 100% of the

cobble-gravel bottom. Hydrogen sulphide odours emanated from the warm (29°C) water, and were associated with very low dissolved oxygen conditions resulting from the large decomposing mats of algae. Only 10 taxa were collected at this station, mostly facultative forms.

Due to low flow and no flow conditions, no samples were collected from the section of river between Station 9 and the Town of Clinton.

Low flow conditions were very evident at the Highway #4 bridge, Clinton. Flow was estimated at approximately 0.03 m^3/sec (1 cfs) at Station 15 Located upstream from the bridge. A diverse community of benthic organisms including many intolerant caddisfly and mayfly species suggested that water quality conditions were satisfactory and that the stream does not entirely dry up in this area.

Downstream from the Clinton sewage treatment plant, the river was completely dry and what little flow was present disappeared into the cobble-gravel river bottom. The stream bed remained entirely dry to its junction with Trick's Creek.

Trick's Creek

Trick's Creek flows from a bog. The stream substrate consists of sand, gravel, organic debris and silt, with the occasional area of rock and cobble. The water was clear and cool (15°C) on August 14, 1978.

The 18 taxa collected were dominated by intolerant forms. The dobsonfly (*Corydalus cornutus*), fishfly (*Chauliodes*), and the numerous mayfly and caddisflies indicated excellent water quality conditions were present.

Bannockburn River

The Bannockburn River is a major tributary to the Bayfield River. Due to low flow conditions in this tributary, only one station was sampled. Station 20 located approximately 2 kilometers upstream from the junction of the two streams produced 15 taxa with intolerant and facultative forms represented. The crayfish *(Orconectes propinquus*) was unusually numerous in this section of stream, possibly because of upstream sections drying up causing downstream migration.

Aquatic plants, pondweed (*Potamogeton spp*.), bulrush (*Scirpus validus*) and arrowhead (*Sagittaria latifolia*) were common. Mats of decomposing *Cladophora* (filamentous green alga) were also present.

The remaining stations sampled on the Bayfield River (Station 26, Station 19 and Station 28) produced 27, 21 and 17 taxa respectively. Pollution-intolerant forms were well represented, although flows were very low. The stream was characterized by cobble, boulder, gravel substrate with good tree cover along its banks.

FISH MORTALITIES

Since 1973 a total of seven incidents involving fish mortality have been reported and investigated in the Bayfield River watershed.

Four of the fish kills were judged to be moderate, two major and one minor. Five of the incidents were related to agri-business, usually involving the discharge of toxic wastes, such as liquid manure or corn leachate. One kill was a result of a municipal lagoon discharge and the cause of the remaining minor fish kill was not determined.

A Summary Of Fish Mortalities, Reported In The Bayfield River Basin From 1973 To 1979

Water Body	Location	Severity of Fish Kill*	Cause
1973			
Bayfield River	Seaforth	Moderate	lagoon discharge
1974			
Bannockburn River	Tuckersmith Township	Major	agricultural (corn leachate)
1975			
Bannockburn River	Tuckersmith Township	Moderate	agricultural (corn leachate)
1977			
Bannockburn River	Tuckersmith Township	Moderate	agricultural (corn leachate)
Bayfield River	Hibbert Twp.	Minor	unknown
1979			
Bannockburn River	Tuckersmith Township	Moderate	agricultural (poor spreading of liquid manure)
Bayfield River	Hibbert Twp.	Major	agricultural (liquid pig manure)

* Severity of Fish Kill
- Minor 1-100 fish
- Moderate 100-1000 fish
- Major 1000+ fish

AQUATIC VEGETATION

Estimates of percentage bottom coverage by aquatic plants were made for 25 locations throughout the watershed on June 6, 1978 (Figure 4, Tables C5 and C6). Stream characteristics including temperature, width, depth, stream cover and substrate type were also recorded.

Profuse *Cladophora* growths were present throughout the watershed. The cobble rock gravel substrate which is very characteristic of the Bayfield River provides excellent growth areas for *Cladophora*. Stations 17 and 19 downstream from Clinton and Stations 7, 8 and 9 in the Seaforth area on the main Bayfield River were characterized by particularly heavy growths.

Severe growths of *Cladophora* were common throughout the Bannockburn River. The majority of the stream has been channelized and bank cover removed. Stations 22, 24 and 25 downstream from Kippen produced profuse growths of *Cladophora* in some sections of the stream.

In summary, the Bayfield River system had profuse *Cladophora* growths. These growths were aesthetically displeasing, fouling the stream bottom and causing serious dissolved oxygen fluctuations through their respiratory demands. They also produced very low dissolved oxygen conditions in the stream upon decomposition. Complaints about plant growth in the Bayfield River have been investigated by the Ministry in 1973 and 1974.

DISCUSSION

The water quality and biological communities of the Bayfield River have been adversely affected by several point source discharges from urban and industrial areas and from diffuse agricultural runoff. Excessive growths of aquatic plants have been documented throughout the watershed in 1973, 1974 and 1978 and are probably the direct result of elevated concentrations of total phosphorus. Several fish kills have occurred as a result of spills associated with agricultural activities.

POINT SOURCES

Clinton Sewage Treatment Plant

The sewage treatment plant at Clinton is the largest point source for phosphorus in the watershed. It discharges continuously during the growing season for aquatic plants. As a result, water quality downstream from Clinton is the poorest in the watershed. Ideally, the Town of Clinton should be required to store sewage from May 1 to October 31 since there is little or no streamflow during the summer. However, the addition of chemical for phosphorus removal would reduce the environmental impact of the continuous discharge. There is a possibility that the effluent that disappears into streambed (e.g. July and August, 1978) may be having an adverse effect on groundwater quality.

Seaforth Lagoon System

The parameters of greatest concern in Seaforth's discharge are phosphorus and ammonia. The average concentration of total phosphorus in the effluent during the 1978 survey (0.35 mg/L) was low in comparison to many sewage system discharges which typically average 1.0 mg/L. Since the discharge occurred in May, the concentration rose from 0.022 mg/L at Station SB3 to 0.128 mg/L at Station SB4. The Ministry of the Environment's criterion (0.03 mg/L) was therefore violated from Station SB4 to Station SB9 at Clinton.

The concentration of free ammonia in the effluent during the 1978 survey (1.5 mg/L) was lower than that experienced during other discharge periods (Table A2). The un-ionized ammonia concentration (0.014 mg/L) at Station SB4 was within the Ministry of the Environment's Objective to protect aquatic life. If the effluent concentration had been higher or the streamflow (22 cfs) had been closer to the one-in-ten year minimum monthly average flow (11 cfs), a violation of the Objective would have occurred. The following table presents examples of ammonia concentrations downstream from Seaforth under design sewage flow (15-day discharge of lagoon contents) and low streamflow conditions.

Month	Stream flow (cfs)	pH	Temperature (°C)	Effluent flow rate (cfs)	Effluent free ammonia (mg/L)	Downstream un-ionized ammonia (mg/L)
April	41	8.1	15	6	10	0.06
May	11	8.1	20	6	5	0.11
October	2	7.9	10	6	5	0.07
November	12	7.9	10	6	5	0.03

From the above hypothetical calculations, it can be seen that only the November discharge is even close to meeting the Ministry's Objective. If the spring discharge is extended earlier into April, hydrogen sulphide toxicity may be a problem. Extending the discharge into May provides elevated phosphorus concentrations to promote the growth of aquatic plants.

Other Sewage Treatment Systems

The lagoon system serving the Huronview Home for the Aged and the Huron Centennial School as well as Vanastra's sewage treatment plant do not appear to be adversely affecting the Bayfield River.

The lagoon at the East Huron Produce Limited Plant has had poor effluent quality for the last two years. The effect on the river has not been fully documented, but the impact of this source could be minimized by careful regulation of the discharge period.

APPENDIX A

Effluent data from sewage treatment systems

Table A1. Effluent data from Clinton sewage treatment plant, 1978-1979.

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P		Nitrogen as N			
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered		
											Ammonia	Nitrite	Nitrate
Jan 17, 1978		0.5	6.0					3.45	3.35	16.0	15.5	0.32	0.8
Feb 8		2	3.8					4.20	4.05	14.3	14.3	0.27	2.0
Feb 20		0.5	2.6					4.10	3.85	19.5	17.2	0.30	0.6
Mar 28		2.5	5.4					1.05	0.85	2.35	2.2	0.05	5.5
Apr 12		<0.5	1.0					0.79	0.55	0.45	<0.5	<0.1	7.4
May		1.0	3.8					3.60	3.00	15.2	14.4	0.18	0.9
May 23		7.5	2.8					3.18	2.90	10.4	9.9	0.37	2.6
June 6		<0.5	5.6					4.75	4.00	19.0	18.4	0.41	0.8
June 28		4	6.6					3.44	3.15	25.8	21.5	0.09	<0.1
July 11		8.0	4.2					5.10	4.65	1.25	0.6	1.24	10.0
Aug 8		5.0	1.8					6.30	5.85	2.05	1.6	0.56	15.3
Aug 29		<0.5	2.8					5.50	5.10	0.80	0.2	0.10	23.4
Sept 11		5	1.8					6.30	5.70	1.10	0.2	0.23	22.7
Oct 3		3	6.4					6.00	5.65	2.40	2.1	0.93	16.5

Note: All results are in mg/L except where indicated

Table A1. Continued

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P			Nitrogen as N		
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered		
											Ammonia	Nitrite	Nitrate
Oct 23, 1978		1.5	2.4					4.70	4.30	0.50	0.1	0.07	18.9
Nov 14		1.5	1.6					3.90	3.50	3.00	2.6	0.10	9.8
Jan 8, 1979		2.0	1.0					2.35	2.35	0.30	<0.1	0.02	13.4
Jan 29		1.0	1.4					3.30	3.20	0.55	0.2	0.05	16.2
Feb 26		10.5	1.6					1.94	1.75	0.55	0.2	0.12	11.2
Apr 3		0.5	33.0					0.74	0.55	1.00	0.5	0.05	6.5
May1		1.0	15					2.10	1.75	--	7.0	1.50	4.0
May 28		0.5	2.6					3.10	2.80	5.20	4.7	0.88	7.9
June 12		3.5	G14					5.55	5.15	13.3	12.3	2.5	1.5
July 3		3	6.8					3.45	3.45	--	16.4	0.90	0.4
July 24		1	G28					5.60	0.85	--	12.5	17.0	2.5
Aug 13		1	9.6					4.60	4.40	15.0	14.4	1.60	2.3
Aug		15	14.4					4.50	4.05	20.5	11.6	1.32	0.7
Sept 17		2.0	3.0					4.90	4.70	24.0	23.5	0.45	0.1
Oct 1,1979		5	5.2					5.90	5.55	18.5	14.5	0.87	3.3

Note: All results are in mg/L except where indicated

Table A2. Effluent data from Seaforth lagoon system, 1978-1979.

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P		Nitrogen as N			
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered		
											Ammonia	Nitrite	Nitrate
April 10/78	middle (e)	16.5	13	G220,000	7,800	G32,000		2.26		10.6	9.6		
	lowest (e)	26	14.8	24,000	264	576		5.75		31.2	9.1		
May1	lowest (e)	24.5	11.6					0.31	0.05	3.70	2.4	0.41	1.1
May 3	lowest (e)	13	10					0.30	<0.05	3.35	1.5	0.30	1.1
May 5	lowest (e)	24	16.4					0.36	<0.05	3.40	2.1	0.42	1.2
May 7	lowest (e)	25	10.4					0.35	<0.05	5.35	3.5	0.19	0.9
May10	lowest (e)	21	10					0.45	<0.05	5.40	2.2	0.15	1.1
May12	lowest (e)	21	58					0.35	<0.05	5.2	0.1	0.14	1.2
Oct 18	lowest (e)	19.5	2.6	C250	36	568	<4	0.58	0.20	2.70	1.0	0.04	<0.1
Oct 22	lowest (e)	10.5	4.0	1800	28	<4	<4	0.42	0.10	3.10	1.4	0.05	<0.1
Oct 24	lowest (e)	2	3.6	C90	4	8	<4	0.72	0.40	7.50	5.7	0.04	<0.1
Oct 28	lowest (e)	2	3.8					0.58	0.25	7.20	6.4	0.02	<0.1

Note: All results are in mg/L except where indicated

April 10/78 Sample was collected prior to chemical addition

Table A2. Continued

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P			Nitrogen as N		
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered		
											Ammonia	Nitrite	Nitrate
March 20/79	lowest (e)	2	8.4	4900	92	248		1.04	0.80	7.65	7.0	0.01	< 0.1
Apr 26	lowest (e)	35	6.8	1700	210	A50		0.57	0.10	4.05	3.8	1.15	0.2
Apr 28	lowest (e)	31.5	9.2	C920	180	A70		0.38	L0.05	6.25	4.1	0.05	< 0.1
Apr 30	lowest (e)	9.5	12.7	C13100	830	170	28	0.32	L0.05	6.4	4.5	0.06	0.4
May 2	lowest (e)	41	12.8					0.30	L0.05	7.70	4.0	0.07	0.5
Oct 20	lowest (e)	23.5	13.2					0.86	0.35	6.40	2.6	0.23	< 0.1
Oct 22	lowest (e)	12.5	8.4	C33000	G1500	130	8	0.78	0.35	8.50	5.3	0.08	< 0.1
Oct 24	lowest (e)	9.0	10.4	G212000	G1500	340	<4	0.71	0.20	8.25	5.0	0.14	< 0.1
Oct 26	lowest (e)	14.5	12	190000	42000	G1500	124	0.58	0.15	7.00	3.8	0.82	< 0.1
Oct 28	lowest (e)	20	15.6	49000	5800	A400	<4	0.98	0.20	9.50	4.2	0.14	< 0.1

Note: All results are in mg/L except where indicated

March 20/79 Sample collected prior to chemical addition

Table A3. Effluent data for Vanastra sewage treatment plant, 1979.

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P		Nitrogen as N		
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered	
											Ammonia	Nitrite	Nitrate
Jan18/78		7.0	3.0	1600	90	180		0.30		0.60			
Feb 7		6	2.8					0.25		0.60			
Feb 21		8	0.4	C660	44	76		0.35		0.90			
Mar 6		3.5	3.0					0.40		1.40			
Mar 20		6	3.4	1200	52	96		0.35		0.75			
Apr 17		9	11.6					0.30		6.30			
May 1		6.5	2.6	G50000	G600	G600		0.20		3.35			
May15		7	1.2	680	4	20		0.24		0.40			
June 4		3.5	1.6	G20100	4	12		0.13		0.35			
June 20		3.0	1.2					0.17		0.30			
July 10		5.0	2.0	G270000	10000	G600		0.47		0.50			
Aug 8		5.0	1.2	44	8	4		0.33		0.50			
Aug 22		5.5	2.0					0.49		1.10			
Sept 5		4	1.8	G15000	324	L4		0.35		0.50			

Note: All results are in mg/L except where indicated

Table A3. Continued

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P			Nitrogen as N		
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered		
											Ammonia	Nitrite	Nitrate
Sept 18		9	2.4	C6100	52	40		0.39		0.60			
Oct 2		6.5	0.6	4000	24	36		0.39		0.35			
Oct 16		6	2.0	3500	132	88		0.41		0.50			
Nov 13		6.5	3.4	5100	20	36		0.41		0.45			
Dec 4		8	3.4					0.53		0.55			
Jan 8/79		13.5	4.0	590	16	130		0.35		0.55			
Jan 23		11.5	4.0	1700	48	292		0.33		0.55			
Feb 6		7	5.8	1800	116	220		0.40		1.05			
Feb19		5	6.4	G75000	4	440		0.38		0.60			
Mar 6		6	6.4	G43000	G600	G600		0.33		0.50			
Apr 2		6.5	4.2	18000	11900	1500		0.41	0.10	0.75	0.1	0.06	5.1
Apr 24		11.5	4.0					0.18	0.10	0.40	0.4	0.04	9.5
May 3		93	45					3.80	1.45	8.50	1.90	7.10	2.1
May14		6.5	3.2					0.22	0.10	0.40	0.2	0.08	10.4

Note: All results are in mg/L except where indicated

Table A3. Continued

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P			Nitrogen as N		
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered		
											Ammonia	Nitrite	Nitrate
May 28/79		4.5	0.9	2900	4	4	L4	0.27	1.10	0.45	0.2	<0.01	10.6
June 11		<0.5	0.4					0.32	0.20	0.55	< 0.1	<0.01	18.8
July 3		5	1.2					0.28	0.20	0.55	0.2	<0.01	17.6
Aug 1		3	3.0	G49800	Pres.	72		0.24	0.20	3.25	3.0	0.09	9.6
Aug 13		1.0	0.4					0.28	0.10	0.70	0.5	<0.01	18.9
Oct 1		4.5	1.6					0.34	0.25	1.40	0.6	0.06	18.8
Oct 15		2.0	2.2					0.18	0.05	0.35	0.1	0.01	6.3

Note: All results are in mg/L except where indicated

Table A4. Effluent data East Huron Produce Limited (Dublin) lagoon system, Hibbert Twp., Perth County and the Huron Centennial School, Stanley Twp, Huron County.

Date	D.O.	Susp. Solids	BOD_5	Bacteria/100 ml				Phosphorus as P			Nitrogen as N		
				T C .	F.C.	F. S .	Ps. a.	Total	Filt. diss	Kjel.	Filtered		
											Ammonia	Nitrite	Nitrate
East Huron Product Ltd.													
April 18/78		91	48	A200	190	A500		7.50			17.9		
May 2		265	22	A140	A10	120	<10	7.15	1.65	26.7	15.0	0.07	< 0.1
May 5		472	43					7.15	2.50	26.5	14.7	0.08	< 0.1
May11		105	26					6.65	2.20	24.0	12.7	0.11	< 0.1
May 23		111	14					6.0	4.45	35.0	11.3	0.31	0.1
July 7		125	37					5.55	3.35		3.7		
Nov 28		909	16					5.40	3.70	7.10	1.30	0.76	8.0
Apr 3/79		180	102					6.90	5.25	29.0	23.5	0.02	< 0.1
Nov 13		31	19					6.40	5.10	25.0	11.0	0.03	< 0.1
Huron Centennial School													
May19/76		98	5.6					0.30		2.0			

Note: All results are in mg/L except where indicated

APPENDIX B

Long-term water quality monitoring data

Table B1. Water quality data from long-term monitoring station 8-40-4, near Dublin.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1965	9.0	13.6	6.0	18.3	7.3	21.0	0.9	2.4	3.4	0.36	1.9	3.2	6.7	0.13	3.2
1966	9.2	16.0	4.0	10.8	2.8	7.6	0.9	0.27	1.5	0.02	0.17	0.06	0.78	0.0	1.2
1967	9.4	14.0	2.0	7.8	2.4	4.1	0.8	0.06	0.12	0.01	0.03	0.16	0.79	0.05	0.89
1968	8.3	14.0	4.0	11.0	1.6	6.6	0.6	0.10	0.52	0.02	0.05	0.22	0.98	0.04	0.73
1969	8.6	13.0	5.0	9.3	1.5	3.5	0.6	0.11	0.40	0.02	0.04	0.14	0.57	0.02	0.76
1970	8.4	17.0	4.0	10.8	4.7	14.0	0.4	0.30	0.70	0.02	0.22	0.51	1.8	0.04	1.2
1971	8.9	12.2	5.0	12.7	3.2	7.0	0.5	0.27	0.91	0.05	0.17	0.34	1.2	0.03	1.6

Note: All results are in mg/L except where indicated

Table B1. Continued .

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1965	22,000				0.03	2.0		78	530	5	19
1966	1,100				0.03	1.1		19	552	11	31
1967	4,200				0.01	1.6		10	551	8	15
1968	1,300				0.01	1.3		15	558	7	12
1969	1,100				0.02	1.9		28	571	7	11
1970	2,900				0.04	3.1		23	593	18	24
1971	10,000				0.08	3.2		28	532	25	44

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B1. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1965	20	45	2	2.9	3.4	0.56
1966	16	28	7	0.42	1.5	0.04
1967	25	82	5	0.05	0.11	0.02
1968	17	28	10	0.14	0.52	0.02
1969	12	20	5	0.10	0.20	0.02
1970	18	35	5	0.44	1.3	0.01
1971	49	130	15	0.26	0.75	0.05

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B2. Water quality data from long-term monitoring station 8-40-5, near Dublin.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1965	11.4	16.2	4.0	17.6	7.3	16.0	0.80	4.2	11.0	0.28	3.3	3.0	6.4	0.0	4.1
1966	10.4	15.0	3.0	10.7	3.3	9.6	0.70	0.56	2.8	0.02	0.50	0.17	0.66	0.0	1.3
1967	10.0	13.0	7.0	9.1	2.1	5.0	0.20	0.10	0.34	0.01	0.06	0.30	1.1	0.06	1.0
1968	8.3	13.0	2.0	9.9	15.7	210.0	0.60	0.54	1.3	0.04	0.31	2.1	26.2	0.06	2.8
1969	8.2	12.0	5.0	9.6	7.4	55.0	0.80	0.37	1.6	0.04	0.24	0.28	1.2	0.01	1.2
1970	8.0	15.0	4.0	10.7	2.4	4.8	0.60	0.17	0.48	0.02	0.09	0.23	0.53	0.02	0.94
1971	8.5	12.0	5.0	12.8	3.7	8.0	0.50	0.51	1.4	0.08	0.39	0.78	2.5	0.09	1.6
1972	6.5	13.0	3.0	11.9	3.6	9.0	0.60	0.32	1.1	0.04	0.14	0.35	0.88	0.04	1.1
1973	6.0	12.0	1.0	9.1	7.1	34.0	1.0	0.62	2.0	0.06	0.33	1.3	5.5	0.07	2.6
1974	4.8	7.5	3.0	8.2	4.6	13.0	1.8	0.49	2.2	0.05	0.26	0.63	4.4	0.01	2.0
1975	6.2	7.0	5.0	9.3	1.9	3.6	0.50	0.11	0.22	0.07	0.05	0.23	0.60	0.05	0.80

Note: All results are in mg/L except where indicated

Table B2. Continued.

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1965	26,000				0.03	3.2		67	475	7	27
1966	11,000				0.07	1.7		26	607	9	29
1967	18,000				0.01	1.6		11	563	8	12
1968	17,000				0.05	1.2		17	543	12	26
1969	5,100				0.05	2.1		19	597	9	17
1970	4,300				0.05	3.1		27	570	40	57
1971	16,000				0.12	3.1		29	627	21	34
1972	34,000	260	190		0.12	4.2		- -	599	- -	13
1973	21,000	210	490		0.10	5.3		--	689	6	14
1974	17,000	630	450		0.33	6.2		38	616	9	21
1975	9,100	980	1,500		0.07	7.4		18	457	7	14

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B2. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1965	23	40	15	7.2	11.0	0.60
1966	23	56	2	0.99	2.8	0.12
1967	13	22	4	0.14	0.34	0.03
1968	13	26	7	0.54	1.3	0.04
1969	30	80	5	0.83	1.6	0.04
1970	14	31	5	0.22	0.48	0.06
1971	22	35	15	0.40	0.76	0.08
1972	12	20	5	0.45	1.1	0.04
1973	16	30	5	1.3	2.0	0.72
1974	19	30	10	0.57	1.2	0.12
1975	13	15	10	0.09	0.10	0.08

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B3. Water quality data from long-term monitoring Station 8-40-3, Silver Creek.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1965	11.5	13.8	8.0	13.0	4.3	7.0	1.7	2.4	3.8	1.2	1.6	1.2	2.5	0.20	2.2
1966	11.4	13.0	9.0	10.6	3.9	10.4	1.4	1.5	5.6	0.20	1.1	0.33	0.72	0.02	1.2
1967	9.8	12.0	6.0	9.6	2.8	6.0	0.9	0.46	3.3	0.01	0.26	0.57	1.8	0.05	1.4
1968	9.2	13.0	4.0	10.3	4.5	13.0	1.1	0.68	1.9	0.07	0.24	1.2	4.1	0.16	2.2
1969	9.2	12.0	4.0	10.6	4.8	12.0	1.0	0.55	1.7	0.11	0.36	0.90	3.1	0.06	1.7
1970	8.5	13.0	4.0	12.5	4.8	22.0	0.8	0.71	1.9	0.19	0.48	1.4	3.9	0.17	2.7
1971	8.8	13.0	3.6	12.3	6.2	12.0	2.2	0.73	1.6	0.20	0.54	1.7	7.0	0.96	3.0
1972	8.3	13.0	2.0	11.7	4.2	16.0	0.8	0.53	3.2	0.07	0.42	0.56	2.9	0.01	1.5
1973	8.7	13.0	5.5	9.2	2.8	13.0	1.2	0.33	1.4	0.07	0.24	0.17	0.52	0.02	0.71
1974	7.2	12.0	4.0	7.4	2.4	5.5	0.5	0.21	0.42	0.04	0.14	0.35	1.6	0.01	0.76
1975	7.0	11.0	4.0	9.6	2.6	5.8	0.5	0.17	0.26	0.07	0.08	0.14	0.21	0.11	0.72

Note: All results are in mg/L except where indicated

Table B3. Continued.

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1965	8,000				0.09	1.0		47	560	5	29
1966	15,000				0.12	1.9		33	672	7	20
1967	120,000				0.07	1.7		29	677	14	21
1968	53,000				0.05	1.6		47	742	13	28
1969	18,000				0.14	2.4		34	696	6	31
1970	7,800				0.41	3.6		46	814	9	12
1971	40,000				0.40	3.0		51	857	10	28
1972	23,000	400	250		0.13	3.6		--	729	--	8
1973	31,000	160	350		0.08	4.2		--	875	5	15
1974	37,000	1,600	910		0.12	4.8		50	798	8	21
1975	20,000	2,200	820		0.07	6.2		29	632	15	31

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B3. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1965	48	132	6	2.8	3.8	1.7
1966	15	36	4	2.7	5.6	0.86
1967	29	72	5	0.93	3.3	0.01
1968	48	185	17	1.2	1.9	0.07
1969	21	55	8	0.63	0.86	0.29
1970	12	15	5	1.0	1.9	0.19
1971	18	30	5	0.73	0.98	0.20
1972	8	15	5	0.70	3.2	0.08
1973	16	30	5	0.65	1.4	0.21
1974	15	15	15	0.25	0.33	0.20
1975	32	49	15	0.23	0.26	0.20

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B4. Water quality data from long-term monitoring Station 8-40-2, near Seaforth.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1964	12.3	12.8	11.8	4.5	3.5	4.6	2.4	--	--	--	--	--		--	_
1965	12.6	19.0	8.0	12.6	2.5	5.5	1.0	2.0	5.6	0.48	0.67	0.41	1.1	0.0	1.1
1966	12.0	15.0	7.0	12.0	2.8	5.1	0.7	0.78	4.75	0.02	0.57	0.14	0.23	0.0	1.4
1967	9.9	13.0	6.0	9.5	1.8	4.3	0.8	0.14	0.62	0.02	0.09	0.31	1.2	0.06	0.84
1968	9.4	12.0	5.0	10.2	2.4	6.0	0.6	0.27	1.2	0.04	0.16	0.38	1.3	0.10	0.82
1969	8.6	16.0	4.0	11.0	2.9	6.0	0.4	0.67	5.2	0.07	0.27	1.2	13.0	0.04	1.1
1970	8.7	14.0	4.0	12.5	4.2	9.5	0.8	0.41	1.3	0.05	0.37	0.32	1.0	0.04	1.2
1971	8.7	12.5	6.2	12.8	3.8	7.0	0.6	0.68	2.5	0.09	0.54	0.77	2.7	0.04	1.7
1972	7.1	10.0	3.3	10.5	5.2	17.0	0.5	0.47	2.5	0.03	0.37	0.35	1.0	0.01	1.2
1973	7.3	10.5	4.0	9.0	2.4	9.5	1.0	0.32	1.3	0.04	0.23	0.54	2.5	0.01	1.2
1974	7.9	12.0	3.5	8.9	6.2	40.0	0.5	0.21	0.40	0.04	0.13	2.0	13.0	0.01	3.0
1975	6.8	10.0	3.0	10.4	2.8	4.5	0.6	0.15	0.30	0.06	0.04	0.12	0.40	0.02	0.87

Note: All results are in mg/L except where indicated

Table B4. Continued .

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1964	3,600				--	--	--	--	--	8	4
1965	2,500				0.06	1.3		36	576	3	6
1966	3,300				0.08	2.1		22	608	39	15
1967	20,000				0.02	1.7		14	565	6	12
1968	7,300				0.06	1.5		22	589	8	16
1969	2,700				0.08	2.1		25	605	9	14
1970	3,400				0.18	3.3		34	639	8	16
1971	13,000				0.17	2.8		41	725	5	17
1972	14,000	350	110		0.14	4.1		--	631	--	8
1973	7,800	110	120		0.07	4.7		--	768	4	21
1974	14,000	470	420		0.17	5.3		49	745	8	20
1975	6,300	640	930		0.05	5.7		20	542	12	27

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B4. Continued

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1964	4	4	4	--	--	--
1965	6	11	1	2.1	5.6	0.48
1966	11	15	8	1.5	4.8	0.22
1967	7	59	2	0.29	0.62	0.05
1968	25	47	6	0.54	1.2	0.06
1969	20	60	5	1.3	5.2	0.07
1970	20	49	5	0.69	0.90	0.03
1971	18	25	15	0.80	2.5	0.10
1972	8	15	5	0.77	2.5	0.07
1973	29	70	15	0.64	1.3	0.18
1974	15	15	15	0.25	0.31	0.22
1975	24	33	15	0.10	0.14	0.06

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B5. Water quality data from long-term monitoring station 8-40-9, near Seaforth.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1975	9.0	13.0	2.5	14.3	1.4	3.2	0.10	0.06	0.09	0.03	0.02	0.12	0.63	0.0	0.64
1976	10.5	15.0	5.0	9.5	1.8	5.4	0.10	0.07	0.17	0.02	0.04	0.27	1.6	0.01	0.80
1977	8.8	14.5	6.0	11.7	1.9	4.8	0.40	0.10	0.32	0.05	0.05	0.36	2.1	0.01	1.1
1978	8.7	11.0	5.0	9.6	2.3	4.0	0.60	0.14	0.28	0.04	0.07	0.36	1.2	0.01	1.1
1979	- -	- -	- -	- -	1.5	3.8	0.10	0.08	0.28	0.02	0.04	0.20	1.2	0.01	0.74

Note: All results are in mg/L except where indicated

Table B5. Continued.

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1975	4,700	135	120	9	0.03	2.7		25	635	2	14
1976	2,500	260	170	4	0.04	3.3		31	625	2	11
1977	3,500	225	450	4	0.07	4.8		32	646	5	14
1978	4,300	260	760	7	0.07	5.8		26	611	12	19
1979	1,200	160	260	4	0.03	5.3	7.9	27	605	2	5

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B5. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1975	12	20	2	0.07	0.09	0.04
1976	8	15	1	0.04	0.07	0.02
1977	11	23	5	0.09	0.16	0.05
1978	22	70	6	0.13	0.28	0.06
1979	5	9	2	0.03	0.06	0.02

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B6. Water quality data from long-term monitoring station 8-40-6, near Clinton.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1972	8.5	10.0	8.0	12.4	2.0	4.8	0.50	0.39	1.4	0.05	0.40	0.04	0.11	0.01	0.61
1973	8.3	10.5	5.0	9.6	3.1	11.0	1.0	0.35	1.0	0.08	0.24	0.29	1.7	0.01	1.0
1974	8.2	12.0	2.0	7.5	1.9	5.0	0.50	0.18	0.38	0.07	0.12	0.13	0.42	0.01	0.70
1975	9.2	13.5	3.0	12.9	1.3	3.0	0.20	0.12	0.21	0.05	0.08	0.07	0.26	0.0	0.59
1976	11.3	15.5	7.0	9.1	1.6	4.2	0.70	0.12	0.45	0.03	0.08	0.12	0.32	0.01	0.61
1977	10.5	13.5	8.0	10.5	1.5	2.9	0.60	0.17	0.38	0.05	0.13	0.18	0.67	0.01	0.74
1978	9.5	13.0	5.0	8.8	1.6	2.8	0.30	0.15	0.23	0 06	0.11	0.18	0.55	0.01	0.74
1979	--	--	--	--	1.5	3.4	0.10	0.16	0.36	0.04	0.12	0.11	0.46	0.01	0.65

Note: All results are in mg/L except where indicated

Table B6. Continued.

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1972	5,400	85	115	--	0.06	4.4		--	525	--	15
1973	5,000	50	100	--	0.05	4.5		--	603	2	13
1974	3,300	280	195	--	0.06	4.4		31	560	9	25
1975	2,300	300	115	5	0.05	3.8		24	571	4	16
1976	1,800	170	180	5	0.04	3.3		27	585	2	13
1977	1,800	260	350	5	0.04	4.5		30	619	3	11
1978	2,000	145	215	6	0.05	4.9		25	574	9	5.5
1979	1,100	115	125	5	0.03	5.5	8.1	30	566	2	6

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B6. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1972	--	--	--	0.79	1.4	0.18
1973	8	15	5	0.75	1.0	0.36
1974	15	15	15	0.17	0.20	0.13
1975	10	15	2	0.11	0.17	0.07
1976	13	15	9	0.16	0.45	0.03
1977	5	15	2	0.23	0.38	0.12
1978	7	17	1	0.16	0.23	0.09
1979	9	15	3	0.24	0.36	0.04

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B7. Water quality data from long-term monitoring station 8-40-10, near Vanastra.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1976	15.3	15.5	15.0	0.5	0.95	1.1	0.80	0.04	0.06	0.02	0.03	0.09	0.17	0.01	0.52
1977	9.8	14.0	6.5	13.9	1.3	2.8	0.80	0.05	0.09	0.02	0.03	0.08	0.46	0.01	0.56
1978	9.6	13.0	5.0	10.4	1.4	2.6	0.70	0.07	0.18	0.02	0.05	0.09	0.27	0.01	0.54
1979	--	--	--	--	1.3	2.4	0.70	0.05	0.12	0.02	0.03	0.10	0.25	0.02	0.53

Note: All results are in mg/L except where indicated

Table B7. Continued

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1976	1,100	115	50	4	0.02	6.1		24	665	2	15
1977	1,300	175	150	4	0.03	3.8		20	539	3	9
1978	1,400	110	60	4	0.03	4.5		19	533	7	6
1979	1,670	135	165	4	0.03	4.6	8.0	17	525	2	5

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B7. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1976	--	--	--	--	--	--
1977	7	15	2	0.04	0.09	0.02
1978	6	14	1	0.05	0.09	0.02
1979	7	23	2	0.03	0.08	0.02

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B8. Water quality data from long-term monitoring station 8-40-8, near Varna.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1975	11.0	14.0	6.3	14.3	0.83	1.3	0.50	0.03	0.05	0.01	0.01	0.01	0.02	0.0	0.42
1976	11.7	16.5	8.0	9.0	1.2	3.1	0.10	0.04	0.08	0.02	0.02	0.05	0.16	0.01	0.51
1977	16.0	14.0	8.5	10.6	1.1	2.4	0.10	0.05	0.11	0.02	0.03	0.08	0.29	0.01	0.50
1978	10.2	12.8	8.0	9.9	1.2	2.6	0.20	0.07	0.21	0.02	0.04	0.08	0.22	0.01	0.55
1979	--	--	--	--	1.0	2.1	0.40	0.05	0.13	0.01	0.02	0.05	0.19	0.01	0.47

Note: All results are in mg/L except where indicated

Table B8. Continued.

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1975	1,000	80	100	5	0.01	2.6		19	553	3	12
1976	645	100	60	4	0.02	3.4		21	554	3	12
1977	770	110	130	6	0.03	4.4		19	558	3	12
1978	1,000	90	75	5	0.04	5.0		16	535	9	9
1979.	740	85	100	5	0.05	7.0	8.1	17	539	5	9

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B8. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1975	9	18	1	0.03	0.05	0.01
1976	13	16	6	0.03	0.07	0.02
1977	7	15	3	0.03	0.04	0.02
1978	13	35	4	0.05	0.10	0.02
1979	14	63	1	0.04	0.13	0.01

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B9. Water quality data from long-term monitoring station 8-40-7, Bayfield.

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1974	10.4	14.8	6.6	11.7	1.3	2.8	0.50	0.05	0.15	0.02	0.02	0.03	0.07	0.01	0.53
1975	12.7	17.1	9.2	10.2	2.0	5.5	0.80	0.06	0.15	0.03	0.02	0.03	0.06	0.01	0.58

Note: All results are in mg/L except where indicated

Table B9. Continued

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1974	440	73	110	--	0.02	2.5		14	452	11	17
1975	260	40	45	--	0.03	3.5		16	500	12	28

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B9. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1974	21	50	15	0.06	0.15	0.02
1975	18	25	15	0.04	0.04	0.04

Note: All results are in mg/L except where indicated

Seasonal = May to October

Table B10. Water quality data from long-term monitoring stations.

8-40-1. Bayfield

	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
1964	12.8	13.6	12.0	4.8	2.2	2.5	1.9	0.36	0.36	0.36	0.06	0.0	0.0	0.0	0.20
1965	9.7	13.6	6.4	11.5	1.4	3.2	0.5	0.18	0.42	0.10	0.07	0.09	0.13	0.0	0.54
1966	9.1	27.0	7.0	10.1	1.8	2.8	0.6	0.11	0.24	0.02	0.05	0.13	0.66	0.0	0.85
1967	9.3	14.0	7.0	8.8	1.2	2.6	0.8	0.04	0.07	0.02	0.03	0.12	0.23	0.03	0.64
1968	9.3	12.0	6.0	10.3	1.2	3.0	0.5	0.07	0.12	0.02	0.03	0.14	0.39	0.04	0.52
1969	8.6	12.0	6.0	10.6	1.4	2.0	0.5	0.06	0.13	0.02	0.03	0.08	0.22	0.01	0.56
1970	9.0	12.0	5.0	12.3	2.0	3.5	0.6	0.08	0.13	0.02	0.03	0.07	0.17	0.02	0.69
1971	8.9	11.5	7.0	12.6	1.8	3.2	0.5	0.06	0.12	0.02	0.02	0.05	0.14	0.01	0.62
1972	8.8	11.5	7.0	11.4	1.9	3.0	0.8	0.07	0.15	0.03	0.02	0.06	0.26	0.01	0.59
1973	8.6	12.0	6.0	10.9	1.6	2.4	0.6	0.06	0.10	0.02	0.03	0.11	0.76	0.01	0.58
1974	9.9	13.0	7.5	10.6	1.4	4.0	0.5	0.09	0.32	0.02	0.03	0.04	0.12	0.01	0.58
1975	8.2	12.0	6.0	11.5	2.2	3.5	1.1	0.13	0.22	0.03	0.03	0.09	0.30	0.01	0.78

Note: All results are in mg/L except where indicated

Table B10. Continued .

	Bacteria /100 ml				Filtered	Filtered	pH	Cl^-	Cond.	Turbidity	Suspended
	T.C.	F.C.	F. S.	Ps. a.	NO_2	NO_3					Solids
1964	1,400				0.0	0.0		--	--	8	8
1965	160				0.0	1.2		15	520	18	12
1966	220				0.01	1.7		12	479	13	26
1967	880				0.01	1.7		13	502	13	36
1968	230				0.01	1.4		9	476	9	11
1969	290				0.01	1.9		12	447	8	12
1970	260				0.02	2.7		15	486	24	17
1971	540				0.03	2.0		13	408	7	18
1972	870	60	36		0.03	4.0		--	492	--	32
1973	1,120	36	33		0.02	3.8		--	477	11	16
1974	1,100	190	200		0.02	3.6		13	457	35	52
1975	1,500	210	89		0.03	5.0		15	486	26	53

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table B10. Continued.

Date	Seasonal Suspended Solids			Seasonal Total Phosphorus		
	Avg.	Max.	Min.	Avg.	Max.	Min.
1964	--	--		0.36	0.36	0.36
1965	18	29	9	0.19	0.42	0.10
1966	31	94	10	0.14	0.24	0.02
1967	58	298	4	0.04	0.07	0.02
1968	15	27	7	0.05	0.11	0.02
1969	15	35	5	0.05	0.13	0.03
1970	18	26	10	0.06	0.12	0.02
1971	34	45	15	0.07	0.12	0.02
1972	20	40	5	0.05	0.07	0.03
1973	16	20	10	0.07	0.10	0.04
1974	29	40	15	0.07	0.14	0.02
1975	15	15	15	0.04	0.06	0.03

Note: All results are in mg/L except where indicated

Seasonal = May to October

APPENDIX C

Chemical, bacteriological and biological survey data

Table C1. Water quality data from June 15, 1978 summary.

Station	D.O.	Temp (°C)	BOD_5	Bacteria /100 ml				Phosphorus as P		Nitrogen as N			
				T.C.	F.C.	F.S.	Ps.a.	Total	Filt. diss.	Kjel.	Filtered Ammonia	Filtered Nitrite	Filtered Nitrate
BR-1	10.2	14.2	1.4	1700	300	136	L4	0.014	0.003	0.555	0.025	0.050	8.7
BR-2	9.6	14.5	1.3	2100	140	400	L4	0.025	0.002	0.720	0.005	0.145	9.5
BR-3	9.9	14.2	1.1	3400	440	168	L4	0.017	0.003	0.420	0.010	0.087	11.2
BR-4	11.0	13.5	0.9	C400	20	136	L4	0.020	0.005	0.505	0.010	0.023	4.6
BR-5	9.4	14.5	1.0	C600	930	244	L4	0.018	0.004	0.405	0.015	0.071	11.8
BR-6	10.4	14.2	0.8	710	820	236	L4	0.023	0.005	0.420	0.015	0.083	13.2
BR-7	9.7	15.0	1.2	C2700	120	248	L4	0.055	0.027	0.440	0.020	0.105	15.3
BR-8	9.6	14.8	1.3	2500	240	288	8	0.018	0.003	0.430	0.015	0.079	14.1
BR-9	9.9	15.2	1.1	1500	230	108	L4	0.024	0.009	0.505	0.025	0.066	12.4
BR-10	8.8	15.4	1.1	2000	170	100	L4	0.016	0.003	0.495	0.010	0.054	11.0
BR-11	8.6	15.0	1.0	C2700	310	450	L4	0.016	0.006	0.495	0.015	0.072	16.2
BR-12	11.4	15.4	5.7	2800	76	72	L4	0.025	0.005	0.530	L0.005	0.044	7.0
BR-13	11.2	15.2	2.4	2600	170	172	L4	0.105	0.007	0.695	0.005	0.073	7.0
BR-14	13.8	13.8	0.9	1600	270	576	L4	0.015	0.008	0.225	0.015	0.047	9.2
BR-15	7.8	16.0	1.0	1400	84	48	L4	0.018	0.004	2.00	1.26	0.280	8.4
BR-16	8.8	16.0	1.1	1900	120	128	L4	0.018	0.001	0.687	0.035	0.215	9.5
BR-17	13.8	16.0	5.3	1300	130	60	L4	0.114	0.003	1.10	0.015	0.102	3.14
BR-18	12.5	15.2	1.6	1700	200	180	L4	0.019	0.002	0.685	0.015	0.099	3.44

Note: All results are in mg/L except where indicated

Table C1. Continued.

Station	Cond µmho/cc	Turb (form.)	Chloride	pH	Susp. Solids
BR 1	565	2.4	16.5	7.91	9
BR 2	685	1.5	18.0	7.95	4
BR 3	605	1.2	18.0	8.24	15
BR 4	630	0.65	31	8.22	3
BR 5	635	1.6	14.5	8.10	2
BR 6	645	2.7	15.0	8.17	13
BR 7	645	1.0	19.5	8.24	4
BR 8	635	1.0	18.0	8.26	1
BR 9	625	1.0	18.5	8.12	5
BR 10	615	1.1	17.5	8.11	4
BR 11	695	1.0	15.5	7.87	3
BR 12	585	1.0	26.5	8.35	1
BR 13	600	1.4	22	8.28	4
BR 14	705	0.8	22.5	8.34	1.5
BR 15	595	1.2	24	8.09	1
BR 16	585	0.65	18	8.22	1
BR 17	525	1.2	21.5	8.42	11
BR 18	545	0.75	15	8.37	3

Note: All results are in mg/L except where indicated

Table C2. Water quality for July 31, 1978 survey.

Station	D.O.	Temp (°C)	BOD_5	Bacteria /100 ml				Phosphorus as P		Nitrogen as N			
				T.C.	F.C.	F.S.	Ps.a.	Total	Filt. diss.	Kjel.	Filtered Ammonia	Filtered Nitrite	Filtered Nitrate
BR 3			1.0	100	A70	A30	L4	0.014	0.002	0.545	0.015	0.008	0.66
BR 3A			0.1					0.018	0.003	0.435	0.015	0.016	1.54
BR 4			0.6	1300	68	260	L4	0.042	0.022	0.575	0.005	0.002	L0.01
BR 5			0.8	A200	A50	A40	L4	0.015	0.003	0.565	0.015	0.007	0.33
BR A			0.3	C580	A80	150	L4	0.012	0.008	0.175	0.015	0.005	4.88
BR 7A			1.1					0.78	0.73	0.600	0.005	0.011	1.75
BR 7B			2.8					1.18	0.97	0.930	0.005	0.023	2.9
BR 7C			1.2					0.91	0.89	0.655	0.035	0.057	3.0
BR STP			1.6					5.90	5.56	1.10	0.425	0.43	20.5
BR 8			0.9					0.018	0.003	0.465	0.015	0.006	0.16
BR 9A	11.2	21.5	1.2	A20	L10	A30	L4	0.024	0.003	0.755	0.005	0.001	0.01
BR12	12.8	25.8	2.5	C200	A80	120	L4	0.050	0.004	0.730	L0.005	0.005	0.04
BR13	14.3	27.2	1.9	C800	230	390	L4	0.081	0.020	0.735	0.035	0.015	0.15
BR16	11.4	23.0	1.4	C200	150	180	L4	0.037	0.002	0.730	L0.005	0.005	0.02

Note: All results are in mg/L except where indicated

Table C2. Continued

Station	Susp. Solids	µmho/cc (Cond.	Turb. (Form)	pH	Chloride
BR 3	2	368	1.9	8.58	11.5
BR 3A	4	413	1.3	8.39	13.5
BR 4	3	525	0.95	8.56	41.0
BR 5	3	422	1.5	8.51	9.0
BR A	1	492	0.47	8.19	10.0
BR 7A	5	565	1.0	9.04	44.5
BR 7B	31	565	8.5	8.99	50
BR 7C	5	565	1.5	8.36	40
BR STP	3	1220	0.8	7.77	15.5
BR 8	5	443	1.2	8.19	21.5
BR 9A	3	367	1.0	8.79	16.0
BR 12	5	600	1.9	8.83	46.5
BR 13	9	790	2.4	8.55	58
BR 16	3	348	1.1	8.27	8.0

Note: All results are in mg/L except where indicated

Table C3. Water quality data for Bayfield River in the vicinity of Seaforth, May 2-4, 1978.

Station	Dissolved Oxygen			Temp.	BOD_5			Phosphorus as P				Nitrogen as N			
								Total			Filt.	Filtered Ammonia			Kjel.
	Avg.	Max.	Min.	(°C)	Avg.	Max.	Min.	Avg.	Max.	Min.	diss.	Avg.	Max.	Min.	
SB 1	12.0	14.2	9.7	10.3	1.1	1.3	0.9	0.020	0.024	0.016	0.003	0.009	0.015	0.005	0.375
SB 2	11.9	15.4	9.4	9.8	1.1	1.5	0.4	0.021	0.044	0.009	0.003	0.005	0.015	L0.005	0.305
SB 2A	12.7	17.7	8.9	9.1	1.2	1.4	0.9	0.039	0.067	0.025	0.017	0.013	0.045	L0.005	0.331
SB 3	12.0	15.2	9.2	9.7	1.1	1.3	0.8	0.022	0.035	0.015	0.005	0.006	0.015	L0.005	0.411
SB LAG	13.9	15.9	12.5	9.7	12.1	14.0	10.4	0.347	0.382	0.320	0.005	1.47	1.80	1.14	3.83
SB A	11.9	15.3	10.4	9.7	11.3	13.2	9.6	0.337	0.362	0.308	0.006	1.18	1.57	0.785	3.24
SB 4	12.4	16.2	9.1	9.8	5.2	5.6	4.4	0.128	0.168	0.116	0.003	0.327	0.168	0.116	1.24
SB 5	12.8	17.0	8.4	10.1	4.5	7.4	1.6	0.098	0.109	0.078	0.003	0.073	0.155	0.025	0.89
SB B	11.2	14.3	8.7	9.3	1.2	3.5	0.7	0.016	0.019	0.012	0.004	0.008	0.015	L0.005	0.376
SB 6	12.7	15.8	9.6	10.1	3.5	4.8	2.1	0.075	0.088	0.061	0.003	0.018	0.060	L0.005	0.744
SB 7	12.9	16.4	9.2	9.8	3.3	4.2	2.2	0.058	0.074	0.035	0.003	0.011	0.025	L0.005	0.662
SB 8	13.9	15.3	12.2	10.8	3.5	4.2	2.6	0.061	0.078	0.047	0.003	0.008	0.020	L0.005	0.663
SB 9	12.6	13.0	11.9	10.7	2.2	3.3	1.4	0.042	0.051	0.023	0.002	0.008	0.015	L0.005	0.568

Note: All results are in mg/L except where indicated

Table C3. Continued.

Station	Bacteria /100 ml				Filtered NO_2	Filtered NO_3	pH	Cl^-	Cond.	Turbidity	Suspended Solids
	T.C.	F.C.	F. S.	Ps. a.							
SB 1	53	L10	L4	L4	0.027	4.37	8.32	17	505	1	L15
SB 2	220	L10	30	L4	0.026	5.43	8.12	21	695	1	L15
SB 2A	5000	290	60	2	0.045	5.76	8.15	28	711	1	L15
SB 3	830	15	20	2	0.034	4.83	8.32	19	552	1	L15
SB LAG	2800	80	83	5	0.257	1.38	8.12	101	996	9	33
SB A	2000	84	45	4	0.232	1.71	8.14	97	960	6	25
SB 4	770	17	77	L4	0.094	3.62	8.27	46	703	3	L11
SB 5	270	L10	32	L4	0.077	3.58	8.28	42	669	1	L12
SB B	40	6	2	L4	0.034	6.51	8.10	12	583	1	L15
SB 6	120	2	23	L4	0.059	4.14	8.30	37	646	I	L15
SB 7	100	A10	20	L4	0.043	4.05	8.30	34	629	1	L15
SB 8	46	L10	92	L4	0.035	4.00	8.38	35	612	1	L15
SB 9	20	L10	48	L4	0.026	3.80	8.39	31	598	1	L15

Note: All results are in mg/L except where indicated

Bacteriological results are geometric means.

Table C4. Macroinvertebrates collected at 9 stations in the Bayfield River Basin.

	STATIONS																	
	5		6		9		15		19		20		26		27		28	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
ORGANISMS																		
DOBSONFLIES																		
Corydalus cornutus												2				2	1	
FISHFLIES																		
Chauliodes																1		
STONEFLIES																		
Acroneuria									4	1	3	1	3				3	7
Nemoura															1	5		
MAYFLIES																		
Baetis															2	2		
Caenis	14	5																
Ephemerella														1		14		
Heptagenia							1											
Leptophlebia													2					
Pseudocloeon													3					
Stenonema canadense							6		5				1					1
Stenonema rubrum									1						3			
Stenonema tripunctatum					1		4	7						3				
Stenomema sp.			3			3	1									3		
Tricorythodes stygiatus							1											
CADDISFLIES																		
Cheumatopsyche	21	8	1				22		3		5	21	2	3	2	1		1
Chimarra							3						4	1				
Doiophllodes																3		
Glossosoma															17	4		

Table C4. Continued.

	STATIONS																	
	5		6		9		15		19		20		26		27		28	
	A	8	A	8	A	B	A	8	A	B	A	B	A	B	A	B	A	B
CADDISFLIES - continued																		
Helicopsyche			1				15	14		2	8	5	5	15				3
Hydropsyche							4					2	4	1	3	14	5	2
Oecetis								1						2				
Pycnopsyche			2				1	1	5	1	6	7	5	8	6	10		4
pupae(unidentified)							5			7				5		14		5
DAMSELFLIES																		
Agrionidae													2				2	2
Coenagrionidee	3	2	1		1					2	2	1	3				4	1
DRAGONFLIES																		
Aeschnidae									2			1	1	4		1		
BEETLES																		
Culicidae		1																
Dytisoidae																1		
Elmidae									2	1		1		1	1	1		2
Hydrophilidae		2																
Psephenidae		1	1		1	6	2		1	7			2	3				2
adult(unidentified)	2	2	4	3			4	6	5	40	3	5	3	11		2	1	5
TRUE BUGS																		
Corixidae	1			4														
Nepidee									1									
MITES(unidentified)		2		2					3	3								
AMPHIPODS																		
Hyalella azteca	5	7	2	7	2			1	2	3			1	2			3	
CRAYFISHES																		
Orconectes propinquus			3	2			2	1	2	1	4	2		1			1	3

Table C4. Continued.

	STATIONS																	
	5		6		9		15		19		20		26		27		28	
	A	B	A	B	A	B	A	8	A	B	A	B	A	B	A	B	A	B
SNAILS																		
Amnicola						1		6					1					
Ferrissia				3	1													
Goniobasis																	9	6
Gyraulus				3														
Helisoma							3	4	1		3	1		5			3	3
Lymnaea			1													3		3
Physa	16	3	9	3		2	22	1	15	9	10	12	12	11	8	5	15	10
CLAMS																		
Pisidium									1									
Sphaerium			1						2			1						
Unionidae												1						
TRUEFLIES																		
Chironomidae	3	2	4	4	1	1			3				I		12	19		
Rhagionidae													2					
Simuliidae															4	1		
Tipulidae											1		1					
WORMS																		
Tubificidae	5	1					4			1								
LEECHES (unidentified)		2		3		2	2			1			1					
FLATWORMS (unidentified)			1	8	13	1							2					
Total number of taxa	13		18		10		18		21		15		27		18		17	
Total number of organisms	70	38	34	42	20	16	102	42	58	79	45	63	61	77	62	107	47	60

Table C5. Station Locations for *Cladophora* observations on the Bayfield River (June 6/78).

Station	Lot	Concession	Township	Remarks
1	18	II	McKillop	Silver Creek
2	20	II	McKillop	Silver Creek
3	20	I	McKillop	Silver Creek
4	23	I	McKillop	Upstream from Seaforth
5	9	III	Tuckersmith	Downstream from Seaforth
6	1	III	Tuckersmith	
7	10	III	Tuckersmith	Egmondville
8	14	III	Tuckersmith	Upstream from Seaforth lagoons
9	15	III	Tuckersmith	Downstream from Seaforth lagoons
10	20	IV	Tuckersmith	
11	22	V	Tuckersmith	Broadfoot Creek
12	26	II	Tuckersmith	
13	31	II	Tuckersmith	
14	36	I	Tuckersmith	
15	41	I	Tuckersmith	Clinton
16	34	II	Stanley	
17	32	IV	Stanley	
18	55	XIII	Goderich	Tributary-cold water stream
19	29	XII	Goderich	Federal gauge
20	BRN21	IV	Stanley	Bannockburn River
21	BRN24	IV	Stanley	Bannockburn River
22	10	IV	Stanley	Bannockburn River
23	6	IV	Stanley	Bannockburn River
24	3	II	Stanley	Bannockburn River
25	1	I	Stanley	Bannockburn River

Table C6. Observations and documentation of Cladophora growth on the Bayfield River (June 6, 1978).

Location	Temperature	Depth	Substrate	Stream cover	Growth Present
Bayfield River Station#1	26°C	5-15 cm	Sand Silt	Open field	grassed-ditch
Bayfield River Station #2	26°C	5-20 cm	Sand Silt	Open field	grassed-ditch
Bayfield River Station#3	26°C	5-30 cm	Sand Silt	Open field	ditch, grassed banks
Bayfield River Station #4	26°C	16-60 cm	Sand	Open field	heavy aquatic growth Milfoil spp.
Bayfield River Station#5	26°C	5-20 cm	Sand Gravel	Open field; golf course Cattle Pasture	*Cladophora* present 10% substrate limiting. Blue-green alga present
Bayfield River Station#6	26°C	15-60 cm	rocks clay gravel sand	Open field pasture cattle access	*Cladophora*. 70% cover unhealthy - moss like * (Flow almost nil).
Bayfield River Station #7	24°C	15-60 cm	cobble gravel sand	meadow and pasture some trees	*Cladophora*. 100% cover strands 2 m, sloughing off mats present.
Bayfield River Station #8	24°C	15-60cm	cobble rock	open meadow some pasture	*Cladophora*. 100% cover strands 3 m long. large mats present
Bayfield River Station#9	25°C	15-60 cm	cobble rock gravel clay	open meadow pasture	*Cladophora*. 80% cover silted, strands 2 m. long sloughing off
Bayfield River Station10	23°C	15cm- 1 m.	cobble rock clay	cattle access open pasture	*Cladophora*. 40% cover heavily silted, unhealthy strands 1 m. long

Table C6. Continued

Location	Temperature	Depth	Substrate	Stream Cover	Growth Present
Bayfield River Station # 11	24°C	5-60 cm	sand silt	cattle access pasture	rooted aquaticspresent even flow area
Bayfield River Station#12	21°C	15-60 cm	cobble gravel sand	some trees and bushes along streambank	*Cladophora*- 60% bottom cover strands 60 cm long.-aquatic plants (water lilies) growing in pool areas.
Bayfield River Station#13	21°C	15cm 1.5 m.	cobble gravel silt	open pasture cattle access	*Cladophora*-60% cover heavily silted, rooted aquatics *Potamogeton spp*. also common
Bayfield River Station#14	20°C	60 cm 1m.	rock cobble	trees,bush grass	*Cladophora* present but sparse. Rooted aquatics, waterlilly bullrush, reeds
Bayfield River Station#15	21°C	15cm 1 m.	cobble rock clay gravel	well treed willows	*Cladophora* -60 strands,1 m. long-silted poor health
Bayfield River Station#16	20°C	15 cm 60 cm	cobble gravel	openfield withbush along bank	*Cladophora*-presentshortstrands Green slime covering all rocks
Bayfield River Station #17	20°C	15cm 1 m.	cobble rock clay	open field some bush along bank	*Cladophora* -100% coven strands 5 metreslong,very healthy
Bayfield River Station #18	12°C	15-60 cm	cobble gravel	excellent cedan bush	*Cladophora* present. Strands 1 cm long on odd stones
Bayfield River Station#19	19°C	15cm- 2 m.	rock cobble sand clay	good cover trees, brush	*Cladophora*-80% cover. all suitable substrate strands up to 4 m. long
Bayfield River Station#20	17°C	15 cm- 1 m.	cobble silt clay	cedar bush good cover	*Cladophora*-30% cover Strands 2 cm long, growing on larger stones

Table C6. Continued

Location	Temperature	Depth	Substrate	Stream Cover	Growth Present
Bayfield River Station #21	17°C	15cm - 1m.	cobble clay	cedar bush some open meadow	*Cladophora* 30% cover strands 2 cm long on larger stones, rooted aquatics present
Bayfield River Station #22	17°C	30 cm -1.5 m.	cobble sand	openfields bank grassed	*Cladophora* 100% cover silted, poor health. Pond weeds growing in even areas
Bayfield River Station#23	19°C	30-60 cm	sand silt	openfield stream ditched	*Cladophora* present on suitable substrates *Spyrogyra* growth heavy
Bayfield River Station #24	18°C	30 cm - 1m.	rock cobble sand	open pasture cattle access	*Cladophora*100% cover strands several metres long mats forming
Bayfield River Station #25	18°C	30 cm - 1m.	rock cobble sand	open meadow and fields	*Cladophora*100% cover, large mats to surface *Potamogeton spp.* in pool areas

APPENDIX D

Streamflow data

Table D1. Streamflow data for Bayfield River nean Varna. Federal gauge 02FF007 - drainage area 180 square miles - period of record is Oct, 1966 to Dec, 1976.

Month	Mean monthly flow (cfs)	Minimum monthly mean flow with return period of one-in-ten years (cfs)
January	281	57
February	299	50
March	658	420
April	481	150
May	161	42
June	44	15
July	22	9
August	21	5
September	13	4
October	46	7
November	178	44
December	229	52

Table D2. Streamflow data for Bayfield River downstream from Seaforth as pro-rated from Federal Gauge 02FF007, Bayfield River near Varna. The drainage area at the gauge is 180 square miles and at Seaforth, 49 square miles. The period of record is 1966-1976.

Month	Mean monthly flow (cfs)	Minimum monthly meanflow with one-in-ten year return period [a] (cfs)
January	76	16
February	81	14
March	179	114
April	131	41
May	44	11
June	12	4
July	6	2
August	6	1
September	4	1
October	13	2
November	48	12
December	62	14

a. See text for reference to extneme low-flow events in the summer.

Table D3. Streamflow data for Bayfield River at Clinton as pro-rated from Federal Gauge 02FF007, Bayfield River near Varna. The drainage area at the gauge is 180 square miles and at Clinton, 81 square miles. The period of record is 1966-1976.

Month	Mean monthly flow (cfs)	Minimum monthly mean flow with one-in-ten year return period (cfs)
January	126	26
February	135	23
March	296	189
April	216	68
May	72	19
June	20	7
July	10	4
August	9	2
September	6	2
October	21	3
November	80	20
December	103	23

Table D4. Streamflow data for Bayfield River downstream from Seaforth. MOE gauging site 02FF101 - 1966 to 1974.

Month	Number of streamflow measurements in range specified (cfs)					
	0	0.0 - 10	10.1 - 20	20.1 - 30	30.1 - 40	G40.1
Jan	0	0	1	0	0	0
Feb	0	0	0	0	0	1
Mar	0	0	1	0	0	1
Apr	0	0	1	2	1	10
May	0	2	2	2	0	5
June	0	8	2	2	0	0
July	2	11	2	0	0	0
Aug	7	8	1	0	0	0
Sept	1	11	0	0	0	0
Oct	2	8	0	0	0	4
Nov	0	4	2	2	0	4
Dec	0	0	1	0	0	1

Table D5. Streamflow data for Silver Creek just upstream from confluence with Bayfield River. MOE gauging site 02FF100 1966 - 1974.

Month	Number of streamflow measurements in range specified (cfs)					
	0-2	2.1 - 5	5.1 - 10	10.1 - 20	20.1 - 30	G30.1
Jan	0	0	0	1	0	0
Feb	0	0	1	0	0	0
Mar	0	0	0	I	0	1
Apr	0	0	3	3	2	2
May	0	5	2	2	0	0
June	4	5	2	0	0	0
July	9	2	0	0	0	0
Aug	13	0	0	0	0	0
Sept	8	0	0	0	0	0
Oct	6	0	3	0	0	0
Nov	3	4	1	2	0	2
Dec	0	2	1	0	0	0

Table D6. Streamflow data from surveys of the Bayfield River, 1978.

Station	Date	Streamflow (cfs)	Average
Seaforth Survey			
SB-1	May 3	8.3	
	May 4	6.1	7.2
SB-2	May 3	3.0	
	May 4	2.9	3.0
Upstream lagoon	May 4	0.04	0.04
Lagoon discharge	May 3	7.6	
	May 4	7.6	7.6
SB-4	May 3	23.1	
	May 4	21.2	22
SB-B	May 3	1.5	
	May 4	1.4	1.5
SB-7	May 3	30.9	
	May 4	28.9	29.9
Clinton Survey			
BR-8	July31	0.73	
STP	July31	0.28	
BT-7	July31	DRY	
BR-7A	July31	DRY	
BR-A	July31	2.8	
BR-3A	July31	2.5	
BR-5	July31	0.82	
BR-3	July31	4.0	