

**Lake
Simcoe
Environmental
Management
Strategy**



**Implementation
Program**

**Assessment and Control of Duckweed in the
Maskinonge River, Keswick, Ontario.**

Technical Report: Imp. B.6



1992



**ASSESSMENT AND CONTROL OF DUCKWEED
IN THE MASKINONGE RIVER,
KESWICK, ONTARIO**

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for

The Lake Simcoe Environmental
Management Strategy Technical Committee
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LAKE SIMCOE ENVIRONMENTAL MANAGEMENT STRATEGY IMPLEMENTATION PROGRAM

FOREWORD

This report is one of a series of technical reports prepared in the course of the Lake Simcoe Environmental Management Strategy (LSEMS) Implementation Program. This program is under the direction of the LSEMS Steering Committee, comprised of representatives of the following agencies:

- Ministry of Agriculture, Food and Rural Affairs;
- Ministry of the Environment and Energy;
- Ministry of Natural Resources; and
- Lake Simcoe Region Conservation Authority.

The Lake Simcoe Environmental Management Strategy (LSEMS) studies were initiated in 1981 in response to concern over the loss of a coldwater fishery in Lake Simcoe. The studies concluded that increased urban growth and poor agricultural practices within the drainage basin were filling the lake with excess nutrients. These nutrients promote increased weed growth in the lake with the end result being a decrease in the water's oxygen supply. The "Final Report and Recommendations of the Steering Committee" was released in 1985. The report recommended that a phosphorus control strategy be designed to reduce phosphorus inputs from rural and urban sources. In 1990 the Lake Simcoe Region Conservation Authority was named lead agency to coordinate the LSEMS Implementation Program, a five year plan to improve the water quality of Lake Simcoe. The Conservation Authority will have overall coordination responsibilities as outlined in the LSEMS Cabinet Submission and subsequent agreement (Recommendation E.1). At the completion of the five year plan (1994) a report will be submitted to the Cabinet. This report will outline the activities and progress of the LSEMS Implementation Program during its five years. After reviewing the progress of the program the Cabinet may continue the implementation program.

The goal of the LSEMS Implementation Program is to improve the water quality and natural coldwater fishery of Lake Simcoe by reducing the phosphorus loading to the lake. The LSEMS Implementation Program will initiate remedial measures and control options designed to reduce phosphorus inputs entering Lake Simcoe, monitor the effectiveness of these remedial measures and controls and evaluate the overall response of the lake to this program. Through cost sharing programs, environmental awareness of the public and further studies, the goal of restoring a naturally reproducing coldwater fishery in Lake Simcoe by improving water quality can be reached.

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DISCLAIMER

The material presented in these reports is analytical support information and does not necessarily constitute policy or approved management priorities of the Province or the Conservation Authority and/or the evaluation of the data and findings, should not be based solely on this specific report. Instead they should be analyzed in light of other reports produced within the comprehensive framework of this environmental management strategy and the implementation of the recommendations.

Reference to equipment, brand names or suppliers in this publication is not to be interpreted as an endorsement of that product or supplier by the authors, the Ministries of Agriculture, Food and Rural Affairs, Environment and Energy or Natural Resources or the Lake Simcoe Region Conservation Authority.

EXECUTIVE SUMMARY

An explosive growth of duckweed (*Lemna minor*, *Wolffia* sp.) covered 100% of the lower Maskinonge River in 1987 and created problems to commercial and public users.

This condition is believed to have been the result of enriched stormwater flow from the surrounding agricultural land gaining access to the water course. During June, July and August 1987, rainfall was above the thirty year average and concentrations of ammonia, nitrate and phosphorus were the highest concentrations reported since implementation of the MOE water quality monitoring program at the Woodbine Avenue location.

There has been a recent increase in the acreage of sod farms in the Maskinonge River watershed. The amount of fertilizer applied to sod is significantly greater than quantities used for other agricultural crops. For these reasons changes in land fertilizer use was probably a contributing factor to the problem in 1987 and will be in the future unless corrective action is taken.

The study reported herein addresses the cause of the problem and means for future control. Two means to control the problem are discussed; improvement in water quality and the use of herbicides as a preventative measure.

Water quality improvement will require the identification of specific sources of nutrients to the watercourse and action to reduce or eliminate them. An objective for water quality equivalent to the Black River is proposed. Herbicide control using Reglone A in nursery areas was found to be an effective means of preventing duckweed growth.

The report recommends that a detailed evaluation of all fertilizer use and other potential sources of plant nutrients be made by an enforcement agency and that best available agricultural practice be required as the means to achieve the proposed water quality objective. A water sampling program is recommended to improve the data available on water quality and to identify specific sources of nutrient inputs. It is recommended that herbicide control be continued as a preventative measure until such time as water quality improvements ensure that the 1987 duckweed problem will not reoccur.

An estimate of cost to implement the water quality monitoring and herbicide control programs are provided.



Plate A. Duckweed seed nursery area in cattails. Herbicide treatment was carried out at this site.



Plate B. Duckweed growth in the same vicinity of Plate A, two weeks following herbicide treatment. Note the extension of the duck-weed mat toward the middle of the channel and the free-floating duckweed moving down-stream.



Plate C. Duckweed growth (100% cover) above the forks of the Maskinonge River. This section was not treated with herbicide.

Figure 1. Duckweed Growth and Herbicide Control Program on the Maskinonge River in 1988.

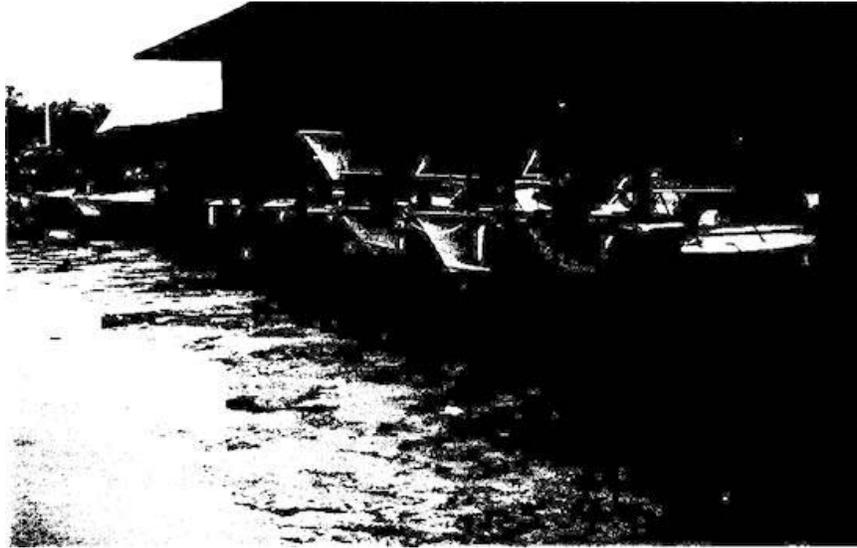


Plate D. Duckweed growth in Keswick Marine just below the Don Mills Road bridge. The marina offers a protected environment that is ideal for duckweed growth.



Plate E. Herbicide application at Keswick Marine using a backpack sprayer.

Figure 1. (cont'd)

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INTRODUCTION

The growth of duckweed (*Lemna minor*, *Wolffia* spp.) has become a problem in the lower stretches of the Maskinonge River at Keswick, Ontario, during recent growing seasons. During the summer months in 1987 duckweed formed a thick mat on the water surface, covering the entire river. The excessive growth of duckweed created various problems users of the river and interfered with boating, swimming, fishing and general aesthetic enjoyment of the river. Entrainment of duckweed into the cooling systems of boat motors resulted in costly engine damage and loss of business to marina operators.

Duckweed has been described as the fastest-growing plant in the world, frequently doubling their biomass in only two or three days (Rejmankova, 1971). Although sexual reproduction may occur in duckweed, the predominant means of reproduction is vegetative, through budding, whereby each plant divides to form two identical plants.

The protected, quiescent environment of the Maskinonge River provides optimal growth conditions for duckweed. The river watershed drains a land base that is primarily agricultural and nutrient input from non-point sources would be anticipated. Anecdotal evidence suggests that duckweed growth has increased significantly in recent years. This indicates that environmental conditions may have changed to provide favourable conditions for duckweed growth, though it has not been established that nutrient inputs to the river are responsible for increase in duckweed growth.

In response to public concern, the Ministry of the Environment and the Lake Simcoe Region Conservation Authority accepted a comprehensive proposal by the consultant to investigate the possible causes of problem duckweed growth in the Maskinonge River and to implement a study to develop and demonstrate an effective means of controlling duckweed.

STUDY OBJECTIVES

The study and control program were conducted with the following specific objectives:

1. to assess available water quality information to determine if changes in water chemistry are responsible for the proliferation of duckweed in the river.
2. to identify any point source discharges or changes in fertilizer practice in the Maskinonge River watershed that may directly impact the availability of plant nutrient resources.
3. to implement and monitor an effective herbicide program to control the problem growth of duckweed during the 1988 growing season.

METHODS

Review of Water Quality Information

Changes in plant nutrient availability was believed to be responsible for the heavy growth of duckweed that has occurred in the Maskinonge River during the last several growing seasons. In order to determine if changes in nutrient availability has occurred available water quality information was reviewed to ascertain whether concentrations of nitrogen and phosphorus had reached the levels that would be needed to support luxuriant duckweed growth. Meteorological data was also reviewed in conjunction with water quality data to determine if weather events and general climatic conditions could have been a contributing factor. Rainfall is of special importance as runoff may carry increased nutrient inputs from non-point sources.

Water quality data from the MOE Provincial Water Quality Monitoring Program was available beginning in 1971 and 1985 from two locations on the Maskinonge River; Don Mills Road and Woodbine Avenue, respectively. The water quality parameters assessed were phosphorus, ammonia and nitrates. Average monthly values were determined from May to September each year, for each station to evaluate possible changes with time.

Water quality data from other Lake Simcoe tributaries was reviewed to determine whether nutrient concentrations in the Maskinonge River significantly different from comparable watersheds. Water quality from the Holland River polder at Bradford, which normally supports heavy duckweed growth, and the Black River at Sutton, which has no record of supporting excessive growth of duckweed, was

assessed. By comparing water quality data from watersheds with a history of supporting different degrees of duckweed growth, additional insight into the relationship between nutrient availability and growth rates under comparable climatic conditions could be obtained. Relevant scientific literature was also reviewed to determine whether the minimum concentrations of nutrients required to support luxury growth of duckweed had been identified.

Documentation of Potential Sources of Nutrient Enrichment to the Maskinonge River

Personnel from the Ontario Ministry of Agriculture and Food (OMAF) were contacted to obtain information on changes in agricultural practices, acreage occupied by different agriculture land uses and fertilizer practices in the Maskinonge River watershed.

A turf specialist from the University of Guelph, Department of Horticultural Science was contacted to obtain specific information on sod farming practices and any changes that have occurred with them in the recent past, such as fertilizer use and application rates.

A survey of the land use activities adjacent to the Maskinonge River tributaries was carried out to determine if point source discharges and inputs to the river were evident. The survey involved a number of site investigations at locations accessible to the tributaries. At each site water flow, evidence of nutrient enrichment in the water (algal, duckweed growth), surrounding vegetation and land use, identification of point source nutrient input to the river plus other relevant site information was recorded. A 1:50,000 topographic map was used to locate and document land use activities in the

Maskinonge River watershed.

Other potential sources of nutrient input to the river including septic system leakage, barnyard drainage, erosional material and storm water runoff were considered.

Chemical Control Program

The strategy selected to control duckweed growth was preventative rather than a full treatment of the watercourse. This followed the means employed in the United States for water hyacinth control whereby surveillance of seed areas is maintained and small amounts of chemical are used to reduce the explosive growth potential of the plant.

In order to apply a herbicide in public waters a permit must be obtained from the Ontario Ministry of the Environment and both the operator and applicator must be licenced. Limnos staff obtained the required operators license and water exterminator's license issued upon passing mandatory examinations. To obtain a permit to carry out the water treatment a number of criterion had to be met as specified by the Pesticides Act and Regulation 751 and administered by the Environmental Approvals and Land Use Planning Branch and the Central Region Office of the Ministry of the Environment.

Reglone A, a commercial brand of diquat, was selected as the control chemical. Reglone A is a registered, aquatic herbicide commonly used to control submerged macrophytes, duckweed and other floating plants. It is relatively non-toxic to aquatic and terrestrial animals and is non-persistent. Reglone A is inactivated by sunlight, by

absorption to suspended soil particles and sediments.

A survey of the river identified potential areas of problem duckweed growth which would be sites for herbicide treatment. These sites were identified as duckweed seed areas and were characterized by protected, quiescent water. They included cattail margins, boat slips, dredged access channels and marinas (Figure 1; plate A, plate D). Treatment sites were located on a tax assessment map which provided corresponding information on landowner properties along the watercourse. In compliance with MOE regulations landowners adjacent to sites of problem duckweed growth were contacted to obtain permission to treat their shoreline with the herbicide. A total of 50 litres of Reglone A was approved under the permit for the treatment. The amount of chemical required was calculated from the approximate surface area of the river requiring treatment, the anticipated frequency of spraying, and the recommended application rate (22 L/ha diluted to 4 parts water : 1 part herbicide) as prescribed in the "Guide to Weed Control" (OMAF Publication #75, 1988).

Prior to each application, written notification was delivered to the involved landowners indicating the specific date on which spraying was to occur. Likewise, public notification indicating the date of spraying and restrictions on water use following application was posted, as required, on properties adjacent the river where the application was made.

The herbicide was applied, as per label instructions, directly to duckweed growth using a back pack sprayer (Figure 1; plate E). While some spraying was done from shore, the majority of spraying was conducted from a small boat. A second person assisted the herbicide applicator by operating the boat. Applications were made on

calm evenings to minimize chemical drift and to provide at least one complete night of chemical activity before potential sunlight inactivation the following day. Evening application minimized the effect of restrictions on water use (no drinking or swimming for 24 hours) in treated areas.

In practice, the applicator and the boat operator moved along the shoreline in the boat and sprayed patches of developing duckweed. Spraying was also done, when required, in man-made channels, around docks and in boatslips. By agreement with the landowner (Brouwer Sod Farms), the section of the river upstream from the forks of the main tributaries was not sprayed at all, as water was routinely withdrawn from this area for irrigation.

All requirements identified by MOE regulations were met during the course of the 1988 control program.

RESULTS

Water Quality Analysis

Water quality data from 1982 to 1988 from two sites on Maskinonge River (Don Mills station and Woodbine station) were assessed (Figure 2). As well, water quality data from the Black and Holland Rivers were evaluated to provide a comparison of water quality as it may affect duckweed growth. This data analysis provided an indication of the amount of phosphorus and nitrogen in the water that would be available for plant growth. It was anticipated that any developing trends or dramatic increases in nutrient availability in the water might be reflected by an evident increase in duckweed growth.

The duckweed problem on the Maskinonge River peaked in 1987 with duckweed growth occurring over most of the river surface. Previous to 1987, duckweed had become established in the river during the growing season, but had created only occasional problems. Water quality data indicates that a large increase in nutrients occurred in the river in 1987.

Ammonia increased from 0.057 to 0.210 mg/L from 1986 to 1987 at the Woodbine station and increased from 0.081 to 0.154 mg/L at the Don Mills station from May to September Figure 3. Nitrates increased from 0.186 mg/L in 1986 to 0.326 mg/L in 1987 at the Woodbine station decreased from 0.156 to 0.05 mg/L at the Don Mills station from 1986 to 1987, respectively (Figure 4). Phosphorus concentration at the Woodbine station increased from 0.130 to 0.237 mg/L from 1986 to 1987, however there was no increase in phosphorus at the Don Mills station from 1986 to 1987,

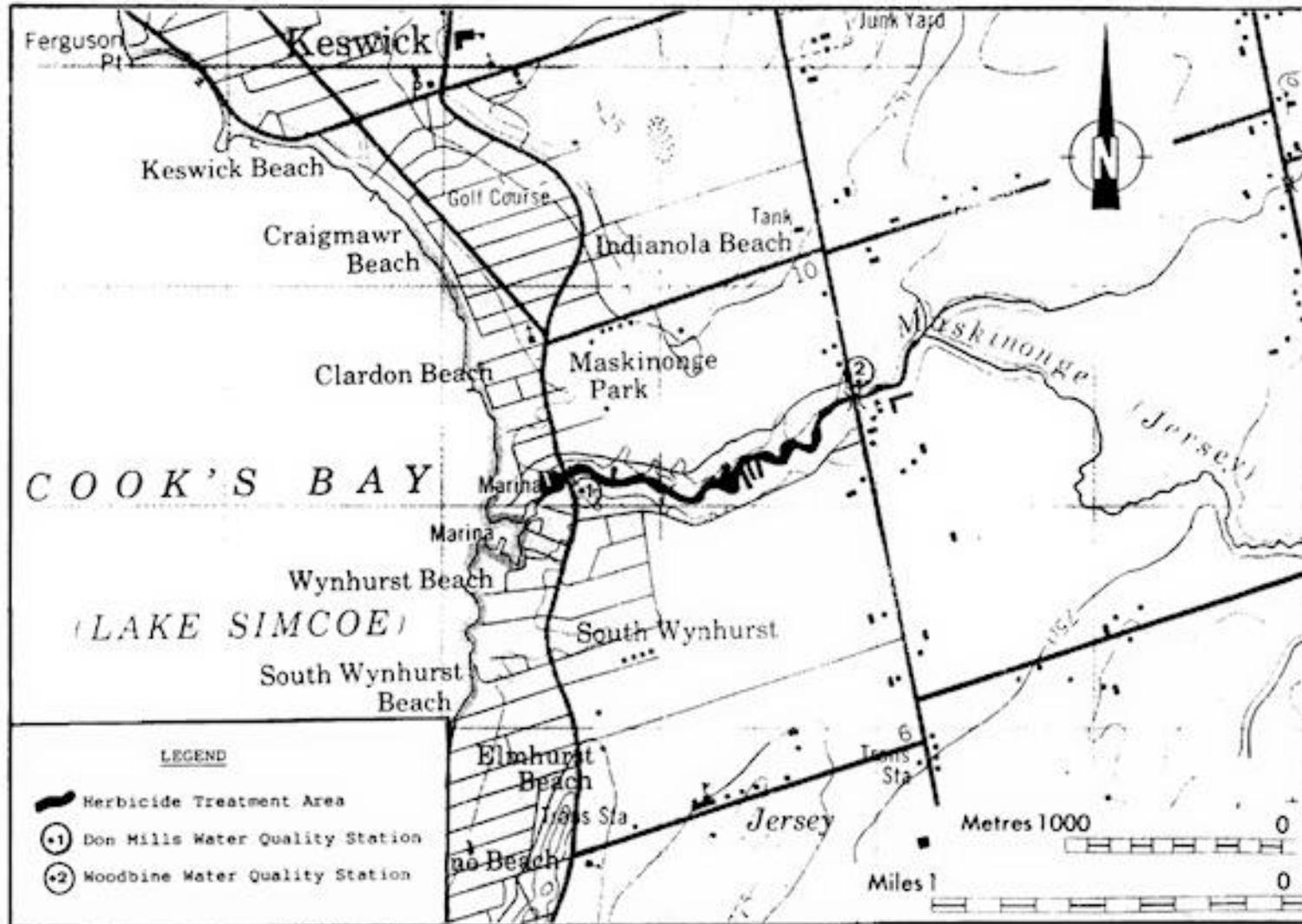


Figure 2. Maskinonge River herbicide treatment area and location of Woodbine and Don Mills water quality monitoring stations.

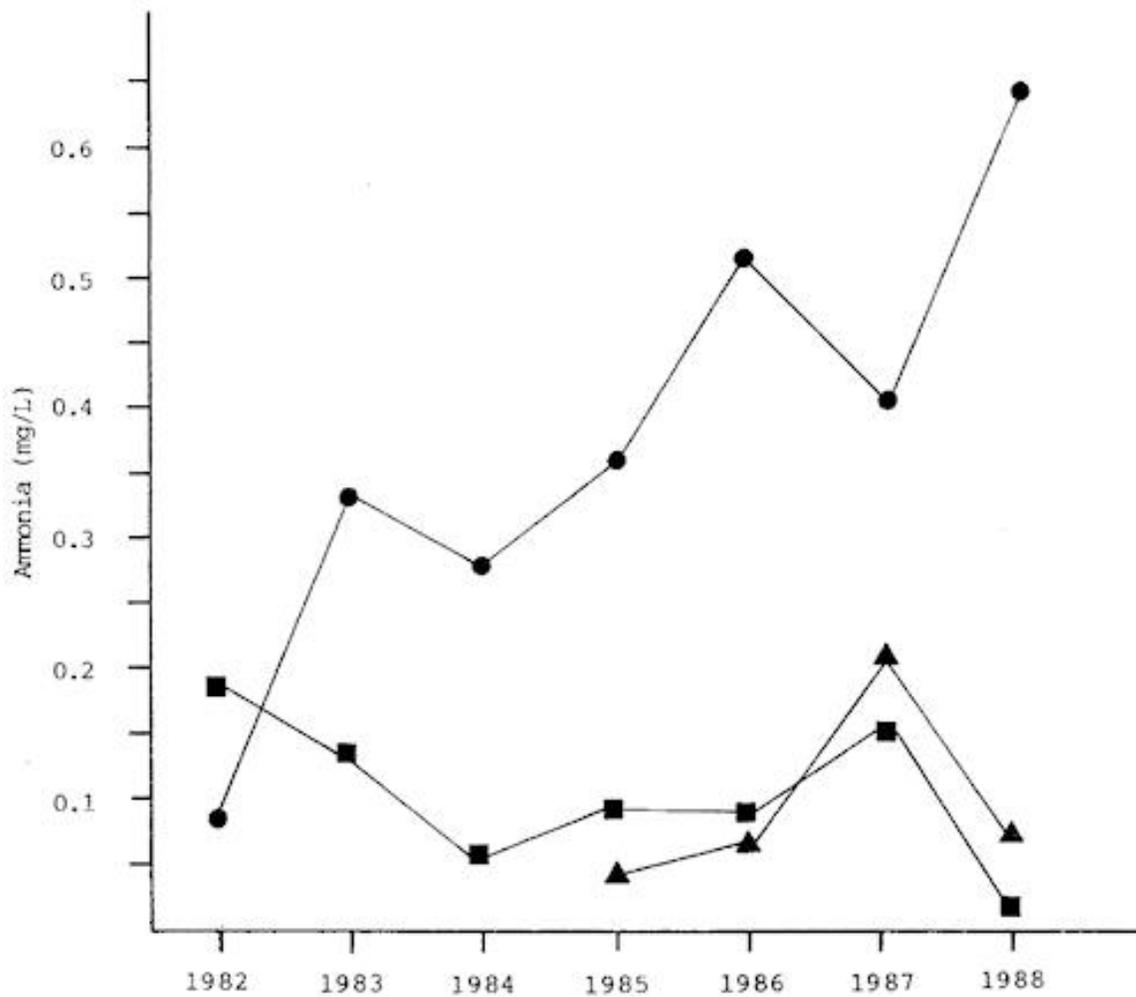


Figure 3. Ammonia concentrations from 1982-1988 in the Maskinonge River at the Woodbine Station(▲) and Don Mills Station(■), and the Holland River(●).

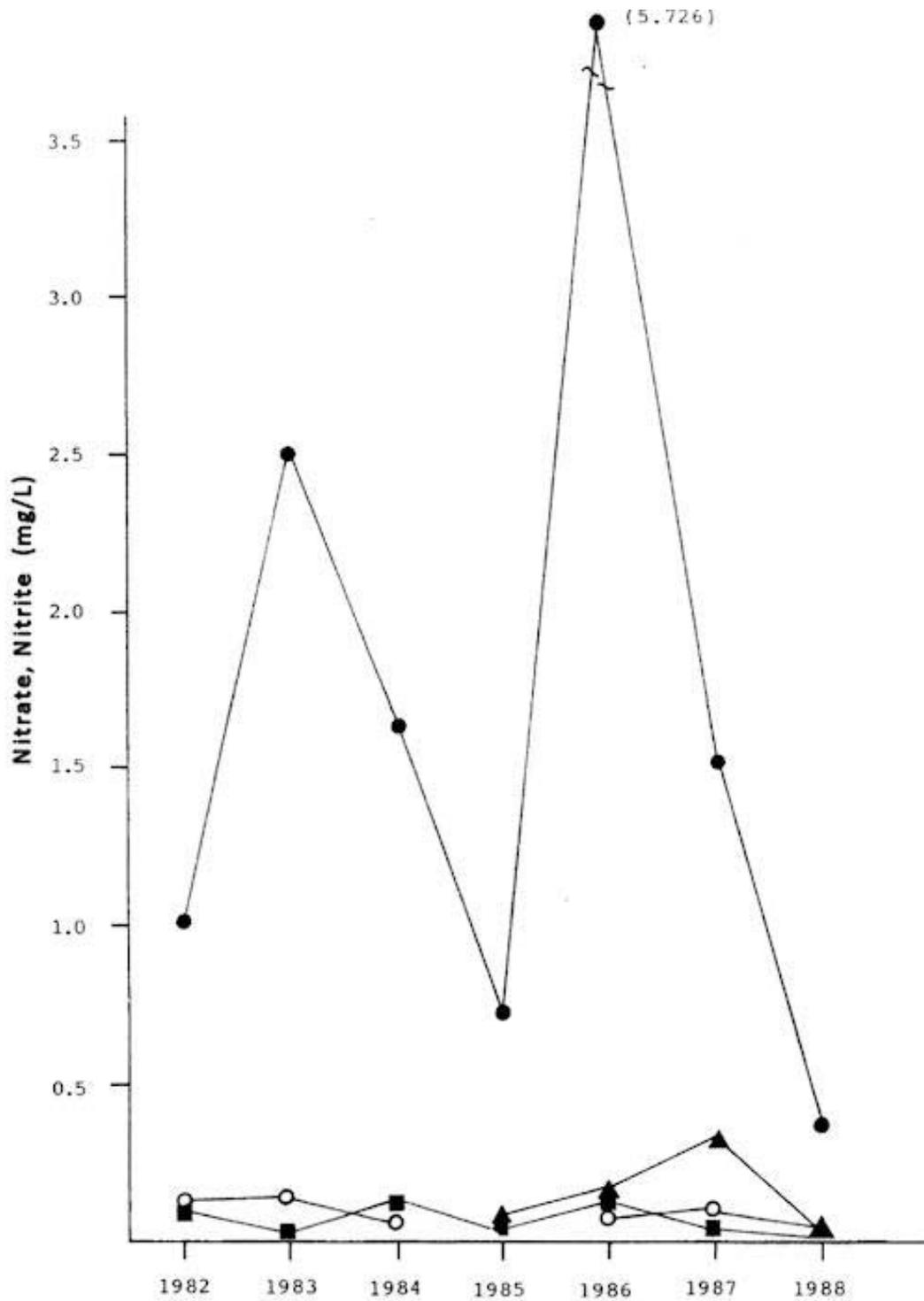


Figure 4. Nitrate, nitrite concentrations from 1982-1988 in the Maskinonge River at the Woodbine Station(▲) and Don Mills Station(■), and the Holland(●) and Black Rivers(○).

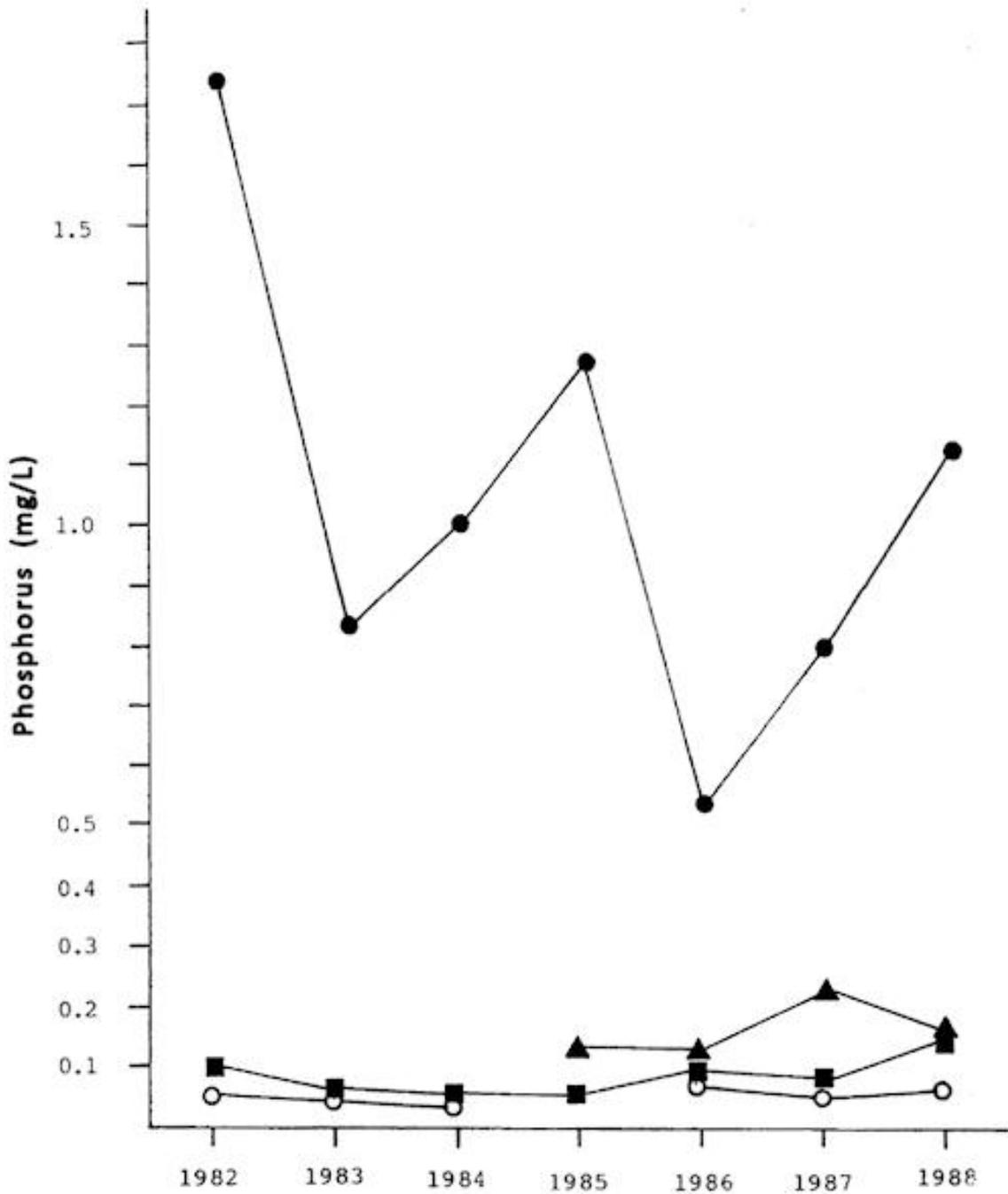


Figure 5. Phosphorus concentrations from 1982-1988 in the Maskinonge River at the Woodbine Station(▲) and the Don Mills Station(■), and the Holland(●) and Black Rivers(○).

although, phosphorus did increase from 0.074 to 0.101 mg/L from 1985 to 1986, prior to the abundant growth in 1987 Figure 5).

Analogous to the increase in ammonia and nitrates in 1987 is the large amount of rainfall recorded during the growing season. Total monthly precipitation recorded at the Ravenshoe Climatological Station Climate Canada, indicates that there was almost three times as much rainfall in June 1987 compared to June 1988. The June 1987 value twice the 30 year mean for rainfall at the Ravenshoe station. Rainfall for the months of July and August was a little higher than for the same months in 1988, and were both above the 30 year mean.

In 1988, the nutrient levels in the Maskinonge River had decreased significantly from 1987. Ammonia decreased to 0.072 mg/L Figure 3), nitrates decreased to 0.045 mg/L Figure 4), and phosphorus decreased to 0.162 mg/L Figure 5 at the Woodbine station. A decrease in ammonia and nitrates 0.016 and 0.020 mg/L, respectively was also observed at the Don Mills station in 1988. Phosphorus increased by approximately 50% at the Don Mills station from 1987 to 1988. Corresponding to decrease in nutrient availability duckweed growth was reduced in 1988.

The decrease in nutrient availability in 1988 corresponded with reduced rainfall during June and August, 1988 compared to the 30 year mean. July, 1988 rainfall was 17 mm above the 30 year mean. By the beginning of August, duckweed growth had increased significantly compared to abundance in early July. This was probably a result of July rainfall levels plus other climatic factors which contribute to duckweed growth.

The Black River is not known for having duckweed growth problems. Unfortunately, ammonia values were not available for the Black River during this time period for comparison. Instead, an evaluation of nitrate concentrations was used. Nitrate concentrations from the Black River showed no identifiable trend, however, concentrations did peak in 1987 but the value was two and a half times less than that recorded at the Maskinonge River in the same year. Also, nitrate values recorded at the Don Mills station from 1982 to 1988 provided no indication of increased nitrogen enrichment to the river from this chemical form.

The Holland River which drains the fertile Holland Marsh agricultural area is known to have a severe duckweed problem. Ammonia concentrations have increased steadily from 1982 to 1988; 0.081 to 0.634 mg/L, respectively (Figure 3). However, in 1988 with a high ammonia concentration recorded 0.634 mg/L there was very little duckweed growth. It would be anticipated that the available ammonia in 1988 would support luxuriant growth of duckweed since previous years lower ammonia levels supported abundant growth. Phosphorus concentrations from the Holland River from 1982 to 1988 showed no trends, although values were greater than those at the Don Mills and Woodbine station, and capable of supporting abundant duckweed growth. Nitrate concentrations decreased by 3.8 times from 1987 to 1988 and therefore may be partially responsible for the limited duckweed growth in the Holland River in 1988.

Documentation of Potential Sources of Nutrient Enrichment of the Maskinonge River

The Maskinonge River watershed drains a land base that is primarily agricultural. The agricultural practices vary with most of the land being used to produce crops. Specific information on agricultural land use acreage and changes in agricultural practices in the Maskinonge River watershed, which might provide an indication of increased nutrient input to the river, was not available. However, since 1986 the number of acres in sod production has increased substantially (E. Cavanagh, OMAF, pers. comm.).

Tributary sites of the Maskinonge River were inspected in order to document any evident sources of potential nutrient input to the river. Eight sites were investigated Figure 6 , but no evidence or signs of nutrient input in the near vicinity of the site was observed. Due to the lack of rainfall this spring and for part of the summer, most of the tributaries were dry or had very little running water. The stream at site 6, immediately adjacent sod fields, was choked to the surface with healthy, robust, Canada Waterweed (*Elodea canadensis*) which restricted water flow. Approximately 50% of the stream surface at this site was covered with duckweed, suggesting nutrient enrichment.

On the opposite side of the road, where the land was in active pasture for cattle, there was no macrophyte, duckweed or algae growth in the stream. However, the absence of at least any rooted macrophyte growth is probably a result of cattle movement not allowing the plants to take hold. It is anticipated that algae and duckweed growth could develop in this environment given suitable nutrient availability.

Figure 6. Maskinonge River watershed land use evaluation sites.



Only one site specific source of potential nutrient input to the river was observed. At site 5, a large manure pile was located immediately adjacent to the stream. Since there was no water flow through the site at this time there was no evidence in the stream that this source had contributed to the nutrient availability ie. algae, duckweed growth. However, some nutrient input from this source would be anticipated during a growing season of normal rainfall levels.

Residences along the Maskinonge River between Woodbine Avenue and Don Mills were connected to a sewer system in 1985. Therefore, possible nutrient contributions from septic tank systems that were functional prior to 1985 is no longer a potential source of nutrient enrichment of the river. As well, water quality data provides no evidence of increased nutrient levels at the sampling site downstream from the residential area (Don Mills station Figure 2).

A detailed assessment of nutrient inputs from stormwater runoff septic tank systems and agricultural tile drainage systems over the complete drainage basin was not within the scope of this study. In order to assess these potential sources a detailed site specific water quality monitoring program would be required. This information would provide insight on the flow of nutrients from the agricultural fields into the tributaries and the main river.

Chemical Control of Duckweed Growth

Herbicide applications were carried out on seven occasions between July 6 and August 18, 1988. Growth was monitored on an approximately weekly basis from mid-May until October 1, 1988. The treatment areas producing seed material to the

river covered a total area of 0.5 ha and the application sites were distributed from the Don Mills Road bridge to just below the forks of the river, above the Woodbine Road bridge Figure 1). Forty one litres of Reglone A, applied as a 20% solution, were used during the control program.

Duckweed growth during May and June had become dense in some shoreline locations but had not progressed to a stage of nuisance growth. Because of the delay in receiving the required permits, spraying was initiated on July 4, 1988, somewhat later than originally intended, and duckweed growth was evident in nursery areas of the river. Following receipt of the permit, established growth was effectively killed and prevented from increasing coverage and abundance to a level that resulted in problems.

Likewise, no reports of hardship or adverse impacts were received by Limnos, the Lake Simcoe Region Conservation Authority or the Township of Georgina as a result of duckweed growth in 1988. While there was no formal process to receive feedback from river users or landowners regarding the herbicide treatment program, we asked landowners to contact us if they should have concerns or questions. No complaints were received.

Complete coverage of duckweed did develop upstream of the river forks above the Woodbine Road bridge, in areas adjacent to and downstream from the sod farms Figure 1; plate C). This growth provided a continual source of duckweed drift to the lower reaches of the river. This section of the river was not treated because water from the river was used for irrigation of the sod crop. This constraint was agreed to with the owner.

Dense submerged macrophyte growth developed in the river over the growing season. Submerged macrophytes in most instances completely clogged dredged slips and the shallow water area (less than 1.5m) adjacent to shoreline cattails. By the end of July macrophyte interference prevented treatment of unmanaged boat slips, and impeded effective treatment of duckweed growth along shorelines by preventing access. However, continual treatment of duckweed at the edge of macrophyte growth effectively restricted progressive development of duckweed into the centre channel. The inability to treat duckweed growing on top of dense macrophyte beds did not appear to pose a serious concern to the effectiveness of the program as the duckweed was effectively rendered immobile where the aquatic plant growth reached the surface.

The effect of herbicide application was normally noticeable within four days after treatment. Treated plants turned yellow-green, and subsequently degraded. Affected duckweed either sank to bottom of the river or was carried away by wind or washed up on the shore. In treated areas, total kill of duckweed was not always achieved where individual plants were not contacted by spray droplets so that some small patches of viable plants remained in treated areas.

The recommended application rate of Reglone A to control duckweed growth is 22 L/ha (OMAF, 1988). Thus in an estimated treatment area on the Maskinonge River of 0.5 ha, 11 L was required in one treatment to provide control. However, since more than one treatment was required to keep the duckweed growth under control a total of 41 L was used during the program. Unlike rooted macrophytes, duckweed is subject to dispersal in the river and as a result, viable duckweed could be dispersed to those areas where treatment had occurred and continue to grow. Sites where duckweed proliferated, received as many as five treatments to control growth (Figure 1; plate B)

While Reglone A is a recommended chemical for the control of aquatic plants no damage to submerged macrophyte beds was observed during the program, even though the same duckweed growth areas were routinely treated. The only non-target species affected by chemical treatment was the white-water lily (*Nymphaea odorata*) whose floating leaves have a large surface area, making it susceptible to surface treatment when interspersed amongst duckweed growth. No damage to emergent or terrestrial growth was observed.

The herbicide treatment program conducted in 1988 cost approximately \$3,500.00. A single herbicide treatment based on an application of 10 L of herbicide per treatment cost approximately \$550.

DISCUSSION

Under conditions of abundant plant nutrient resources and appropriate water clarity some form of aquatic plant life will proliferate. This may be rooted submerged species, a variety of algal forms or various species of duckweed.

The Maskinonge River watercourse is particularly vulnerable to the development of this type of nuisance. Stream flow is generally low during the growing season leading to pulses of runoff with associated high nutrient concentrations occurring during storm events.

Evidence indicates that the problem growth of duckweed that developed in 1987 was a result of unusually high rainfall that led to a runoff of nutrients, including ammonia, nitrates and phosphorus into the Maskinonge River during storm events. Both the Don Mills and Woodbine stations on the Maskinonge River had significant increases in ammonia, nitrates and phosphorus in 1987, followed by decreases in 1988. This corresponded with abundant duckweed growth in 1987 and reduced growth in 1988.

Moving from upstream to downstream on the Maskinonge River there is a marked decrease in nutrients available in the water. Ammonia, nitrates and phosphorus decrease in the water column from the Woodbine station to the Don Mills station with the greatest decrease in nitrates and phosphorus occurring in 1987. The apparent influx of nutrients into the upper river during the early summer of 1987 was followed by an explosion of duckweed growth along the length of the river. The decrease in ammonia and nitrates recorded at the Don Mills station is probably a result

of uptake by duckweed and other aquatic plant species.

In 1988, with reduced duckweed cover, sunlight was not limiting to submerged macrophyte growth. Field observations indicated that submerged macrophyte beds had become more dense from early June to mid July, and by the middle of August, plant coverage and density had increased significantly, creating problems to boat navigation upstream from Don Mills Road. Water depth limits the growth of rooted plants below Don Mills Road and for this reason was not a serious problem around the marinas.

In order to determine a level of nutrients that might protect the river from a reoccurrence of the 1987 problem the literature pertaining to duckweed nutritional requirements was examined. In addition the water quality records for the Holland River, a traditional duckweed producer, and the Black River, where no problem has been experienced, were assessed.

Unfortunately, the literature is not very definitive of critical levels of nutrients that will promote duckweed growth. None the less the concentrations of nitrate and ammonia reported from the MOE water quality stations on the Maskinonge River exceed growth requirements reported by Culley *et al.* 1981), Ferguson and Bollard (1969), Joy 1969) and Rejmankova (1971).

Nutrient levels measured in the Holland River polder which is strongly influenced by intensive farming in the Holland Marsh continually exceeds nutrient concentrations of the Maskinonge River. In most years it produces a heavy crop of duckweed, although with nutrients above 1987 Maskinonge River levels, duckweed did not develop in 1988. The reason for this is not known at this time. The Black River which is an

adjacent watershed to the Maskinonge River, has never produced a duckweed crop. It is our suggestion therefore in seeking a nutrient level for the Maskinonge River to protect it from future problems that an objective for water quality equivalent to the Black River or approaching the provincial water quality objectives be set Table 1.).

Table 1. Comparison of Ammonia, Nitrate and Phosphorus Concentrations (mg/L) in the Maskinonge and Black Rivers in 1987 and Provincial Water Quality Objectives.

	Ammonia	Nitrate	Phosphorus
Maskinonge River	0.210	0.326	0.237
Black River	n.a.	0.133	0.060
Provincial Water Quality Objectives	0.020	n.a.	0.030

n.a. not available

It is our recommendation, therefore, that the water quality objectives for the Maskinonge River be set at: ammonia - 0.02 mg/L, nitrate - 0.130 mg/L and phosphorus - 0.06.

Reduction of sources of fertilizing elements requires that the sources be identified and measures be taken to minimize their input. This will require action by a regulatory authority with the power to examine fertilizer use by upstream agricultural users and to regulate and enforce appropriate land use practices.

The Maskinonge River watershed is agricultural in nature with a concentration of sod

farms located upstream from the Woodbine Avenue bridge. Sod farms are high fertilizer users and land is cropped close to the river bank. The river adjacent to these operations produced a 100% duckweed cover in 1988 in those areas which could not be treated with herbicide because of water taking for irrigation. Other potential nutrient sources include barn yard drainage, the manure pile noted adjacent to the river bank and agricultural drains directed to the watercourse.

While conclusions on water quality have been drawn, the record available is a monthly sample which is minimal and not sufficient to understand the seasonal dynamics or to identify sources of fertilizing elements. To obtain the information required, a weekly sampling program during the growing season will be necessary from the two existing water stations and two others located upstream on each of the main branches. In addition, samples from all suspect drainage sources and the river will be required during two or three storm events over the summer. This information would be used to identify the principal-contributors for subsequent enforcement action.

The second alternative for control is an ongoing surveillance program to monitor the development of duckweed and treatment of seed areas, as required, to prevent plant growth from developing out of control. This is a less desirable option as there will be an ongoing cost for surveillance and chemical control.

Herbicide control of duckweed will not preclude the development of other plant nuisances and the river will remain a source of fertilizing elements contributing to the general problem of eutrophication in Lake Simcoe. None the less, the treatment will be necessary until such time as water quality in the river is improved if repetition of the 1987 problem is to be prevented.

For herbicide control to be effective it will be necessary to treat growth areas adjacent to the sod farms as these constitute a seed stock to the lower river. Under conditions of storm water flow or easterly winds duckweed is moved downstream to the broad, sluggish areas of the lower river where enriched, sheltered waters provide an ideal habitat and explosive growth can be expected. As water adjacent to the sod farms is used for irrigation the use of chemical in this stretch of the river would be a hazard to the crop. The solution would appear to be moving the irrigation intake upstream or use of an alternative water supply.

RECOMMENDATIONS

1. Identification of Nutrient Sources

To prevent an ongoing problem caused *by* duckweed and/or rooted aquatic plants, nutrient sources to the Maskinonge River must be stringently controlled. This will require a detailed study of land use in the watershed, identification of all potential nutrient sources and enforcement of a policy to limit fertilizer application to minimum practical levels. As information including records of fertilizer use, timing of application and assessment of the drainage systems will be required, a regulatory agency with power of enforcement should be responsible for the implementation of this recommendation.

2) Comprehensive Evaluation of Water Quality

Existing monthly water quality analyses are not sufficient to document the nutrient dynamics of the watercourse. To provide the necessary information to understand current water quality conditions and the benefit of future land use controls, a sampling program designed to monitor stream conditions and identify nutrient sources is required. For this reason it is recommended that four locations be sampled from May to September including the two main branches upstream from Woodbine Avenue, below the confluence at Woodbine Avenue and at Don Mills Road. A further sampling program associated with storm events should be conducted on two or three occasions to identify sources and quantity of fertilizing elements gaining access to the watercourse. The estimated cost for field work and analysis is documented in Appendix 2.

3) Surveillance and Herbicide Control

As an interim measure and until such time as limiting nutrient conditions can be achieved, a surveillance and herbicide control program should be maintained from the beginning of June to the end of August. The necessary permits should be arranged in advance and a liberal maximum quantity of chemical authorized to enable an appropriate response in the event of a critical developing problem. The water taking source for sod farm irrigation should *be* moved upstream to allow for the safe treatment of duckweed in seed growth areas of the river bounded by their property. The estimated cost for surveillance, herbicide chemicals and their application to the watercourse is provided in Appendix 3.

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APPENDICES

Appendix 1

Maskinonge River Watershed Land Use Evaluation Sites

- Site 1 - site on major tributary leading to the river
 - very little flow through a wet meadow/shrub thicket of grasses, sedges, cattail and willow
 - no evidence of nutrient input
- Site 2 - site of drainage from surrounding fields (50% crops, 50% fallow, grass fields, treed)
 - drainage channel dry
- Site 3 - site of drainage from area of mixed pasture, fallow and crops (corn)
 - drainage channel dry
- Site 4 - site of drainage from area of pasture and crops (corn)
 - tributary dry with some cattails, grasses, sedges and goldenrod
- Site 5 - large pile of manure directly above drainage channel - no visible input of nutrients to drainage channel
 - ponding at culvert but no water flow
 - sod farm to SE from this site
 - no evidence of nutrient enrichment in creek on other side of the road adjacent this site
- Site 6 - site bordering sod farm to the east and northeast
 - stream 2-3 m wide, 1m+ depth, choked with *Elodea canadensis* and abundant duckweed growth
 - slight flow in the stream
 - lush vegetation on both banks of the stream
- Site 7 - site in a flat, treed, floodplain area
 - water flow slowly from pasture land through a swamp
 - water turbid
- Site 8 - site of crop and pasture land use
 - water flow through LSRCA soil erosion prevention project area of cattails and grasses
 - ideal habitat for duckweed growth, but none observed
 - no evidence of nutrient input

Appendix 2

Costs Associated with an Expanded Water Quality Monitoring Program on the Maskinonge River in 1989.

Personnel

Technician	1 sample per week for 10 weeks @ \$200/day	= \$2,000.00
	3 storm events; 2 days/event @ \$200/day	= \$1,200.00
		\$3,200.00

Expenses

Water Sample Analysis	36 samples @ \$100.00/sample	= \$3,600.00
Mileage(Approx.)	16 trips @ 170 km/trip@ \$0.25/km	= \$430.00
Boat and Motor Rental		= \$300.00
Miscellaneous		= \$270.00
		\$4,600.00

Total Cost = \$7,800.00

Appendix 3

Anticipated Costs Associated with a Herbicide Treatment Program on the Maskinonge River in 1989.

<u>Personnel</u>		
Senior Technician (Licenced Herbicide Applicator)	10 days @ \$150/day	= \$1,500.00
Assistant	10 days @ \$125/day	= \$1,250.00
Observer	20 x 1/2 days @ \$70/day	= \$700.00
		\$3,450.00
<u>Materials and Expenses</u>		
Herbicide (Reglone A)	10 treatments @ 10 L / treatment x \$20.00/L	= \$2,000.00
Backpack Sprayer		= \$200.00
Boat and Motor Rental		= \$300.00
Travel	170 km/trip x 10 trips @ \$0.25/km	= \$425.00
Miscellaneous Expenses	meals, maps, protective clothing, etc.	= \$300.00
		\$3,225.00
Total Cost = \$6,675.00		

* these costs relate to one herbicide treatment per week based on costs associated with the herbicide treatment program carried out in 1988.

APPENDIX

MEMBERSHIP ON THE STEERING COMMITTEE FOR THE LAKE SIMCOE ENVIRONMENTAL MANAGEMENT STRATEGY IMPLEMENTATION PROGRAM

- D. Marquis, Lake Simcoe Region Conservation Authority (Chairman)
- J. Barker, Maple District, Ministry of Natural Resources
- E. Cavanagh, York County, Ministry of Agriculture and Food
- R. DesJardine, Central Region, Ministry of Natural Resources (past member)
- J. Kinkead, Watershed Management Branch, Ministry of the Environment
(past member)
- J. Merritt, Director - Central Region, Ministry of the Environment
- P. Miller, Watershed Management Branch, Ministry of the Environment
- A. Morton, Lake Simcoe Region Conservation Authority (past member)
- B. Noels, Lake Simcoe Region Conservation Authority (Secretary)

APPENDIX

MEMBERSHIP ON THE TECHNICAL COMMITTEE FOR THE LAKE SIMCOE ENVIRONMENTAL MANAGEMENT STRATEGY IMPLEMENTATION PROGRAM

- B. Noels, Lake Simcoe Region Conservation Authority (Chairman)
- J. Beaver, Central Region, Ministry of the Environment (past member)
- I. Buchanan, Maple District, Ministry of Natural
- R. DesJardine, Central Region, Ministry of Natural Resources (past member)
- J. Dobell, Huronia District, Ministry of Natural Resources
- H. Farghaly, Central Region, Ministry of the Environment
- D. Green, Resources Management Branch, Ministry of Agriculture and Food
(past member)
- B. Kemp, Lake Simcoe Region Conservation Authority
- J. Kinkead, Watershed Management Section, Ministry of the Environment
(past member)
- R. MacGregor, Central Region, Ministry of Natural Resources (past member)
- N. Moore, Victoria-Haliburton County, Ministry of Agriculture and Food
- K. Nicholls, Water Resources Branch, Ministry of the Environment
- B. Peterkin, Central Region, Ministry of Natural Resources
- T. Rance, Maple District, Ministry of Natural Resources
- B. Stone, Northumberland County, Ministry of Agriculture and Food
- M. Walters, Lake Simcoe Region Conservation Authority
- C. Willox, Lake Simcoe Fisheries Assessment Unit, Ministry of Natural Resources
- K. Willson, Watershed Management Section, Ministry of the Environment

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