Lake
Simcoe
Environmental
Management
Strategy

Implementation
Program

Duckweed Harvest from the Holland River

Technical Report: Imp. B.5

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DUCKWEED HARVEST FROM THE HOLLAND RIVER, LAKE SIMCOE - ASSESSMENT OF STRATEGIES AND BENEFITS

Prepared by

Limnos Ltd.
J. Neil and J. Graham
591 Liverpool Road
Pickering, Ontario L1W 1R1

for

The Lake Simcoe Environmental
Management Strategy
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Liaison: K. H. Nicholls
Water Resources Branch
Ontario Ministry of the Environment

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.

Questions with respect to the contents of this report should be directed to:

Supervisor of Environmental Services
Lake Simcoe Region Conservation Authority
120 Bayview Parkway
P.O. Box 282
Newmarket, Ontario.
L3Y 4X1

OR

Chief Administrative Officer
Lake Simcoe Region Conservation Authority
120 Bayview Parkway
P.O. Box 282
Newmarket, Ontario.
L3Y 4X1

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

Harvest of duckweed from the Holland River polder has been identified as a means to remove approximately 500 kg of phosphorus annually from the Lake Simcoe watershed. To facilitate initiation of a duckweed harvesting program, the current and future status of the Bradford pumping station and the associated trash removal system was determined.

A new pumphouse is to be built approximately 170 m upstream from the existing pumphouse, and should be operational by fall, 1988. It is recommended that the 1988 season be used to investigate different features of the existing trash removal system in order to optimize the design of the conveyor and booms that will most probably be employed at the new pumphouse to remove duckweed and extraneous floating material. It is also recommended that an aquatic plant harvester be employed in 1988 to ensure that all available duckweed is harvested from the river.

Various disposal alternatives for harvested duckweed were investigated as part of the study. Harvested duckweed would be suitable as a soil amendment, particularly if applied to mineral soils. Significant amounts of extraneous matter would limit the use of duckweed as a soil amendment, however, and it is recommended that the occurrence of such materials should be documented in 1988. A suitable landfill site equipped with weigh scales is located 7 km north of Bradford, if landfill disposal of duckweed is required.

All available duckweed should be harvested during 1988 to determine the potential for phosphorus removal by duckweed harvest. Based on work done in 1988, capital and operating costs for an ongoing harvesting program could be developed and compared to costs of phosphorus removed at sewage treatment plants to determine cost effectiveness.

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Introduction

Extensive growth of duckweed *Lemna minor, Wolffia* sp. develops during the summer period in the original channel of the Holland River that drains the Holland Marsh polder. An enriched supply of plant nutrients and sheltered growing conditions encourages prolific growth of duckweed in the channel. The action of wind and current results in accumulation of the duckweed in the lower end of the river adjacent to the Bradford pumphouse. A trash removal system located immediately upstream of the pumphouse removes a significant amount of the duckweed growth. The trash removal system consists of a surface boom directing floating material to a shore based conveyor that removes material from the river and piles it on the shore. The canal and channel system draining the Holland Marsh polder and location of the Bradford pumping station is shown in Figure 1.

Complaints from downstream marina owners of excessive floating material in the river resulted in the construction of the trash removal system to remove duckweed and floating material prior to pumping. The trash removal system is operated infrequently during pumping, and while not specifically designed to harvest duckweed, has proved to be a reasonably effective removal procedure. Duckweed removed from the river by the conveyor is presently piled on shore along the river bank and allowed to decompose. As a result, the plant nutrients contained within the duckweed mass seep back to the river, and ultimately contribute to nutrient loading of Lake Simcoe.

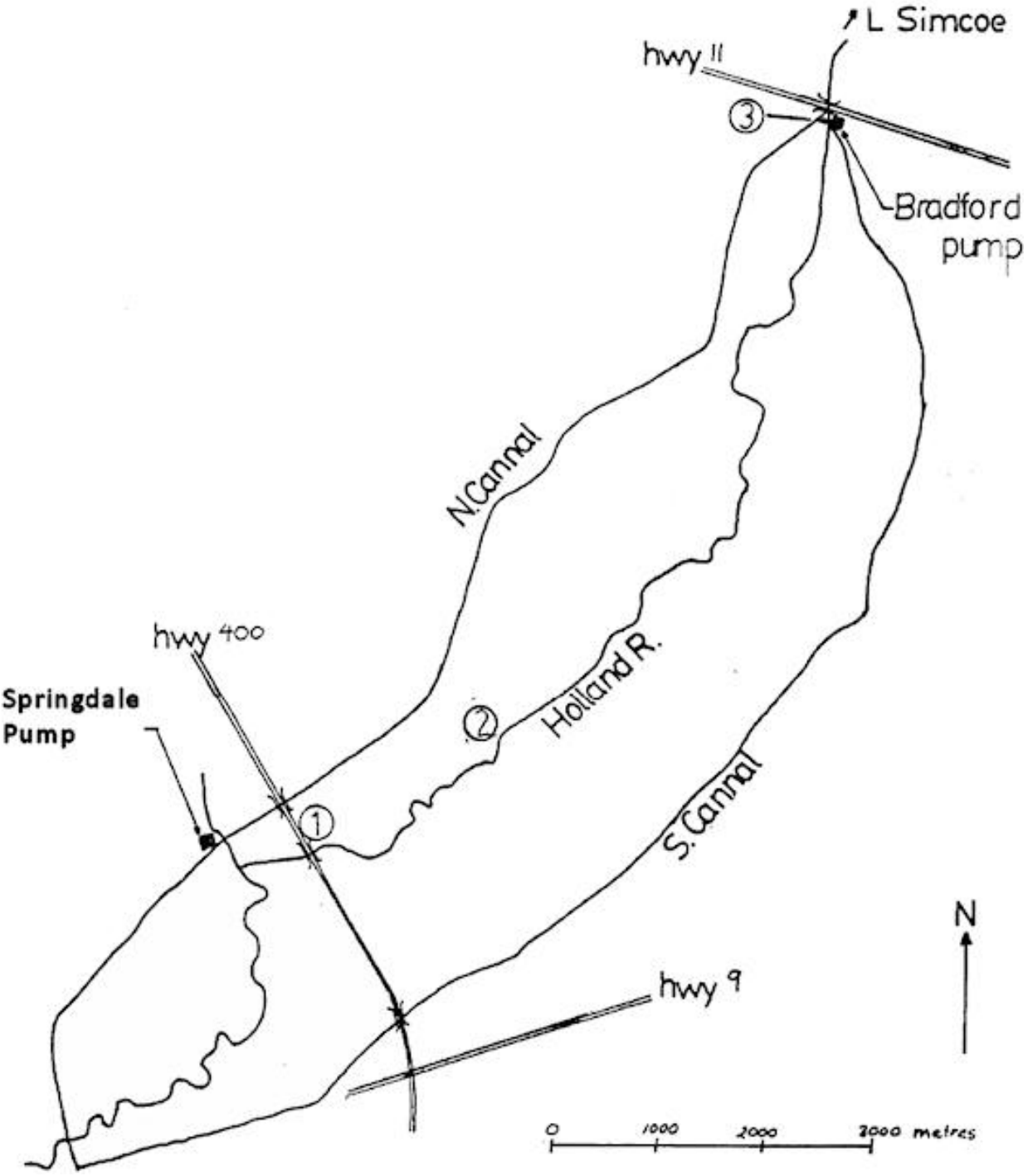


Figure 1. Canals and River Channel System of the Holland Marsh and Location of the Bradford Pumphouse.

In 1984, a study was conducted to determine duckweed production in the polder - enclosed portion of the Holland River, and to estimate the nitrogen and phosphorus contained within the duckweed crop (Limnos, 1984). At that time, it was estimated that approximately 500 kg of phosphorus could be potentially removed through harvest of duckweed. A number of recommendations were also prepared as to improvements that could be made to the existing trash removal system to increase removal of duckweed from the river by utilizing the existing conveyor. (Limnos, 1984).

More recently, it has been recommended that an effective duckweed harvesting program be implemented as a means to reduce loadings of nutrients to Lake Simcoe (LSEMS Steering Committee, 1985). In order to initiate a program to harvest duckweed from the river channel, the Ministry of the Environment requested Limnos Limited to develop recommendations as to a preferred duckweed harvesting strategy that could be implemented beginning in the summer of 1988.

Objectives

The specific objectives of the study were as follows;

1. Recommend harvesting methods to maximize duckweed harvest from the old channel of the Holland River that drains the Holland Marsh polder.

2. Determine effective methods of disposing harvested duckweed to ensure that nutrients contained in the duckweed biomass do not contribute to nutrient loading of Lake Simcoe.

3. Determine the potential amount of duckweed that can be harvested from the river channel and the amount of phosphorus that can be removed by duckweed harvest. Compare costs of phosphorus removal by duckweed harvest to costs of conventional phosphorus removal at sewage treatment plants.

Methods

In order to provide harvesting recommendations, the current status of the Bradford pumphouse and the trash collection system was determined. A visit to the pumphouse site was made to review physical constraints such as access and ground conditions that could limit harvesting options. Recommended modifications to the boom and conveyor system that were developed previously Limnos, 1984 were reviewed and re-evaluated.

A number of persons were contacted during the study to obtain information relevant to preparation of recommendations in areas of harvesting, disposal, and assessment of quantity and costs of phosphorus removal by means of duckweed harvest. A list of persons contacted and their affiliation is presented in Appendix A.

Summary of Findings and Recommendations

A summary of pertinent information relating to each of the three study objectives is presented as follows. Specific recommendations for each of the objectives are presented separately following the information summary.

Objective 1:

Recommend harvesting methods to maximize duckweed harvest from the old channel of the Holland River that drains the Holland Marsh polder.

The present status of the existing pumphouse and trash removal system was determined. The township of West Gwillimbury is planning to build a new pumphouse upstream from the existing pumphouse, with completion of the new pumphouse scheduled for the fall of 1988. Use of the existing pumphouse will be discontinued once the new pumphouse is operational. The location of the present pumphouse, the trash collection system and the anticipated location of the new pumphouse is given in Figure 2.

The new pumphouse will be built approximately 170 m upstream from the existing pumphouse, where the old Holland River bends sharply to the north after flowing west through the polder. It is possible that a modified trash collection system will be used at the new facility.

A consulting engineering company has been retained to design the new pumphouse facility. At present, ownership of the land parcel where the new pumphouse is to be built is uncertain. It is anticipated that land ownership questions will be resolved this spring. Final design of the pumphouse will proceed upon obtaining clear title to the land parcel in question.

No major modifications to the existing pumphouse or the trash removal system have been made since operation of the trash collection system was documented in 1984 (Limnos, 1984). Duckweed removed by the conveyor is dumped below the grade of the road, and periodically removed by a backhoe and piled on the north side of the road (Concession 9) where decomposition of duckweed occurs.

Modifications to the existing conveyor system are required to facilitate direct offloading of duckweed to a truck. The truck receiving duckweed would have to remain on the shoulder of the roadway during loading.

Operation of the existing pumphouse during the summer period is infrequent. Pumping records for 1986 and 1987 indicate that pumping occurs on average once a week for a period of 2 -10 hours. Anticipated use of smaller pumps at the new pumphouse may increase pumping frequency, however, total pumped volumes will remain relatively unchanged as pumping requirements are dependent on rainfall.

Movement of duckweed to the present trash collection system is dependent on wind, and current induced by pumping. As a result of infrequent pumping during the summer period, harvest of duckweed is not maximized due to minimal water flow past the trash collection system. This situation was documented in previous work (Limnos, 1984). To increase harvest of duckweed, it is necessary to either improve efficiency of the trash collection system, augment harvesting with an aquatic plant harvester, or both.

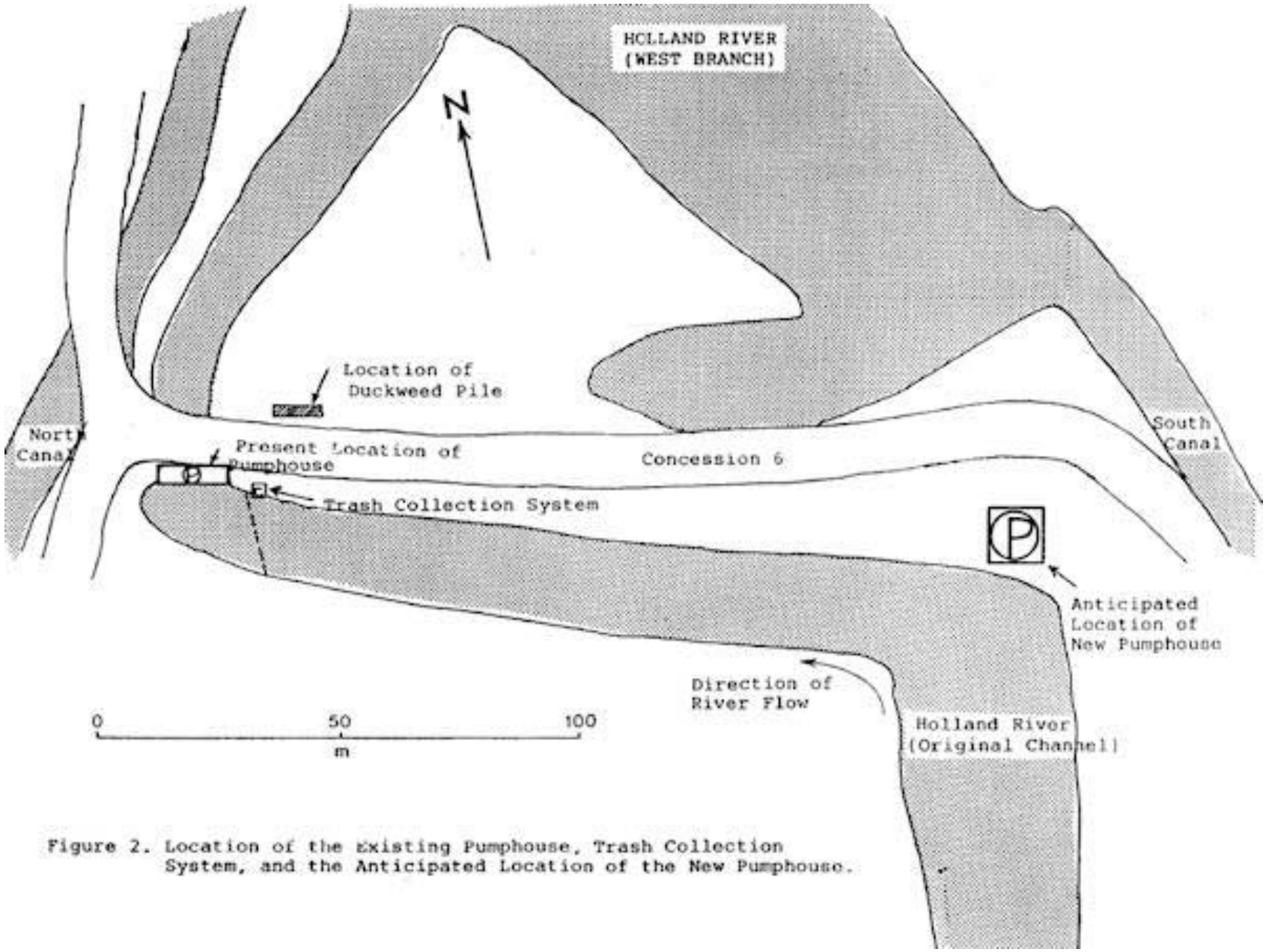


Figure 2. Location of the Existing Pumphouse, Trash Collection System, and the Anticipated Location of the New Pumphouse.

A trash collection system developed for the new pumphouse may not remove all harvestable duckweed if duckweed removal is solely dependent on current induced by pumphouse operation and wind. However, the new pumphouse site may offer a better opportunity to harvest duckweed due to potentially better wind patterns, opportunities to select locations of the conveyor and booms, and an "opportunity to evaluate an improved boom and conveyor to increase harvest of duckweed.

Recommendations

A number of Recommendations relating to harvest of duckweed have been developed to maximize harvest during 1988 and subsequent years. The recommendations are as follows.

1. Minimal capital investment in the existing trash collector system should be made in light of the planned construction of a new pumping station. It is recommended that a bale elevator be substituted for the existing, second conveyor as an inexpensive means to enable direct loading of removed duckweed to a dumptruck. This mode of harvest would be employed only in 1988. Figure 3 illustrates the addition of the bale elevator and other modifications to the trash collection system.

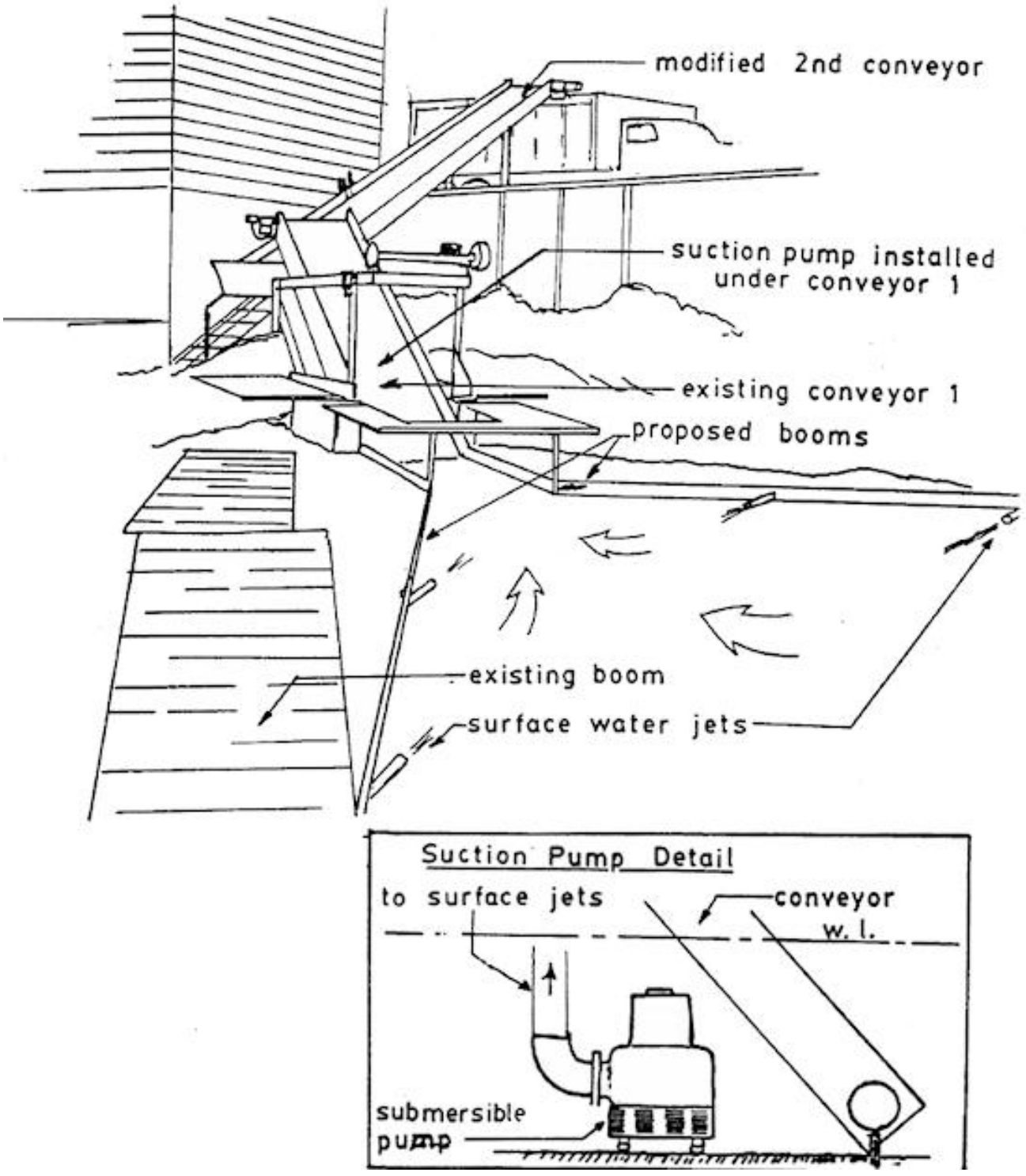
2. It is recommended that the 1988 season be used to experiment with the existing trash collection system in order to optimize the design of a permanent system to be employed at the new pumphouse. A number of different design features should be evaluated during 1988. These features are discussed separately below.

    i) Investigate the advantages of adding a new boom ahead of the existing trash boom. At present, the existing boom approaches an angle perpendicular to the current. A new boom that is angled more upstream may better direct the duckweed and entrained trash to the conveyor. The existing boom would not be interfered with or modified in any way (Figure 3).

    ii) The 1984 study recommended the use of water jets to direct duckweed accumulated in front of the booms toward the conveyor. This relatively simple technique could significantly improve duckweed harvest during the summer, when frequency of pumphouse operation is minimal. A number of aspects of the water jets would be examined, including the number of jets required, flow requirements, and the angle of the jets in conjunction with angle of the experimental trash boom. It is anticipated that electric pumps would be installed behind the conveyor screening, to induce a local flow pattern toward the conveyor and to provide flow for the water jets (Figure 3).

    iii) An additional boom leading toward the conveyor along the north bank of the river should be installed in order to improve movement of duckweed along this shore and to provide an opportunity to install water jets along both sides of the conveyor. The optimal angle and length of the additional boom would be determined by experimentation.

FIGURE 3: Proposed Conveyor Modifications.



iv) The pathway of duckweed movement at the corner of the river where the new pumphouse is to be built should be determined by observation during this study. This information will help determine the best position for the trash booms at the new pumphouse.

3. It is recommended that local assistance be obtained to monitor duckweed accumulation in the lower river, in order that personnel involved with the study may be notified when appropriate amounts of duckweed have accumulated in the lower section of the river channel, so that harvesting may be initiated.

4. It is recommended that use of an aquatic plant harvester be employed during 1988 to augment the trash removal system and to ensure all available duckweed is harvested. With minor modifications, it is anticipated that the harvester will be able to offload directly onto the existing conveyor.

Objective 2:

Determine effective methods of disposing harvested duckweed to ensure that nutrients contained in the duckweed biomass do not contribute to nutrient loading of Lake Simcoe. A suitable landfill for disposal of harvested duckweed has been located, and is situated approximately 7 km north of Bradford near the hamlet of Deerhurst. The landfill site is equipped with weigh scales. Tipping fees for the landfill have been set at $40/ton for 1988.

Support for disposal options other than landfilling was expressed by a number of persons contacted during the study. The potential value of duckweed as a soil amendment was recognized, though it would have little value as such in the organic soils of the Holland Marsh polder. Application of duckweed to mineral soils would have more benefits in terms of conditioning and providing additional organic matter.

Excessive entrainment of extraneous material with the harvested duckweed was recognized as a possible deterrent for use of duckweed as a soil amendment. The presence of cattail roots, wood, or other refuse would create a nuisance during cultivation and for this reason should be removed during the loading operation.

Recommendations

1. Utilization options other than landfilling should be pursued. Use of harvested duckweed as a soil amendment would reduce landfilling costs and possibly trucking costs.

2. If suitable field application sites are not identified, a landfill site is available for disposal of duckweed during 1988.

3. The quantity and type of extraneous materials removed with the harvested duckweed should be determined as this will be necessary information for the design of any future removal systems and may impact upon the available disposal options.

Objective 3:

Determine the potential amount of duckweed that can be harvested from the river channel and the amount of phosphorus that can be removed by duckweed harvest. Determine costs of phosphorus removal by duckweed harvest to costs of conventional removal of phosphorus at sewage treatment plants.

Recommendations

1. It is recommended that 1988 be used as an experimental year to determine the maximum amount of duckweed that can be harvested from the downstream portion of the river channel, and to determine the amount of phosphorus contained and removed by duckweed harvest. Use of an aquatic plant harvester is recommended to ensure that all available duckweed is harvested.

2. Use of a landfill site, if necessary, would allow convenient determination of the total biomass of harvested duckweed, as required to determine the total quantity of removed phosphorus. An appropriate number of duckweed samples should be collected during the first year of the study for laboratory analysis to accurately determine content of organic matter and nutrients.

3. From work conducted in the first year of the harvesting program, it should be possible to estimate the capital and operating costs of a duckweed harvesting system employed at the new pumphouse, and to compare the initial estimate of costs for phosphorus removal by duckweed harvesting to costs of phosphorus removal at sewage treatment plants discharging to Lake Simcoe.

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APPENDIX A

The following is a list of persons and their affiliation who were contacted during the course of this study.

Mr. Art Janse
Drainage Superintendent
Township of West Gwillimbury
Bradford, Ontario

Mr. Ralph Davidson
J.K. Young Associates
Brampton, Ontario

Mr. Wes Lammers
Special Projects Co-ordinator
Technical Support Section
Ontario Ministry of the Environment
Toronto, Ontario

Mr. Dennis Draper
Co-ordinator of Agricultural Programs
Ontario Ministry of the Environment
Toronto, Ontario

Mr. Fritz Engler
Municipal Pollution Control Specialist
Water Resources Branch
Ontario Ministry of the Environment
Toronto, Ontario

Mr. Dale Henry
Assistant Engineer
MISA - Municipal Sector
Ontario Ministry of the Environment
Toronto, Ontario

Ms. Mary Vanderhueler
Ontario Ministry of Agriculture and Food
Newmarket, Ontario

Mr. Matt Valk
Muck Crops Research Station
Ontario Ministry of Agriculture and Food
Kettlby, Ontario

Mr. Mike Walters
South Lake Simcoe Conservation Authority
Newmarket, Ontario

APPENDIX

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

A. Morton, 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

J. Kinkead, Watershed Management Branch, Ministry of the Environment

J. Merritt, Director - Central Region, Ministry of the Environment

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

R. DesJardine, Central Region, Ministry of Natural Resources (past member)

J. Dobell, Huronia District, Ministry of Natural Resources

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

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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