RESEARCH SUB-PROGRAM

ENVIRONMENTAL MONITORING OF AGRICULTURAL CONSTRUCTED WETLANDS - A PROVINCIAL STUDY

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COESA Report No.: LMAP - 014/94

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On behalf of: Research Branch, Agriculture and Agri-Food Canada
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FORWARD

This province-wide constructed wetland research project was funded under the Land Management Assistance Program (LMAP), in association with the Research Sub-Program of the COESA (Canada-Ontario Environmental Sustainability Accord) Canada-Ontario Green Plan. The GREEN PLAN agreement, signed Sept. 21, 1992, is an equally-shared Canada-Ontario program totalling $64.2 M, to be delivered over a five-year period starting April 1, 1992 and ending March 31, 1997. It is designed to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. The Federal component will be delivered by Agriculture and Agri-Food Canada and the Ontario component will be delivered by the Ontario Ministry of Agriculture and Food and Rural Assistance.

From the 30 recommendations crafted at the Kempenfelt Stakeholders conference (Barrie, October 1991), the Agreement Management Committee (AMC) identified nine program areas for Green Plan activities of which the three comprising research activities are (with Team Leaders):

1. Manure/Nutrient Management and Utilization of Biodegradable Organic Wastes through land application, with emphasis on water quality implications
   A. Animal Manure Management (nutrients and bacteria)
   B. Biodegradable organic urban waste application on agricultural lands (closed loop recycling) (Dr. Bruce T. Bowman, Pest Management Research Centre, London, ONT)

2. On-Farm Research: Tillage and crop management in a sustainable agriculture system. (Dr. Al Hamill, Harrow Research Station, Harrow, ONT)

3. Development of an integrated monitoring capability to track and diagnose aspects of resource quality and sustainability. (Dr. Bruce MacDonald, Centre for Land and Biological Resource Research, Guelph, ONT)

The original level of funding for the research component was $9,700,000 through Mar. 31, 1997. Projects will be carried out by Agriculture and Agri-Food Canada, universities, colleges or private sector agencies including farm groups.

This Research Sub-Program is being managed by the Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ONT. N5V 4T3.

Dr. Bruce T. Bowman
Scientific Authority

Green Plan Web URL: http://res.agr.ca/lond/gp/gphompag.html

The following report, approved by the Research Management Team, is reproduced in its entirety as received from the contractor, designated on the previous page.

Environmental Monitoring of Agricultural Constructed Wetlands
- A Provincial Study -

Report for Agriculture and Agri-Food Canada
Record of Progress to December 1994

D. Hayman and K. Maaskant
Upper Thames River Conservation Authority

Executive Summary

A province-wide research project is being conducted to determine the practicality and treatment effectiveness of constructed wetlands for the treatment of barnyard runoff under Ontario's soil and climatic conditions. A total of 12 experimental wetland systems and two experimental grassed strips are being installed and monitored across southern Ontario. Designs incorporate a variety of component including runoff holding ponds, vegetated marsh treatment cells, and water quality polishing cells. Each individual design aspect is repeated at a number of sites to allow for comparison. A base line assessment of all sites includes: monitoring bacterial and chemical parameters in groundwater, surface water, and bottom sediments; continuous monitoring of surface water levels, relative humidity, water temperature, air temperature, and rainfall. Additional research is being conducted at selected sites including monitoring vegetation, macroinvertebrates, and wildlife. These experimental systems will allow for an assessment of treatment effectiveness, management requirements, and economic benefits for Ontario farms. The results of this research will further the development of low-cost alternatives for the farm community to protect water quality.

Sommaire

On a entrepris un projet de recherche à l'échelle de l'Ontario pour déterminer dans quelle mesure il est faisable et efficace d'utiliser des marais artificiels pour le traitment des eaux de ruissellement de ferme, compte terre des sols et des conditions climatiques de la province. En tout, on a aménagé dans le sud de l'Ontario 12 marais expérimentaux et 2 bandes herbeuses où l'on surveillera le traitment. Les installations se composent de divers éléments, notamment de bassins de retenue pour recueillir les eaux de ruissellement, des cellules de traitment aménagées en marais avec végétation et des cellules d'affinage de l'eau. Chacun des éléments est présent dans plusieurs installations, ce qui permet les comparaisons. L'évaluation de base, réalisée pour toutes les installations, porte entre autres sur les points suivants; surveillance des paramètres bactériens et chimiques des eaux souterraines, des eaux de surface et des sédiments; surveillance permanente du niveau des eaux de surface, de l'humidité relative, de la température de l'eau, de la température de l'air et de la pluviosité. Dans certains aménagements, on fait des travaux additionnels tels que la surveillance de la végetation, des macro-invertébrés et de la faune. Grace à ces installations expérimentales, nous pourrons évaluer l'efficacité du traitment at déterminer les critères de gestion et les avantages économiques de que son utilisation suppose pour une exploitation agricole de l'Ontario. Les résultats de ce projet seront utiles dans la mise au point de nouveaux moyens peu coûteux pour la préservation de la qualité de l'eau dans les exploitations agricoles.

Acknowledgements

The following ten Conservation Authorities have participated with landowners in the constructed wetland project sites involved in this study:

Essex Region Conservation Authority (ERCA)
  360 Fairview Ave. W., Essex ON, N8M 1Y6
Upper Thames River Conservation Authority (UTRCA)
  RR.6, London ON, N6A 4C1
Grand River Conservation Authority (GRCA)
  Box 729, Cambridge ON, N1R 5W6
Hamilton Region Conservation Authority (HRCA)
  Box 7099, Ancaster ON, L9G 3L3
Nottawasaga Valley Conservation Authority (NVCA)
  RR.1, Angus ON, L0M 1B0
Niagara Peninsula Conservation Authority (NPCA)
  2358 Centre St., Allanburg ON, L0S 1A0
Metro Toronto Region Conservation Authority (MTRCA)
  5 Shoreham Dr., North York ON, M3N 1S4
Moira River Conservation Authority (MRCA)
  Box 698, Belleville ON, K8N 5B3
Rideau Valley Conservation Authority (RVCA)
  Box 599, Manotick ON, K4M 1A5
South Nation Region Conservation Authority (SNRCA)
  Box 69, Berwick ON, K0C 1G0

In addition, the following Conservation Authority and Remedial Action Plan area participated through the construction of grassed strips to treat manure and feedlot runoff:

Metro Toronto Region Conservation Authority
Severn Sound Remedial Action Plan (SSRAP)
  Wye Marsh Wildlife Centre, P.O. Box 100, Midland ON, L4R 4K6

Thanks to the many partners that are contributing to this project. Special credit goes to the following:

Jim Eddie, MOEE, for monitoring equipment support
Conservation Authority staff for initiating and coordinating projects, and for providing information and writing project descriptions for this report

And most importantly, the 14 landowners installing experimental projects on their farms
(Landowner names and farm locations have been omitted from this public report)

Contact the appropriate Conservation Authority/SSRAP area for further information on individual projects.

Table of Contents

List of Figures

List of Tables

Appendices

1.0 BACKGROUND

1.1 Constructed Wetlands Technology

The use of constructed wetlands for water purification is receiving much attention world-wide. This interest stems from the potential for reduced waste management costs plus the aesthetic and environmental benefits of these systems. The concept of using constructed wetlands for wastewater treatment has only developed within the last 20 years. Today these systems treat wastewater from individual homes, towns, cities, livestock production, paper mills, tanneries, food processing plants, landfill leachate, mine drainage, stormwater runoff, and many other sources (Hammer, 1994). Every continent except Antarctica is using this technology for treatment (Hammer, 1994).

1.1.1 American Experience

Slayden and Schwartz (1989) conducted a survey of each state in the U.S. which showed that few states have rigid policies or criteria on constructed wetland technology. Some states have been more willing than others to approve experimental designs in an effort to further the knowledge of this technology (Slayden and Schwartz, 1989). For some systems where there is discharge to public waters, there are compliance requirements of a wastewater discharge permit (NPDES - National Pollutant Discharge Elimination System). Compliance monitoring involves a specific selection of parameters and discharge limits which relate to the water quality protection level assigned to the receiving waters by the regulatory agency (Hicks and Stober, 1989).

Although constructed wetland technology has been developing for a number of years, the use of these systems to treat agricultural wastewater is essentially in the experimental stages. The U.S. experience has found a high potential for this technology in agricultural operations. Presently some examples of such wetland research include the treatment of livestock wastewater lagoons in Indiana and California, barnyard runoff in Alabama and Mississippi, and milkhouse washwater in Wisconsin and Pennsylvania (Holmes et al, 1992). This research is being conducted to determine the effectiveness of these systems and to establish system design standards (Holmes et al, 1992).

Regulations vary across states regarding the use of constructed wetlands for agricultural runoff. The Soil Conservation Service (SCS) policy does not permit planning and implementing agricultural waste management systems that discharge to waters of the United States without an NPDES permit or an equivalent permit from the state regulatory agency (Krider and Boyd, 1992). The technology for agricultural treatment wetlands is not fully developed such that designs can ensure that effluent meets state discharge standards. Therefore at this stage, a plan for a constructed wetland treatment system must include a plan for management of the effluent from the wetland (Krider and Boyd, 1992). Pilot constructed wetland designs incorporate a storage pond to hold effluent until testing can be done (Krider and Boyd, 1992).

In the U.S., the Tennessee Valley Authority has been a leader in the development of constructed wetland technology including systems for agricultural wastewater treatment. Hammer (1994) has suggested objectives for agricultural treatment wetlands to be:

- able to provide high levels of treatment and discharge relatively clean water,
- low-cost to build and operate, and
- requiring little time, training, or expense for operation and maintenance

Self-maintaining systems of lower operational complexity have shown a greater probability of success. Hammer (1994) recommends sizing based on mass loading, and designs which incorporate an initial settling pond/basin plus emergent marsh and pond cells. Also of importance is a site where an impermeable layer (hydraulic conductivity of $<10^{-6}$ cm sec^{-1}) can be achieved.

Areas in the U.S. have experience with constructed wetlands designed for a cold climate. There are approximately 60 treatment wetlands in use in high elevation areas of Colorado, New Mexico, and Arizona (Gover, 1993). In these cold climate systems BOD, TSS and faecal coliform removal was expected to be effective but an extended retention time is needed because of lower reaction rates (Gover, 1993). Design criteria for continuous-input sewage treatment wetlands recommends winter storage in cold climates (Hammer and Knight, 1992).

1.1.2 Canadian Experience

Although there have been an abundance and variety of constructed wetlands installed in the United States and other countries, the Canadian experience with this technology is limited. However, there appears to be a sufficient body of evidence from successful cold climate projects to suggest there is a very good potential for use of this technology in Ontario and other provinces.

One of the most notable constructed wetland research projects in Canada was the Listowel Marsh project in southwestern Ontario, initiated in 1981. This experimental facility treated municipal sewage wastewater, maintaining operations through the winter with ice cover. The project determined that properly designed cattail (*Typha spp.*) marshes are able to improve the quality of sewage wastewaters (Herskowitz, 1986). The experimental setup was terminated. Insufficient phosphorus removal and dissolved oxygen deficits, both in summer and winter were cited as the greatest concerns for Ontario sewage effluent standards (pers. comm. R. Manoharan, MOEE). Enhanced pretreatment recommendations were incorporated into the design of a full-scale marsh treatment at Port Perry (Herskowitz, 1986). However, similar problems were encountered as at the Listowell experimental setup and the project was terminated (pers. comm. R. Manoharan, MOEE). A similar system was attempted in the northern Ontario community of Cobalt (Miller, 1989). An insufficient amount of water to the system at times of the year created operational difficulties and this project was also ended. Cobalt has recently hired consultants to develop recommendations to restore the facility to operational status (pers. comm. R. Lapointe, Cobalt). Finally, Niagara-on-the- Lake has recently initiated experiments using SWAMP (sewage waste amendment process). The concept is to provide an initial form of phosphorous removal and oxygen remediation prior to discharge to a constructed wetland (pers. comm. R. Manoharan, MOEE).

More recently, constructed wetlands have become more common for wastewater treatment in Canada. These projects include treatment of sewage wastewater, landfill leachate, industrial site runoff, petroleum and oilsands wastewater, and urban stormwater runoff (Eastlick, 1993). However, the use of this technology for agricultural wastewater treatment is very limited. As such, there are currently no design criteria for agriculturally-oriented constructed wetlands in Canada.

Research is needed in Canada to determine design standards for effective treatment under the various Canadian climatic conditions and Canadian environmental objectives and standards. Extended monitoring and design reviews will be essential in determining the long-term viability of these systems and the practicality within a farm operation.

1.2 Clean Up Rural Beaches Program

Through 1983 and 1984, fully 10% of all monitored beaches in the province of Ontario were posted, warning of the health risks for recreational swimming for a duration of at least two weeks. The predominant factor influencing beach postings was elevated levels of bacteria indicative of faecal contamination in the water. Less frequently beach postings also occurred due to blue-green algal blooms, an indication of elevated phosphorus concentrations. In 1985, the Ontario Ministry of Environment and Energy (MOEE - formerly Ministry of Environment) announced a strategy to study and eventually clean up the widespread beach pollution problem experienced in the province. The program was divided into two components; one rural and one urban.

The Rural Beaches Strategy was initiated as a cooperative venture between the MOEE and local Conservation Authorities (CA's). Conservation Authorities are resource management agencies aligned on a watershed basis (figure 1). Through the study phase, a committee of water quality investigators, food producers, and government representatives developed an accounting procedure for all the upstream sources of beach pollution. All study areas considered bacterial contamination; fewer included phosphorus in the accounting process as well. These sources were then assessed by their relative impact on the study beach. From this assessment, recommendations were made for a cost-effective implementation plan (what sources could be cheaply fixed with the most significant reduction in beach pollution).

Following the Rural Beaches Strategy study phase, the Ministry of Environment and Energy developed an implementation program; Clean Up Rural Beaches (CURB) Program. This program was also a cooperative venture between the MOEE and Ontario Conservation Authorities. The formal announcement was made in September 1991. At that time, 9 Conservation Authorities were participating. Today, 29 Conservation Authorities and one Remedial Action Plan (RAP) organization are involved.

The Clean Up Rural Beaches Program is a $57 million ten year program directed towards correction of four specific impacts identified in the early Rural Beaches Strategy Reports. These are manure runoff, unrestricted livestock access and improper domestic septage and improper milkhouse washwater handling. Through a committee of agencies and farm representation, Water Quality Improvement Plans are reviewed and the limited funds are targeted to the most significant problems as they pertain to downstream beach postings.

Amongst the many significant findings of the study phase, manure runoff containment was found to be a costly approach with respect to downstream beach cleanup efforts for both bacterial and phosphorus impacts (Hayman, 1989). This inefficiency was in large part due to two factors:

- the high capital costs associated with manure containment construction.
- manure runoff events typically occur at either end of the swimming season and therefore not as critical, in relative terms, as daily impacts in summer low flows .

Concerned about the potential localized impacts of manure runoff and the high capital costs of manure containment for landowners, there was a desire to develop alternate cost-effective approaches. A constructed wetland treatment system was one of many alternatives researched.

1.3 Early Stages in Ontario

In 1992 the Upper Thames River Conservation Authority (UTRCA) initiated a research project to design and test a system for barnyard runoff. A literature review was conducted and several tours were arranged to view American efforts to gain first hand insight into effectiveness, practicality and design concerns.

The first prototype constructed wetland for the treatment of barnyard and manure runoff was installed in southwestern Ontario in June 1993. It was a cooperative venture between the UTRCA and a Mitchell, Ontario area dairy operator. The landowner was interested in developing an alternative cost-effective treatment system.

1.3.1 Design Considerations

Currently in Ontario, agricultural constructed wetlands with outflow are considered a sewage works and require a Certificate of Approval from the Ontario Ministry of Environment and Energy. The other option is to prevent outflow and manage excess water through such means as field irrigation.
Based on the variety of input from the township and the provincial government, the UTRCA was left with several considerations in the design;

Generic Considerations
- 1) no direct discharge would be permitted without the appropriate approval,
- 2) groundwater resources must be protected,

Local Considerations
- 1) no earthen manure storages allowed by local bylaw
- 2) demonstration ability was important (location, landowner)

Landowner Considerations
- 1) low cost
- 2) minimal maintenance

Based on these, the artificial wetland was believed to be the ideal approach. A final holding pond for treated effluent was part of the design to prevent outflow. Initial groundwater and soil profile analysis provided insight into location, depth and design criteria to protect ground and surface water during and after construction.

Initiatives to develop low-cost waste management alternatives such as constructed wetlands for farm operations has attracted much interest from the agricultural community. Following construction of the Mitchell area facility within the UTRCA watershed, a landowner approached the Rideau Valley Conservation Authority and another approached the Essex Region Conservation Authority to also construct wetlands. These were completed respectively in September and October 1993. Soon after proposals to build others across the province began to increase.

2.0 Conservation Authority Provincial Study

2.1 Purpose

The purpose of this study is to install and monitor a variety of designs for constructed wetlands which treat runoff from manure storage and barnyards. Monitoring will include baseline environmental measurements of surface and groundwater quantity and quality, precipitation, evaporation and transpiration, farmer attitudes as well as capital and operating costs.

As these wetland treatment systems are in the experimental stages, data collected will provide regulatory agencies the information necessary to determine if these systems will be regulated and the appropriate approval process.

2.2 Study Concept and Design

Agriculture and Agri-Food Canada provided funding for the capital costs in establishing the equipment and piezometer installations necessary to account for site specific design concerns and for long-term monitoring of effectiveness. By the end of October 1993, three wetlands were constructed to handle barnyard runoff. There were numerous additional proposed projects under discussion. Two basic design concepts were used.

1) a settling basin to collect manure runoff from a stack/feedlot/exercise area. Runoff is attenuated for more than 24 hours through a vertical pipe intake. Flow is released to a switchback marsh system followed by a polishing pond. The design is a closed system which requires excess water be pumped back through the system or an occasional field application (Appendix 1).
2) a containment pond which collects both milkhouse washwater and barnyard runoff sized for 240 days storage followed by a controlled warm weather release to a switchback marsh system followed by a finishing pond. The design is a closed system which requires excess water be pumped up back through the system or occasional field application (Appendix 1).

Alternative designs were later proposed which follow similar concepts.
By the end of March 1994, twelve experimental sites were identified for monitoring across the province which will follow the prescribed experimental design. This includes the installation of piezometers for design and long term monitoring, equipment needs for future water sampling of the piezometers, data loggers to measure water level and temperature and the weirs required to control flow and assist with rating curve development. A number of the sites have completed construction with the remaining under design (see 3.4).

3.0 Implementation of the Provincial Study

3.1 Monitoring Equipment

Table 1: Equipment provided through the Agriculture and Agri-Food Canada contract

Ref. #	Site	Depth Gauge	Water Temp	Data Logger	Air Temp	RH /Air Temp	Rain Gauge	Soils / Groundwater Assessment
1	ERCA Wetland *	3	3	1	1	0	1	funded/conducted by Centralia College
2	UTRCA Wetland (1)*	3	3	1	0	1	1	funded/conducted by Centralia College
3	UTRCA Wetland (2)*	3	3	1	1	0	1	yes
4	GRCA Wetland	3	3	1	1	0	1	to be announced
5	HRCA Wetland	3	3	1	1	0	1	yes
6	NVCA Wetland *	3	3	1	0	1	1	yes
7	NPCA Wetland (1) *	3	3	1	0	1	1	yes
8	NPCA Wetland (2) *	3	3	1	1	0	1	to be announced
9	MTRCA Wetland	3	3	1	1	0	1	to be announced
10	MRCA Wetland	3	3	1	1	0	1	to be announced
11	RVCA Wetland	2	3	1	0	1	1	conducted/funded by RVCA
12	SNRCA Wetland	4	3	1	1	0	1	conducted by Alfred College/funded by SNRCA
13	MTRCA Grassed Strip *	1	0	1	0	1	1	to be announced
14	SSRAP Grassed Strip *	0	0	1	1	0	1	yes

Footnote:
* Equipment installed in 1993/94
Depth Gauge is an Ultrasonic Depth Gauge (UDG01)
Data Logger is a Campbell CR10 with PC208 software
Rain Gauge is a tipping bucket (TE52)

3.2 Soils Assessment and Groundwater Investigations

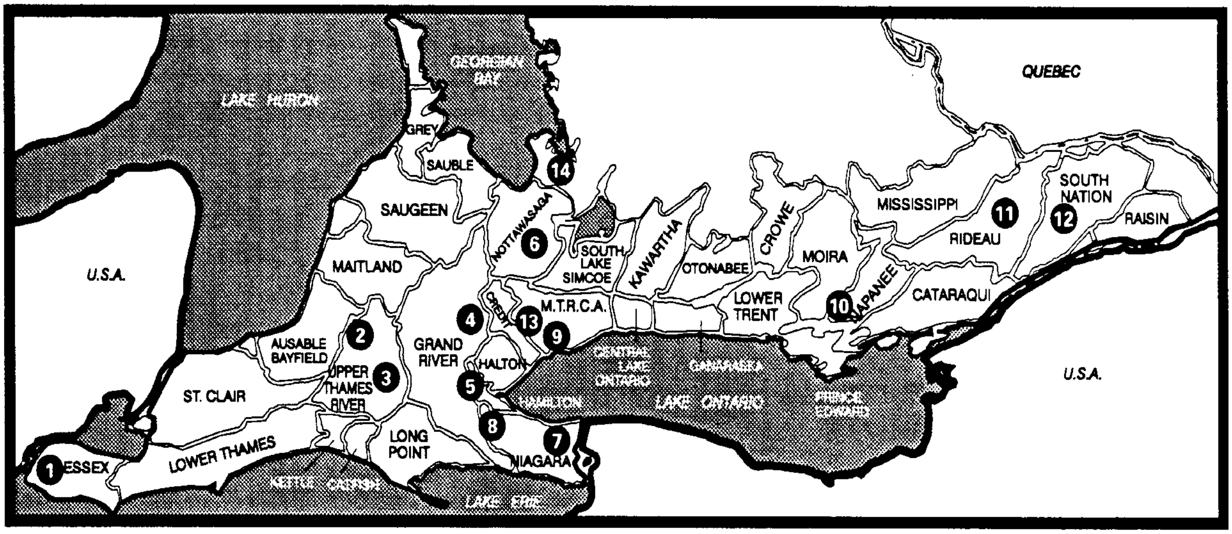
The following summarizes the hydrogeological investigations funded through Agriculture and Agri-food Canada (full reports are appended). Subsurface site condition information for the remaining sites is on file at the Conservation Authority offices.

Table 2: Summary of hydrogeological reports

Ref #	Site	General Subsurface Conditions	Depth to Groundwater below surface	Number of Boreholes
3	UTRCA Wetland	The site is generally covered with 300 to 600 mm of organic topsoil. Topsoil underlain by a sandy silt to clayey silt. Occasional sand seams.	1.2 to 6.0 m	6
5	HRCA Wetland	Surficial layer of organic topsoil 150 to 300 mm thick. Topsoil underlain by sandy to clayey silt till. Silt till generally underlain by a sand to sand and gravel layer.	0.6 to 1.8 m	6
6	NVCA Wetland	The site is generally covered with a 150 to 300 mm thick layer of organic topsoil. Topsoil underlain by sandy silt till with occasional sand pockets and layers.	5.3 to 6.5 m	5
7	NPCA Wetland	The site is generally covered with a 100 to 225 mm thick layer of organic topsoil. The topsoil and fill is underlain by a silty clay till deposit. Occasional silt seams are present	0.9 to 1.8	10
14	SSRAP Grassed Strip	The site is generally covered with a 0 to 200 mm thick layer of topsoil generally underlain by a silty clay deposit.	4.0 to 4.3	5, 1 cluster of 3

Figure 1: Project Site Location

Conservation Authorities in Southern Ontario



ASSOCIATION OF CONSERVATION AUTHORITIES OF ONTARIO

3.3 Project Engineering, Participants and Partners

Table 3: Summary of project engineering, participants, and partners

Ref. # (Site)	Project Engineering and Review	Participants and Partners	Role/Contribution
1 (ERCA Wetland)	Brian Abele P.Eng., ERCA Stan Taylor P.Eng, ERCA Review: Paul Hermans ERCA, Township Engineer, Gilbert Arnold Agr. Canada, MOEE CURB, Brad Glasman UTRCA	Landowner ERCA Ag. Canada MOEE MOEE (SW Region) Canada Trust OMAF	owner and operator, funding, on-going maintenance project design, implementation, research coordinator, materials and monitoring equipment (portable computer, materials and supplies for equipment installation) Rural Conservation Clubs program and Harrow Research Station Environmental Assessment Review, funding for construction technical support for datalogger monitoring, staff gauges, rain gauge Redox meter funding for monitoring equipment (solinst water level meter, supplies and materials for 7 piezometers) groundwater investigations
2 (UTRCA Wetland)	Brad Glasman P.Eng., UTRCA Review: landowner, Karen Maaskant UTRCA, Dave Hayman UTRCA, Township representatives	Landowner UTRCA MOEE (SW Region) MOEE (CURB) Canada Trust Centralia College Ag. Canada	project owner and operator, 25% installation costs, on-going maintenance research, design, engineering, project coordination and technical staffing, equipment (portable computer, battery, peristaltic pump, solinst water depth meter, dissolved oxygen meter, staff gauges, weirs) funding for background research, literature search, design, on-going monitoring, 1992-1995, redox meter 75% installation costs, lab support, monitoring equipment support first year monitoring equipment (dataloggers, pressure transducers, temperature probe, tipping bucket) Piezometer installation materials monitoring equipment, soils assessment and groundwater investigations
3 (UTRCA Wetland)	Brad Glasman P.Eng., UTRCA (in design stage) Review: To be announced	Landowner UTRCA MOEE (CURB) Ag. Canada	site owner and operator, portion of installation costs, on-going maintenance design, engineering, project coordination and technical staffing, portion of installation costs, equipment (portable computer, peristaltic pump, water depth meter, DO meter, staff gauges, weirs) lab support, monitoring equipment support monitoring equipment, soils assessment and groundwater investigations

4 (GRCA Wetland)	Jim Hartman GRCA Review: B. Glasman, UTRCA	landowner GRCA Ag. Canada MOEE	owner and operator, labour and capital expenses project administrator, project coordinator, design, monitoring and research, monitoring equipment (portable computer, water level meter) monitoring equipment CURB lab support
5 (HRCA Wetland)	Mike Toombs OMAFRA Review: TBA	To be announced	
6 (NVCA Wetland)	Mark Peacock P.Eng., NVCA Review: Byron Wesson NVCA, NVCA engineering staff, Gilbert Arnold Ag. Canada, Claude Weil Alfred College, Brad Glasman UTRCA	landowner NVCA South Simcoe Cons. Club Ag. Canada MOEE Salvation Army Correctional Works Dol Brothers Sod Co. Munro Concrete Big `O' Royal Botanical Garden Ritchie Forest Products Ron Johnson Wiremakers Woodburn Holdings	owner and operator engineering, supervision, backhoe donation Rural Conservation Club funding, monitoring equipment CURB staff - monitoring, monitoring equipment support general labour hydroseeding site donation 1000 gallon septic tank donation drainage tile donation marsh vegetation donation fencing posts fence fence installation
7 (NPCA Wetland)	Chris Attema, NPCA Review: landowner, NPCA, MNR	landowner NPCA MNR Brock University Environmental Youth Corps Ag. Canada MOEE (CURB)	owner and operator, 50% of project costs project design, management, and monitoring Community Wildlife Improvement Program - 50% of project costs Water Quality Analysis of Constructed Wetlands in the Niagara Region, 1994 Monitoring equipment, soils assessment and groundwater investigations Lab support, monitoring equipment support

8 (NPCA Wetland)	Chris Attema, NPCA Ian Smith and George Bis, Regional Municipality of Niagara	landowner NPCA OSCIA Ag. Canada MOEE (CURB) Owen McIntyre Contractor Walker Bros./Vineland Quarry Allied Environmental/ NPCA Anderson Haulage General Seed Co.	owner and operator project design, management and monitoring 50% funding for construction monitoring equipment, soils assessment and groundwater investigations Lab/monitoring equipment support construction shale windmill aerator stone grass seed
9 (MTRCA Wetland)	To be announced	Landowner MTRCA Ag. Canada MOEE (CURB)	owner and operator, construction/maintenance costs staff, expenses monitoring equipment lab support, staff/expenses, tech. assistance, construction/maintenance costs
10 (MRCA Wetland)	To be announced	To be announced	
11 (RVCA Wetland)	Terry Davidson P.Eng., RVCA	Landowner RVCA Ag. Canada MOEE (CURB)	owner and operator, 25% of installation cost design, engineering, construction, monitoring, equipment monitoring equipment 75% of installation costs, lab/monitoring equipment support, monitoring equipment

12 (SNRCA Wetland)	Claude Weil P.Eng., Alfred College Eric Tousignant P.Eng., McNeely Engineering Review: MOEE Water Resources, Conservation Authority, OMAFRA, Dr. Hammer, Gilbert Arnold (Ag Can)	Landowner SNRCA Ag. Canada Alfred College McNeely Engineering MOEE (CURB) OSCIA Russell SCIA OMAFRA Ontario Cattleman's Assn. Ag. Can. Rural Cons. Club	owner and operator , funding funding, monitoring (portable computer), project management monitoring equipment design, provided pump and battery, piezometers, groundwater level recorders, construction supervision and monitoring design lab support, monitoring equipment support funding funding project management funding funding
13 (MTRCA Grassed Strip)	Mike Toombs, OMAFRA Review: MTRCA	Landowner MTRCA Ag. Canada OMAFRA MOEE Environment Canada	owner and operator, construction/maintenance/operational costs staff, expenses monitoring equipment design, construction costs, staff construction costs, lab support, technical assistance, staff/expenses Great Lakes Cleanup funding for staff/expenses
14 (SSRAP Grassed Strip)	Mike Toombs, OMAFRA Review: Keith Sherman SSRAP, Julie Cayley, Carrie McIntyre SSRAP, landowner	Landowner SSRAP Ag. Canada OMAFRA North Simcoe SCIA SSRAP(CURB) MOEE Pickseed	owner and operator, skilled labour, plumbing and electrical installation, pump chamber design, barnyard grading, filter screens, material and construction design, review, monitoring and lab analysis, materials, equipment (portable computer, flow meter, peristaltic pump), staff and technical support monitoring equipment project engineering, design, modification, soil sampling, consultation, vegetation selection 100% construction funding, materials project manager/monitoring/data collection, filter box, monitoring equipment technical support Reed canary grass seed

3.4 Status and Summary of Projects

3.4.1 ERCA Wetland (Ref.# 1)

Location: Essex County, Maidstone Township

Completion Dates:
Construction - October 1993
Vegetation Transplanting - Spring 1994
Monitoring Equipment Installation - August 1994 (Ag. Canada equipment), September 1993/spring 1994 (7 piezometers)

There are two main objectives in this wetland design. One is to maximize evapotranspiration so no direct outlet is needed. The second is to research the effectiveness of wetlands to treat wastewater to meet the guidelines needed to release water into a water course.

The wetland has three phases comprised of a storage pond, switchback marsh and polishing pond. The storage pond serves two purposes: to allow settling of finer solids in the pond before they reach the wetland and to store wastewater during the winter months when the wastewater is not released into the wetland. When ambient temperatures are conducive for microbiological activity and plant growth, the waste water is released into the marsh for treatment. From this wetland, the water flows into a polishing pond for final treatment. If a severe rainstorm occurs, the wetland will hold the wastewater due to its additional free board capacities. However, if the wetland can not handle a major rain event, the water will overflow into a grassed waterway area located in the farmer's pasture. The wetland was designed as a closed system, therefore there is no direct outlet into a watercourse. A total of seven piezometers were installed around the site (4 deep piezometers and three shallow piezometers).

3.4.2 UTRCA Wetland (Ref. # 2)

Location: Perth County, Fullarton Township

Completion Dates:
Construction - June 1993
Vegetation Transplanting - July 1993, November 1993
Monitoring Equipment Installation - April 1993 (5 piezometers), July 1993 (sampling), September 1994 (Ag. Canada equipment)

The objective of this project is to design a constructed wetland for the treatment of manure runoff and evaluate the effectiveness and practicality of using constructed wetlands for this purpose.

The constructed wetland is approximately 1 acre in size and consists of a three stage treatment system for manure runoff from a 30 cow dairy operation. Runoff from the concrete yard and solid manure storage area is temporarily ponded in a bermed grass settling basin where solids settle out. Water drains slowly through a vertical pipe inlet to the second treatment cell. The second cell is designed to move the runoff water through a shallow serpentine channel which is planted with cattails and other marsh vegetation. Water from the second cell flows into a third cell (finishing pond) which maintains open water and deeper water vegetation. The system runs by gravity flow with flow based on rainfall and slow drainage from the settling basin. Direct outflow from the system to a watercourse is prevented (in the second year of operation treated water from the finishing pond was irrigated onto an adjacent field). 4 piezometers, one upstream and 3 downstream of the site, are installed for monitoring any effect on local groundwater.

3.4.3 UTRCA Wetland (Ref. # 3)

Location: Oxford County, Zorra Township

Expected Completion Dates (note: project is in the design stage)
Construction - June 1995
Vegetation Transplanting - June 1995, November 1995
Monitoring - May 1994 (groundwater), June 1995 (Ag. Canada monitoring equipment)

3.4.4 GRCA Wetland (Ref. # 4)

Location: Wellington County, Erin Township

Expected Completion Dates:
Construction - June 1995
Vegetation Transplanting - June 1995
Monitoring - June 1995 (Ag. Canada equipment)

This project is a surface flow, two wetland cell system designed to treat low level BOD from barnyard runoff with no effluent discharge after treatment.

3.4.5 HRCA Wetland (Ref. # 5)

Location:

Expected Completion Dates (note: project is in the design stage)
Construction - TBA
Vegetation Transplanting - TBA
Monitoring - TBA

3.4.6 NVCA Wetland (Ref. #6)

Location: Simcoe County, Essa Township

Expected Completion Dates:
Construction - November 1994
Vegetation Transplanting - November 1994
Monitoring - fall 1994, spring 1995

The objectives of this project are to develop and alternative and cost effective approaches to farm wastewater management and to provide an environmental and educational opportunity for members of the South Simcoe Conservation Club and other north and south Simcoe farmers.

This project was developed to treat contaminants generated from the barnyard and milkhouse waste. A three celled approach has been used. Within the barnyard area, and prior to cell one, curbs will be placed with small spacings between them to pond liquid runoff from the manure stack area. This curbing will allow some solid manure wastes to settle onto the concrete manure pad area. The farmer will, on a periodic basis, scrape these sediments back onto the manure stack. An armoured area has been provided for the runoff that exits between the concrete curb barriers to enter the first cell.

Cell 1 is designed such that the farmer can clean it out periodically and inexpensively with a sludge pump or backhoe. A hickenbottom drain is provided as a link between cell-one and cell two. Cell two consists of a meandering channel approximately 5 to 6 feet wide and one foot in depth. Areas of deeper pools are placed strategically to allow habitat for submergent vegetation. Hydrocydic plants with known nutrient uptake capabilities will be planted within this section of the constructed wetland. Care has been taken to provide maintenance access to all portions of the channel. At the outfall of cell two is a berm to ensure that water fills the wetland prior to entering the third cell. Cell three consists of a polishing pond which displaces its water to a concrete weir box, which in turn directs the water into a 400 ft drainage tile and then outlets onto a grassed filter strip.

3.4.7 NPCA Wetland (Ref. # 7)

Location: Region of Niagra, West Lincoln Township

Completion Dates:
Construction - August 1994
Vegetation Transplanting - August 1994
Monitoring - November 1994

The goal of this project is to determine if natural wetland processes can provide an environmentally safe and economically practical treatment of barnyard runoff.

The grass filter storage area (approximately 2400 cubic feet) provides enough storage area for anticipated storm events. Spring run-off manure and feedlot liquids will be temporarily stored in the manure storage area and released when conditions permit. This will provide enough storage volume for spring run-off when the soil is frozen and the grass filter tiles are not functioning.

It is anticipated that most of the phosphorus removal will occur in the grass filter/subsurface drain treatment area. The wetland cells will be the primary source of BOD, faecal bacteria and nitrogen removal. The deep pond will contain the treated discharge from the second wetland cell.

3.4.8 NPCA Wetland (Ref. # 8)

Location: Region of Hamilton-Wentworth, Glanbrook Township

Completion Dates:
Construction - August 1994
Vegetation Transplanting - August 1994
Monitoring - November 1994

The goal of this project is to determine if natural wetland processes can provide an environmentally safe and economically practical treatment of milkhouse washwater and barnyard runoff.

The design is based on the "Sewage Waste Amendment Process" (SWAMP) concept currently under evaluation at the Niagara-on-the-Lake municipal lagoon. Preliminary results at Niagara-on-the-Lake have been encouraging. Municipal waste is pre-processed by passing through two aeration cells and two facultative lagoons. This effluent is pumped through a series of three subsurface flow wetland cells. The wetland cells typically removed up to 90% of the organic matter, nitrogen and phosphorus when loaded at a rate of 50 litres/square meter/day.

This milkhouse washwater, barnyard and manure stack runoff treatment system (Subsurface Flow Wetland) is based on similar principles. The waste water will be pre-processed by passing through an aeration cell and a facultative lagoon. The facultative lagoon discharges to a series of two subsurface flow wetland cells. These one meter deep wetland cells were backfilled with shale. Similar to the Niagara-on-the-Lake system it is anticipated that the shale will be the primary mechanism for the adsorption and removal of phosphorus.

3.4.9 MTRCA Wetland (Ref. #9)

Location: Regional Municipality of Peel, Town of Caledon
Expected Completion Dates: (note: project is in the design stage)
Construction - spring 1994
Vegetation Transplanting - spring/fall 1994
Monitoring - spring 1994

3.4.10 MRCA Wetland (Ref. # 10)

Location: Hastings County, Sydney Township

Expected Completion Dates: (note: project is in the design stage)
Construction - TBA
Vegetation Transplanting - TBA
Monitoring - TBA

3.4.11 RVCA Wetland (Ref. #11)

Location: Regional Municipality of Ottawa-Carlton, Oxford-on-Rideau Township

Completion Dates:
Construction - September 15, 1993
Vegetation Transplanting - September 1993, June/July 1994
Monitoring - September 15, 1994

This constructed wetland is situated on a 30 head cow-calf operation adjacent to the Rideau River. Prior to the construction of the wetland, all runoff generated from precipitation flowed towards the Rideau River. The wetland design/system consists of the following components:

1. Pond 1 (Sediment Basin): which allows removal of large sediments and acts as a storage facility during the winter. The Sediment Basin was constructed with gentle slopes to facilitate sediment removal on a routine basis, with a farm tractor equipped with a front-end loader.
2. Pond 2 (Marsh Cell): designed to remove organic material, suspended solids and pathogens. The marsh is designed to be shallow and vegetated with cattails (*Typha*), bulrushes (*Eleocharis*), and Reeds (*Phragmites*). The marsh cell predominantly functions to treat and improve the water quality by removing the excessive nutrients.
3. Pond 3 (Pond): designed to further reduce BOD_5 and encourage nitrification and denitrification processes. The pond has depths ranging from 0.3 metres to 2.5 metres. Vegetation varies from Duckweed (*Lemna*) and Water Lilies (*Nymphaea*) on the surface of the pond to submerged pondweeds (*Potamogeton*).

The outlet of the Sediment Basin consists of a submersible pump located in a concrete catch basin. Using this system, the operator can determine the optimum residence time of water in the marsh cell/treatment cell and ensure that it is always maintained. Also, there is an emergency overflow spillway from the sediment basin to the marsh cell. The outlet control structure to maintain water levels in the marsh cell consists of a water level control structure. A submersible pump has been installed in the pond to recirculating water from the pond to the inlet of the marsh cell. A pond aerator is being used to encourage evaporation and to promote bacterial die-off by exposing more bacteria to sunlight. The total area of the constructed wetland is approximately 1 acre.

3.4.12 SNRCA Wetland (Ref. #12)

Location: Russell County, Russell Township

Completion Dates:
Construction: September 1994
Vegetation Transplanting: Spring 1995
Monitoring and equipment installation: Spring 1995

The objectives of this wetland design are as follows: to design a system to treat milkhouse washwater and manure runoff from a livestock manure storage and feedlot under Eastern Ontario conditions, to design a cost-effective system requiring reasonable maintenance, and to evaluate the treatment effectiveness of the system.

The constructed wetland design consists of a facultative pond, a wetland, an aerobic pond, another wetland and a low rate overland flow system. The operational plan is to load runoff from the manure storage into the wetland system from June 1 to September 15. From September 15 to June 1 only the feedlot runoff is treated and the manure runoff is stored.

3.4.13 MTRCA Grassed Strip (Ref. # 13)

Location: Regional Municipality of Peel, Town of Caledon

Completion Dates:
Construction - fall 1993
Vegetation planting - fall 1993
Monitoring - fall 1993

The objective of this design is to prevent the contamination of a nearby watercourse by capturing runoff and potentially treating contaminated barnyard runoff. The grassed strip consists of four components: 1) barnyard settling area 2) pump and transfer piping 3) gravel spreader and 4) vegetated strip. Contaminated runoff from the yard is collected in a settling area in the barnyard. From there it flows into a cement filter box which contains a drop inlet. The runoff flows though the holes in the inlet to a pump housed beneath. From there it is transferred uphill to a gravel spreader which evenly distributes the contaminated wastewater across the width of the vegetated strip. As the water flows over the strip it is absorbed by the vegetation. Reed Canary Grass was planted because it is wet-dry tolerant and is able to use large amounts of nitrogen.

3.4.14 SSRAP Grassed Strip (Ref. # 14)

Location: Simcoe County, Springwater Township

Completion Dates:
Construction - August 1994
Vegetation Transplanting - August 1994, re-plant spring 1995
Monitoring - June 1994 (groundwater), October 1994 (datalogger), spring 1995 (surface water)

It is the objective of the SSRAP experimental vegetated filter strip to demonstrate an economical, effective alternative to conventional methods of managing barnyard runoff that can be easily integrated with regular farming practice. The filter strip was designed to handle strictly barnyard runoff. The manure will be scraped and stored in the SSRAP CURB demonstration roofed manure storage. As it enters the filter box, yard runoff, directed by the grade of the yard, will pass through a series of screens to ensure solids (ie. manure, hay, or saw dust) do not reach the strip or clog the pipes. This filter box is equipped with a pump chamber from which the liquids will be pumped to the filter strip (during the dry growing season) or to the southern sloped end of the manure storage (during the frozen winter months). The liquid is pumped to the filter strip through a distribution pipe on to a gravel spreader. Both the distribution pipe and gravel spreader will ensure even flow across the strip, minimizing any chances of channelization. The strip was planted with reed canary grass, vegetation suitable for wet conditions and high nutrient uptake. The filter strip, 300 feet by 12 feet with 0.5% slope and a low ridge on either side, has been designed so that flow depth will never exceed a depth of 0.5 inches.

3.5 Monitoring Program

Under the Agriculture and Agri-Food Canada contract the following parameters are being monitored: air temperature, relative humidity, rainfall, water temperature, and water elevation. The following is the base monitoring program for each of the constructed wetland sites. These are minimum standards and selected additional monitoring is being conducted at individual sites.

Groundwater Samples

- 4 times per year (October, January - weather dependent, April, July) - the frequency is increased if sample results show elevated contamination
- parameters: *E. coli*, nitrates

Surface Water Samples

- samples taken at the outlet end of each treatment stage (eg. holding pond, marsh cells, pond)
- twice monthly from May 1 to October 31
- once monthly from November 1 to April 30 (when not frozen)
- parameters: *E. coli*, Faecal Strep., *Pseudomonas aeruginosa*, ammonia, nitrite, nitrate, total kjeldahl, diss. reactive phosphorus, total phosphorus, BOD_5, suspended solids, pH, conductivity, chloride, and DOC (TBA)

Sediment Samples

- 2 per year (May and October)
- samples taken at water sampling sites
- Parameters: E. coli, Faecal Strep., 2P, plus other parameters as negotiated

Campbell Datalogger

- data is logged to memory - hourly, 15 minute rainfall event, daily summary
- twice monthly downloading datalogger at site, monthly data summary/evaluation

Additional Monitoring

Various additional monitoring is being conducted at individual sites including: redox measurements, vegetation monitoring, invertebrate monitoring, wildlife monitoring, maintenance inventory and soil monitoring for nutrients and bacteria

4.0 Future Activities

4.1 Reporting

Progress reports will be produced annually by the conservation authority and circulated to the various interested government agencies, researchers and other participants. By the fiscal end of Agriculture Green Plan funding (March 31, 1997), a booklet/factsheet is proposed, subject to funding, which outlines design standards, considerations and recommendations for manure runoff treatment in constructed wetland. The booklet will serve as a practical guide to landowners and resource managers alike.

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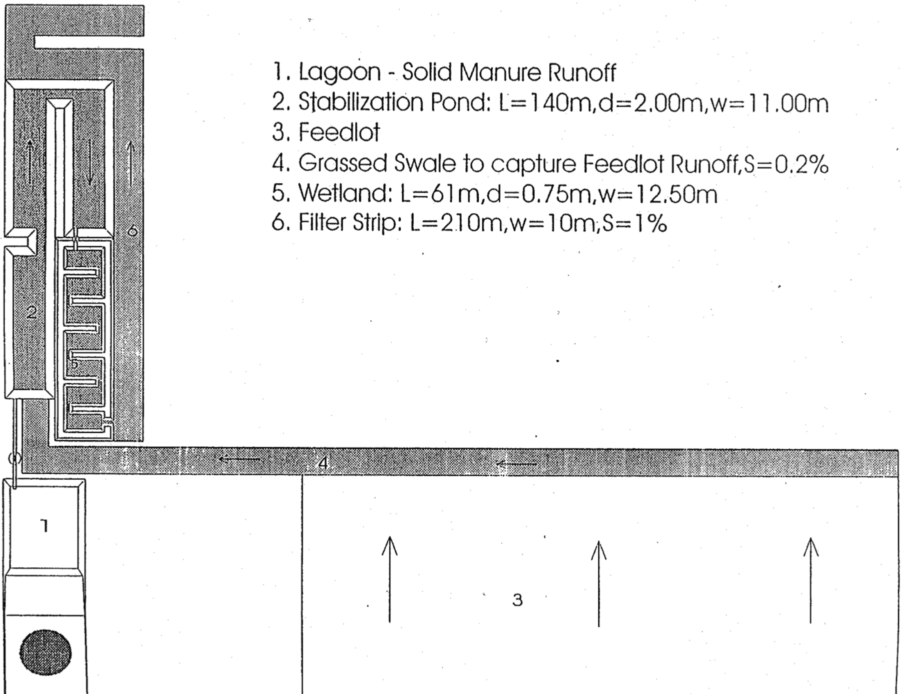
Appendix 1:

Project Designs

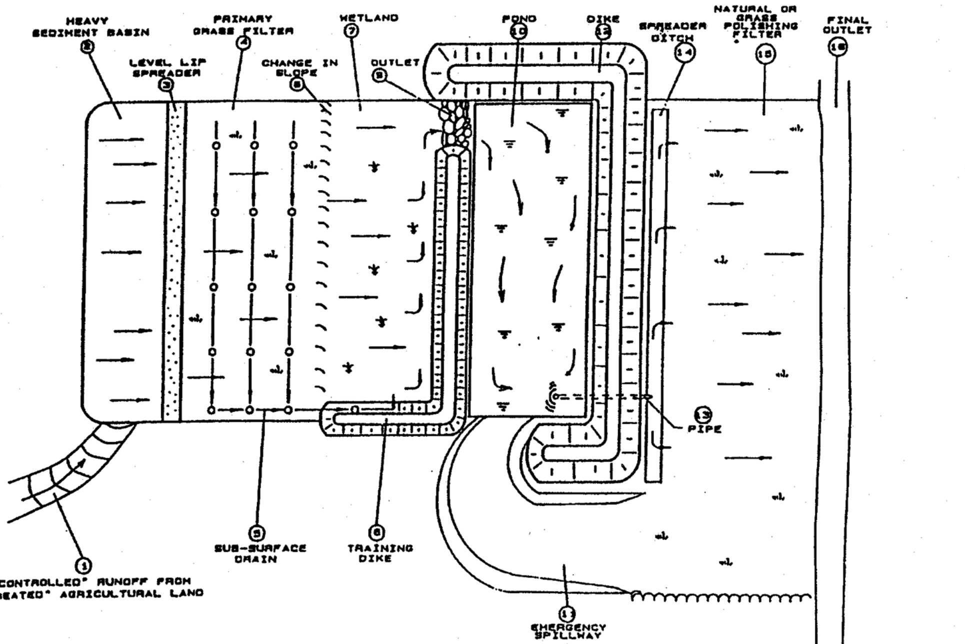
PROPOSED NATURAL SYSTEM IN EMBRUN



South Nation River Conservation Authority

NUTRIENT/SEDIMENT TREATMENT SYSTEM SCHEMATIC

A SYSTEM FOR BIOLOGICAL AND BIOCHEMICAL TREATMENT OF NONPOINT POLLUTION IN RUNOFF



Niagra Peninsula Conservation Authority

USDA
SOIL CONSERVATION SERVICE

SKETCH OF PROPOSED CONSTUCTED WETLAND:

SITE DESCRIPTION:

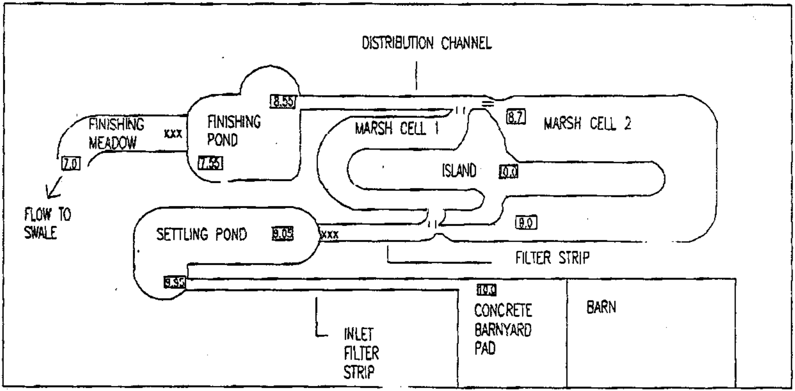
COUNTY: WELLINGTON
TOWNSHIP: ERIN

LEGEND:

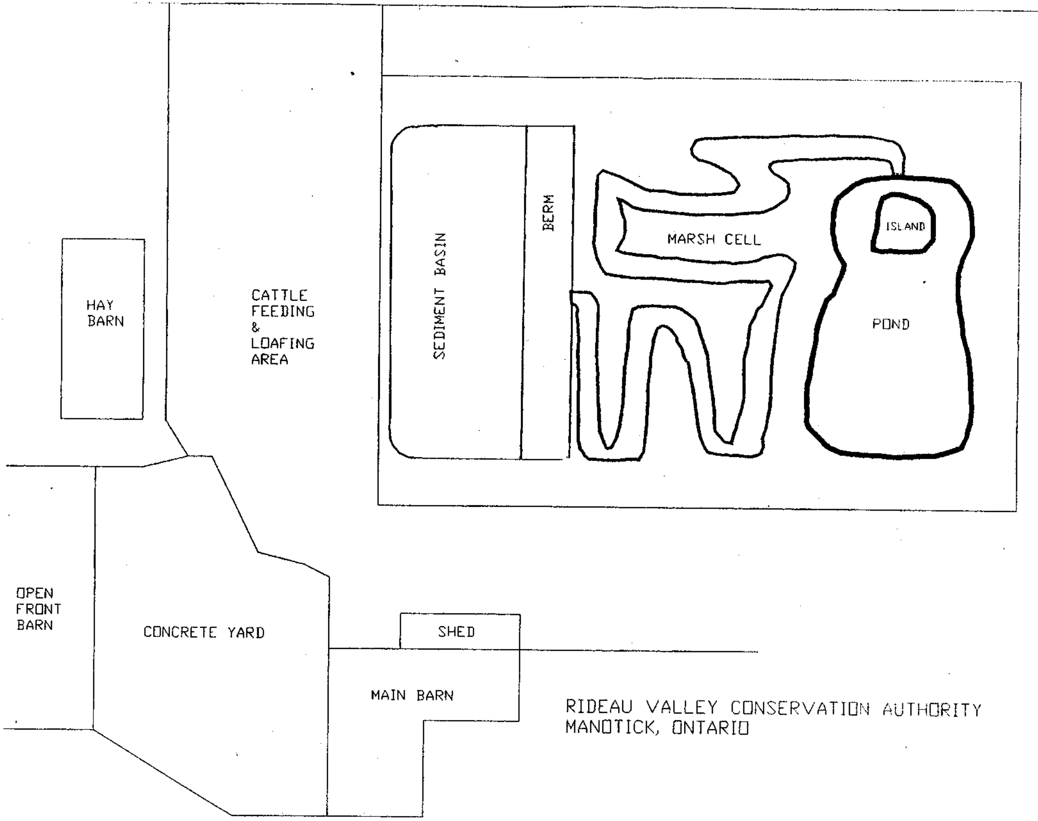
| | : REMOVABLE STOP-LOG/WEIR
xxx : POND OUTLET PIPE
[10.0]: BENCHMARK ELEVATION (ASSUMED)

SCALE:

1 cm = 4 m



Grand River Conservation Authority



RIDEAU VALLEY CONSERVATION AUTHORITY
MANOTICK, ONTARIO

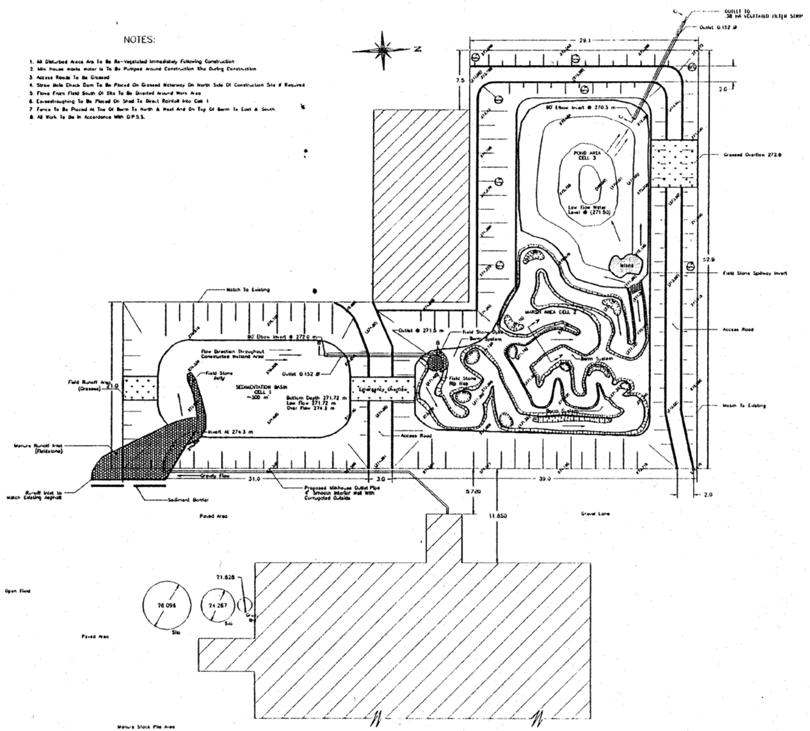
GRUMBLE HILL FARM

PROPOSED CONSTRUCTED WETLAND AREA

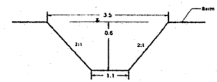
~ 0.243 ha / 0.600 acres

NOTES:

1. All Disturbed Areas Are To Be Re-Vegetated Immediately Following Construction
2. Milk House waste water Is To Be Pumped Around Construction Site During Construction
3. Access Roads To Be Grassed
4. Straw Bale Check Dam To Be Placed On Grassed Waterway On North Side Of Construction Site If Required
5. Flows From Field South Of Site To Be Diverted Around Work Area
6. Eavestroughing To Be Placed On Shed To Direct Rainfall Into Cell 1
7. Fence To Be Placed At Toe Of Berm To North & West And On Top Of Berm To East & South
8. All Work To Be In Accordance With O.P.S.S.

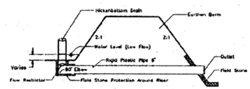


Section A-A



Section B-B & C-C

(Elevations As On Plan View)



LEGEND

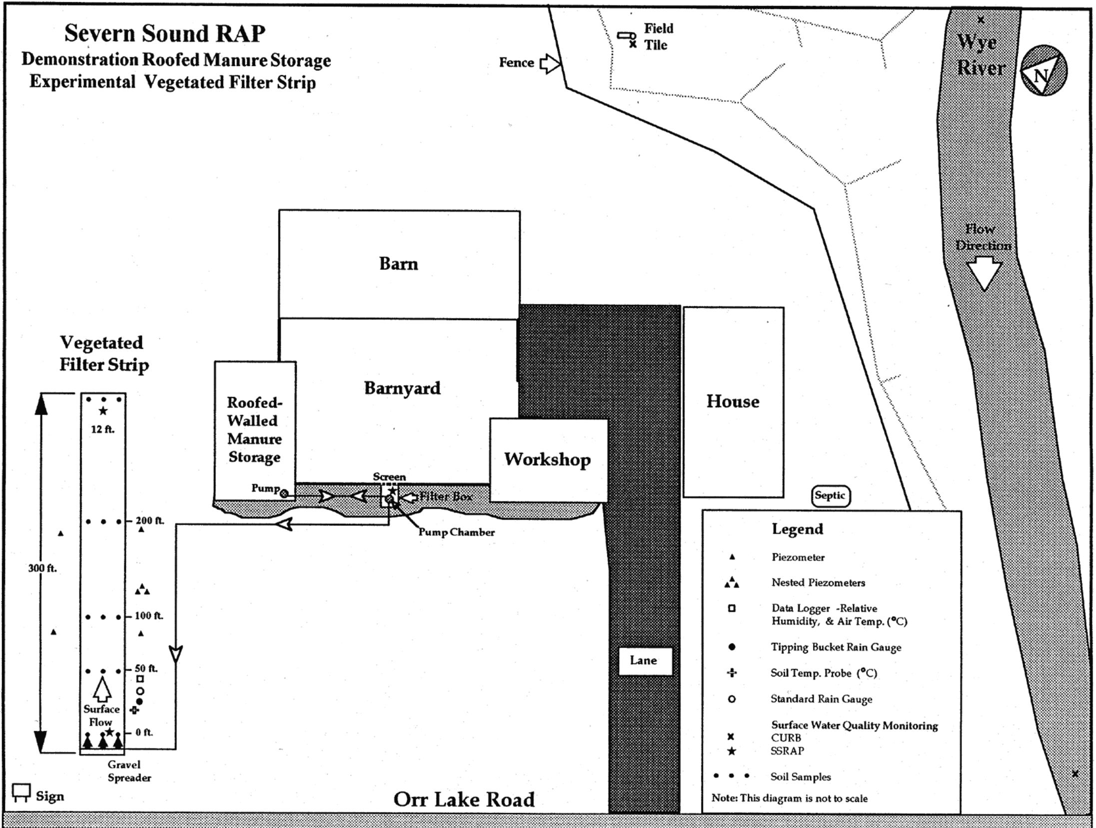
- Storage Shed
- Main Livestock Barn
- Existing Land Elevations (m) (Decimal Point = Shot Location)
- 2:1 Slope Maximum
- Cell 3 Island 4x3 m
- Channel Depression Areas ~ 0.3 m In Depth
- Proposed Land Elevations (m)
- Coniferous Trees

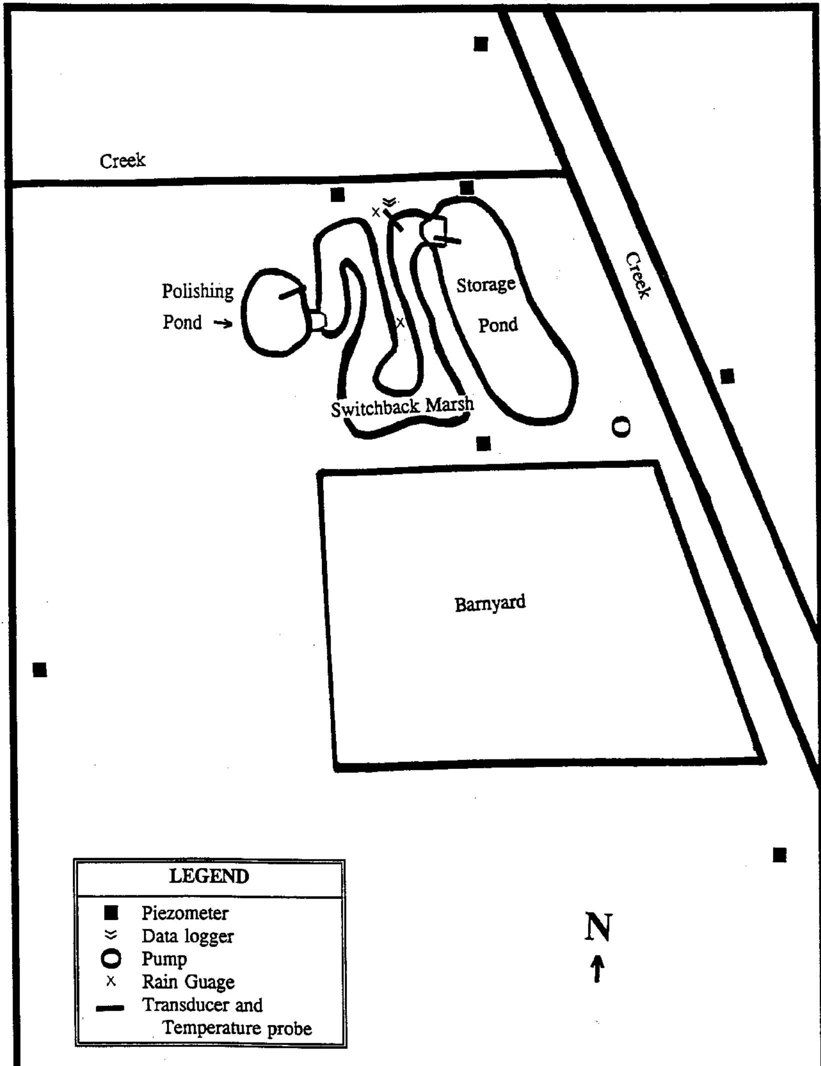
Figure 3 - General Concept

Nottawasaga Valley Conservation Authority

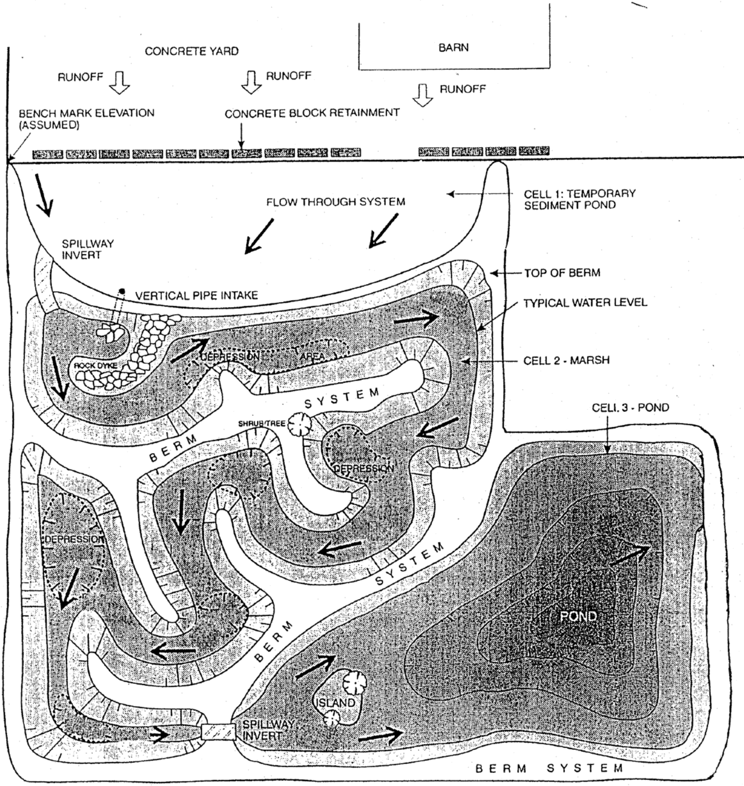
Severn Sound RAP

Demonstration Roofed Manure Storage
Experimental Vegetated Filter Strip





MAP 1: Essex Region Conservation Authority Constructed Wetland #1



N

No.	Date	Revision	By

Upper Thames River Conservation Authority

R.R. #6,
London, Ontario
N6A 4C1

Phone (519) 451-2800
Fax (519) 451-1188

Conservation Lands - Water Quality

Project
Constructed Wetland for Barn Yard Run-off

Location
UTRCA Wetland #1

Drawing Title
Site Plan

Drawn	Checked
BG, DWD	K.P.
Scale	Date
N.T.S.	August 1992
File No.	Drawing