Lower Holland River Erosion Control Study


1994
LOWER HOLLAND RIVER
EROSION CONTROL STUDY

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for

Lake Simcoe Environmental
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Lake Simcoe Environmental Management Strategy

Lower Holland River Erosion Control Study

Lake Simcoe Region Conservation Authority
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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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.
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BACKGROUND

History

From the south end of Lake Simcoe, known as Cook Bay, a broad valley extends southward for 24 kilometres between high morainic hills. Once a shallow extension of Lake Simcoe, the floor of this valley contains a marsh of 8,000 hectares through which the Holland River meanders sluggishly to Lake Simcoe (Putnam and Chapman, 1984). The central portion of the marsh at one time supported a vegetation of sedges, cattails, and other reeds, while the margins had swamp forest consisting mainly of white cedar (Putnam and Chapman, 1984).

During the first century of settlement the marsh remained uncleared, being crossed by a single road now known as Highway 11 (Putnam and Chapman, 1984). However, since the 1930’s, some 4,000 hectares of marsh have been "cultivated" -dyked and drained solely for the purpose of providing prime agricultural land (Draper et. al., 1985). These cultivated marsh areas are referred to as polders. The Holland River system supports a series of vegetable polders, from the Keswick Marsh just south of Cook Bay to the most southerly marsh, Holland Marsh, where the Holland River crosses Highway 400 (See Figure 1). The demonstration sites for the Lower Holland River Erosion Control Study are located in the Colbar Marsh, situated north of Bradford.

Many of the first settlers in the Holland Marsh area were of Dutch descent. To cultivate the marsh, they employed similar techniques that had proven successful in the Netherlands, where the low lying agricultural fields are protected from flooding by the North Sea by a system of polder dykes and canals.

In the Holland Marsh area, an intricate system of dykes and canals were built to prevent the Holland River from over-filling its banks and flooding the fields which lie below lake level. The marsh areas were then drained and stripped to expose their organically rich, deep muck soils which were prime for growing an assortment of vegetables including onions, lettuce, celery, spinach, carrots and potatoes. To maintain water levels suitable for agricultural land use, and in order to drain and irrigate the farmer’s fields, a system of canals were dug around the perimeter of the fields. The dredged material was then used to construct a series of dykes, which separate the canals from the Holland River (see Figure 1). Water drains from the fields into these canals and is periodically pumped back into the Holland River whenever water levels rise above an acceptable level. Water which collects in the canals is also used for irrigation purposes.
Figure 1. Vegetable Polders, Holland River.
Problem Statement

In recent years, riverbank erosion and the deterioration of the cattail margin along the lower Holland River is threatening the stability of the polder dykes of the Colbar Marsh (Draper et al., 1985). A number of theories have been put forth on the actual causes of the erosion, including:

1. **Wave Action**

   An investigation of erosion problems on the Holland River in 1984 cited the increasing amount of motor boat traffic on the river in the 1970's and 80's as the dominant factor creating erosion (Draper et al., 1985). Boat wakes have been identified as contributing significantly to erosive wave action. For example, Berc et al. (1989), found that the added stress from boat wakes undercut a vigorous stand of invading phragmites and necessitated the construction of a breakwater to establish and maintain marsh fringe plantings.

   Both studies also noted that as the river width increased due to the erosion of the riverbank cattail margin, the fetch increased providing a greater opportunity for larger surface waves, created by over-water wind, to erode the riverbanks and cattail margins.

2. **Water Level Fluctuation**

   High water levels which occur annually in the lower Holland River have also been identified as contributing to the loss of the cattail fringe. Every spring the cattail margin is flooded by approximately 15-100 millimetres due to high lake levels in Lake Simcoe, which are regulated by Parks Canada for recreational purposes (Draper et al., 1985). Annual variations are 300-400 millimetres, but may be much higher in some years. This flooding places an upward (buoyant) pressure on the root system of the cattails, resulting in the detachment of large masses of cattails. This condition is exacerbated when ice forms on the marsh at times of low water and then floats, tearing up the mat, as levels rise.

3. **Animal Predation**

   Predation of cattails and other marsh vegetation by fish and wildlife, such as muskrats, carp and ducks, has been recognized as a major constraint in re-establishing marshes (Hollis et al., 1990; Tomljanovich and Perez, 1990; Hoeger, 1988; and Emerson, 1961). Carp are bottom feeders and during their foraging activities stir up bottom sediments, thus preventing seed germination. Ducks feed on the young shoots of cattails and other marsh vegetation. Muskrats have been...
identified as one of the primary factors in the erosion of the polder dykes and the deterioration of the cattail margin along the lower Holland River. These marsh dwellers feed on the young cattails by cutting off the plants at water level. They also use them to construct their lodges. Muskrats create further problems by burrowing through the dykes, enhancing erosion of the dyke walls.

4. Farming Activities

The cash-crop farming industry in the Holland Marsh area is chemical intensive, with large inputs of chemicals and nutrients from pesticide, herbicide and fertilizer applications. These chemicals leach into the groundwater, and during rainfall or irrigation events are washed into the canals lining the agricultural fields and eventually pumped into the lower Holland River. Even though cattails have the ability to take up nutrients such as phosphorous and nitrogen and use them to their benefit, there is a strong possibility that the cattail fringes in the lower Holland River are saturated with chemicals and nutrients, and the additional inputs are stressing the cattails and contributing to their deterioration. Some studies are ongoing in the Holland River to identify concentrations of herbicides in the river and sediments.

It is very likely that some combination, or indeed all of these factors are contributing to the erosion of the polder dykes and cattail fringe on the lower Holland River.

Problem Magnitude

The magnitude of the erosion problem on the lower Holland River has both financial and environmental ramifications for the area:

Financial

Flooding resulting from dyke failure would result in crop damage totalling millions of dollars.

Environmental

Cattails have the natural ability to assimilate nutrients being pumped into the river from normal farm operations, and therefore, are important water quality regulators of the Holland River system and Lake Simcoe. They are also important natural erosion control agents, mitigating the impacts of waves and protecting the dykes from erosion, while providing habitat for a broad range of fish and wildlife species.

The Lake Simcoe Region Conservation Authority has undertaken an analysis of aerial photographs of the Holland River to determine historic changes in river widths and assess
the loss of the riverbank cattail margin. In the Colbar Marsh area alone, river widths increased by as much as 37 metres from an unknown period pre-dating 1954 to 1978 (Draper et. al., 1985). In other polders, such as the Keswick Marsh at the mouth of Cook Bay, the impact has been even more profound - river widths have increased by as much as 100 metres over the same time period.

Personal communication (June, 1991) with farmers in the Colbar Marsh area has confirmed the loss of the riverbank cattail fringe over the years, and identified erosion and dyke failures resulting from muskrat burrowing and old tree roots piercing holes in the dyke.

In determining a management strategy for the Holland River system and the vegetable polders which line its sinuous path, protection of the polder dykes becomes a major component. The status quo, or "do nothing" alternative is not acceptable because of the documented loss of cattails and dyke erosion along the banks of the lower Holland River. The financial and environmental costs of not doing anything far exceed the costs of mitigating the problems now. A management strategy to protect the banks of the river, reinforce the dykes, and re-establish the riverbank cattail margin is needed which will offer permanent solutions and distribute the costs among resource users in an equitable manner.

**PROCESS**

**Project Scope**

The Lower Holland River Erosion Control Study will investigate alternative techniques for mitigating riverbank erosion and re-establishing the riverbank cattail margin in the lower Holland River. The scope of this project is threefold:

1. **Documentation**

   Documentation of all phases of the project will be important if the results of these demonstrations are to be easily replicated by Conservation Authority or Ministry staff, property owners, or citizen's groups elsewhere on the river.

   The first phase will consist of documenting the existing biophysical conditions at each of the demonstration sites including topography, vegetation, soils, and hydrology. The second phase will document clearly how and why specific rehabilitation techniques were used, and what work was actually done at each demonstration site. The final phase of documentation will consist of recording the results of the project 2 -3 years after implementation.
2. Evaluation

Evaluation will occur at two critical junctures in the project. Documentation of existing conditions will facilitate the evaluation of alternative design concepts appropriate for each demonstration site. At each site, a number of different techniques will be implemented. The success or failure of each technique will be evaluated on a regular basis as outlined in the monitoring program, in order to determine what methods worked under what conditions, and in case of failure, to repair or implement other options for preventing further degradation. The cost-effectiveness of each technique used will be evaluated both objectively and subjectively, and will include such factors as erosion control, aesthetics, habitat creation, and installation, management, and maintenance costs.

3. Monitoring

In a project of this scope, which is experimental in nature and employs live systems for erosion control, monitoring becomes an essential component in determining the overall success of the project and must be properly planned for and initiated in the initial phase. A monitoring program will be developed which will monitor changes over the short and long term in order to identify and correct small problems or make improvements, test the ongoing effectiveness of techniques, and assess the continued achievement of the broad objectives outlined. Effective monitoring over the long term can be used to modify techniques, refine budgets, and prove assumptions to the benefit of ongoing management activities.

Site Selection Criteria

The process of selecting demonstration sites along the lower Holland River was based on a number of criteria. First, a cursory study of the Holland River system was performed using aerial photography, field studies, and reports to identify problems and potentials along the river. It became evident that there were three general conditions that were prevalent along the length of the lower Holland River that required active management. These were categorized as:

1. Severe erosion problems where there is little or no cattail fringe remaining, and serious erosion of the polder dykes is occurring.

2. Moderate erosion problems where the cattail fringe has deteriorated, and has exposed the polder dykes to the erosive forces of the river.
3. Maintenance areas where the cattail fringe still remains intact, but requires management to prevent deterioration and enhance the resilience of the wetland vegetation, and the natural function of the marsh.

The second step was to actually identify candidate sites along the river which satisfied these selection requirements. For each condition, two sites were chosen: one which would be actively rehabilitated and managed; and a control. To control for as much variation as possible between the managed and control sites at each location, they were sited immediately adjacent to each other. It is necessary to match as closely as possible control sites with managed sites, in order to verify that results are truly caused by a specific management action.

The final criteria for selection was landowner willingness to actively participate in the project by permitting access to their property, permission to implement the proposed erosion control measures, and their long-term commitment to assist in the implementation, monitoring, and maintenance of the rehabilitation works.

A number of landowners were contacted about the project by Lake Simcoe Region Conservation Authority staff and eventually three sites were chosen which fulfilled all of the site selection criteria (see Figure 2).

**Design**

Having selected the demonstration sites, and surveyed and inventoried them, a number of management actions and techniques will be used to control the erosion of the polder dykes and re-establish the riverbank cattail fringe, including:

1. **Bioengineering** - utilizing live plant material to reinforce the dykes through techniques such as fascines, brush layers, brush mattresses, and live stakes.

2. **Wave Dissemination** - creating flexible, porous barriers which buffer erosive wave currents and trap sediments using a variety of techniques, such as tire clusters, modified wattles, live cribs, anchored christmas trees, or geotextiles.

3. **Revegetation** - re-establishing the cattail fringe using tubers and reed rolls, and constructing exclosures to prevent predation by fish and wildlife.

1. **Soil Bioengineering**

Soil Bioengineering is the practice of planning, designing, constructing, and managing the revegetation and rehabilitation of soil through the use of native plant materials (Sotir, R., 1985). Typically, unrooted live vegetation is installed in an eroding or
unstable slope using a variety of techniques so that the roots and shoots form a permanent vegetative cover and root reinforcing matrix over time. Common plant species used in bioengineering works include dogwood, willow and poplar. Bioengineering acts to consolidate soil particles, remove moisture from the streambank through transpiration, and cause silt deposition which helps to reconstitute the streambanks.

In areas where erosion of the dykes is particularly severe, complex bioengineering systems such as fascines and brush mattresses will be used to resist direct wave action on the surface and reinforce the underlying soil structure.

a) **Fascines**

Fascines are bundles of five or more live branches tied together with the growing tips all placed in the same direction, and laid in a trench dug into the river bank or dyke and secured with live stakes (see Figure 3). They are backfilled with the excavated soil so the branches eventually root, creating a thick, complex mat of roots which bind soil particles together. The shrubby growth at the tips of the branches help to protect the surface of the dyke by laying down during high water levels and covering the exposed slope, retarding surface runoff erosion.

b) **Brush Layers**

Fascines are often used in conjunction with brush layers. Brush layer construction consists of placing live plant materials into cut terraces along the streambank or dyke (see Figure 4). The protruding brush growth assists in retarding surficial runoff erosion, while the branch parts in the bank serve immediately as soil reinforcing units.

c) **Brush Mattresses**

Brush mattresses provide a surface cover for eroding banks. Live branches are placed on the ground very close together so that a complete ground cover of woody vegetation is established (see Figure 5). The branches eventually root and produce leaves along their entire surface. The brush mattress functions by causing sediments to fallout of suspension during flood conditions, causing the bank to rebuild naturally. The soft, flexible live material also lies down during high water levels, lowering velocities and providing additional protection for the bank.
Figure 3.

Live Shoreline Fascine

Used for protection of shorelines with little water level fluctuation, primarily used to protect the base of other shore protection systems such as brush layers.

The fascine is placed at the height of the normal summer water level, on a brush layer which extends 500-800 mm over the water for wave and washout protection. Fascines are staked with 600 mm long stakes at 1000 mm O.C. and filled to facilitate rooting and are tied together at 500 mm intervals. Some dead branches may be used if they are kept dry in the center of the row.

Construction must be executed in the dormant period.
Figure 4.
Figure 5.

Brushmattress

Soil Bioengineering

TO BE USED WHEN THE SOIL SURFACE MUST BE PROTECTED FROM THE IMPACT OF HEAVY PRECIPITATION, RUNNING WATER, WIND OR OTHER FORMS OF EROSION.

LIVE BRANCHES ARE PLACED ON THE GROUND VERY CLOSE TOGETHER SO THAT A COMPLETE COVER IS ESTABLISHED. THE BUILT-UP ENDS ARE IMBEDDED IN THE SOIL AND ARE USUALLY SECURED AND PROTECTED BY BOLTS, FASCINES OR ROCK FILL. THE MATTING IS SECURED TO THE GROUND WITH STAKES AND CROSS-LAND BRANCHES OR WIRE. STAKES SHOULD BE NO MORE THAN 1.000 mm APART. COVER THE ENTIRE MATTING WITH A LIGHT LAYER OF SOIL TO PROMOTE ROOTING.

WORK MUST BE EXECUTED DURING THE DORMANT PERIOD.
(d) **Live Stakes**

Live stakes refer to branches that have been cut and pruned from living plant material, usually willow or poplar. Live stakes are either employed singularly or in combination with other bioengineering systems, such as brush mattresses and fascines, as securing devices (see Figure 6). They are driven into the eroding stream bank or dyke with a soft lead shot mallet. The resulting root and shoot growth provide bank protection.

2. **Wave Dissemination**

It is generally believed that waves from motor boats are contributing significantly to the erosion of the cattail fringe and dykes along the lower Holland River (Draper *et al.*, 1985). Mitigating the effects of wave action is a complex problem since the size and force of the waves, the direction of their approach and their elevation vary with the contours of the river bed, the current in the river, the elevation of the water and the proximity of boat traffic to the site (see Appendix 1). In addition, a number of other factors, such as wind, pump-off water, ice, flooding, and environmental and aesthetic considerations have to be considered in designing and locating the wave dissipation structures.

Dissipating the energy of the waves should not only reduce the mechanical force of the wave action on the marsh vegetation and the polder dykes, but should cause sedimentation to occur within the calm water behind and around the barrier (see Figure 7). Appendix 1 lists the amplitude of waves measured at 2 sites in 1 metre of water. These measurements were taken to assist in determining the location of the dissipation structures, and the heights of the structures. A complete review of all factors (many of which were assumptions) led us to predict that a structure which extended to ±500 mm below the top elevation of the polder dyke would be most effective at varying water levels with the least visual intrusion during the recreational boating season. This structure would be placed in 500 to 750 mm of water under normal summertime conditions and would extend approximately 350 mm above water at that time. In this way it would obstruct all waves under low water conditions, and interrupt the largest waves at times of high water.

In an attempt to determine their cost-effectiveness, a number of wave dissemination structures will be used in conjunction with bioengineering and re-vegetation techniques, and may include anyone or more of the following methods:
(a) Anchored Tire Clusters

Clusters of new or used tires are secured together and anchored into the sediment using metal T-bars. The buoyant tires form a flexible, porous barrier which mitigates the wave impact and helps trap sediment so that marsh re-creation can occur immediately behind the structure (see Figure 7). However, potential environmental and aesthetic constraints might limit the use of tire clusters for shore protection purposes.

(b) Anchored Christmas Trees

This technique is similar to tire clusters, but utilizes live vegetative materials instead. Evergreen trees are secured together and anchored to the sediment using metal T-bars, forming a coarse-textured, thick mat of vegetation which buffers waves and traps sediment.

Modified Wattles

Wattles are a bioengineering technique in which wooden or steel pegs are driven into the sediment at regular intervals and then interwoven and wrapped with long flexible live branches (Schiechtl, 1980). The constructed wattle fences are placed in consecutive horizontal lines, or diagonally, to ensure maximum sediment capture.

Live Crib Walls

Single or double cribwalls consist of round peeled timber frames which abut the bank and are filled with branches of live plants in the open space between the timbers. The wood crib walls eventually rot, leaving behind an thick matrix of leaf growth and root structure which protects the bank from the erosive action of waves.

Geotextiles

Geotextiles refer to polyester or polypropylene synthetic fabric which allows water to pass freely through the microscopic openings while preventing the movement of soil particles. Geotextile filter cloth might be used singularly by draping the cloth across the river some distance out from the bank and securing it with metal T-bars. The filter cloth would trap sediment and reduce wave currents. It might also be used in conjunction with any of the other methods to strengthen their effectiveness.

A program of no-wake zones or speed restrictions for recreational boats on the Holland River in the vicinity of the demonstration sites may need to be implemented to assist in the dissemination of waves. Obviously in order to be effective, either of
Figure 6. LIVE STAKE.
Figure 7. Marsh Re-creation Concept - Lower Holland River.
these measures would need to have the full support of Parks Canada, who regulate the waterway, and boaters, and would have to be rigorously enforced.

The success or failure of these measures will help determine whether the dissemination of waves is enough to re-establish the cattail fringe along the banks of the lower Holland River.

3. Revegetation

Three factors are critical in the attempt to revegetate the riverbank margin with cattails and other reeds:

(a) The re-establishment of marshes in a natural setting requires protection from natural stresses by fish, ducks, and mammals until healthy root systems become established. This is accomplished by constructing wire exclosures which permit water and sunlight to enter, but exclude fish and wildlife such as muskrats, carp and ducks which feed on the young shoots (see Figure 8). The wire exclosures can be removed once the vegetative mat becomes well established.

(b) Since disturbed sediments do not routinely contain an adequate seed source to establish plant growth in the first year, the installation of tubers, cuttings, or plugs will be used to begin the revegetation process within the exclosures. This procedure will also facilitate the selection of suitable colonizing species and help to achieve a desired level of species diversity within the marsh. A variety of techniques will be utilized in an attempt to re-establish the cattail fringe including, reed rolls and reed clumps (see Figure 9).

(c) Natural marsh vegetation has difficulty becoming established in areas where seasonal fluctuations in water levels occur annually, such as on Lake Simcoe where lake levels are controlled to a regulating curve by Parks Canada for recreational purposes. The Holland River is part of the Trent-Severn Waterway, a system of lakes and rivers which link Georgian Bay and Lake Ontario, and attracts millions of tourist dollars to the region. For this reason, water levels are annually regulated to accommodate recreational demands on the resource.

The maximum control elevation has been set at 219.10 metres (Draper et. al., 1985). At this elevation approximately 5 -10 centimetres of flooding occurs into the cattail margins during April and May each year (Draper et. al., 1985). A reduction in the maximum control lake elevation may be necessary to successfully re-establish the cattail margin along the banks of the lower Holland River.
Figure 8. Marsh Creation Exclosures - Lower Holland River.
Figure 9.
**FINAL DESIGN**

**General**

Because the potential causes of marsh deterioration are so varied, it is very difficult to determine the most cost-effective way of reestablishing vegetative cover or what affect various rehabilitation techniques have on the diversity or distribution of marsh vegetation. For each site it was therefore decided to test a variety of rehabilitation techniques of varying complexity. In this way an appropriate level of effort can be identified for ongoing rehabilitation in the river. These should also help to further clarify which of the stresses on the marsh (predation or erosion) is most critical to control in re-establishing the marsh.

*For each site to be rehabilitated, a corresponding comparable site has been surveyed as a control to confirm that changes in rehabilitated sites are the result of our intervention and not other changes in the river.*

**Site #1, Site #2 as control**  (Refer to drawing #1)

At this site the original marsh fringe has been completely eliminated and the dyke has been completely disturbed recently in an attempt to control erosion. Concrete rubble has been dumped along the edge and the dyke regraded to control erosion and overtopping at high water levels. Some dredging of the river to maintain the dyke has occurred in the past, which has created some artificial variations in water depths and sediment composition along this site. The site is on an outside bend of the river and, as such, has extra stress placed upon it by currents and turning boats.

**Rehabilitation Design**

Four distinct rehabilitation areas are proposed for Site #1, as follows:

1. **Dyke Reconstruction**

   The addition of end dumped concrete rubble to the face of the dyke is a stop-gap measure which will eventually contribute to increased erosion on the dykes. Slippage and voids between stones will cause movement in the dyke and expose the soil to focused water erosion and degradation by burrowing rodents.
The first rehabilitation measure then, must be the stabilization of the unprotected dyke and immediate protection against erosion. To accomplish this, a series of brush layers is proposed to be installed in clean fill on the face of the existing dyke (See Detail, Drawing #1). These will protect the surface of the dyke from the backwash action of waves and, in time, consolidate the soil mass with the vigorous rooting action of the plant material. Shrubby willows and dogwood have been selected for use in the brush layer so that the final growth of plant material is relatively small and flexible. This increases the resistance to wave action and avoids the potential long term damage to the dyke caused by the uprooting of large trees.

Between the brush layers and across the surface of the dyke is a geo-grid (Tensar BX1100) which will act to provide immediate stabilization of the soil mass and protection of the soil surface. Live stakes will be randomly placed across the surface of the dyke to consolidate the soil and provide some short term cover to the dyke surface. The elevation of the dyke will be raised ± 200 millimetres above the existing top of marsh as a precautionary measure, to prevent overtopping in this area and to compensate for any settlement in the fill.

2. Marsh Re-establishment

The ultimate protection of the dykes and enhancement of the river ecosystem will be realized through the re-establishment and maintenance of a healthy, diverse marsh fringe along the edges of the river. As mentioned earlier, there are a number of stresses which are placed upon the marsh, both mechanical, chemical and biological, and it is unclear which of these are most critical to control. To help clarify this and to establish the most cost effective methods of counteracting these stresses, a series of three marsh creation techniques has been proposed with varying levels of effort required for their installation. These will be implemented in water depth which does not exceed 500 millimetres, to make certain navigation is not interrupted and that plant material can become successfully established.

Over approximately 1/3 of the site (±20 linear metres) a marsh mat will be installed, a maximum distance of 10 metres from the shore (see Detail A, Drawing #1). This will consist of cattail tubers placed ±1 metre on centre and covered with a continuous blanket of chicken wire mesh. This will be held in place on the bottom by metal staples installed ±1 metre on centre. This system will hold the cattail tubers in place on the bottom and prevent their floating away, as well as maintaining the integrity of the entire mat. Some protection from dislodging through wave action will be provided, however the main protection will be from predation of the tubers and root systems. This is expected to be the least expensive and least obtrusive rehabilitation measure proposed.
The remainder of the site will be enclosed by a wave dissipation barrier (see Detail B, Drawing #1). This will be constructed of a combination of metal T-bars and live plant material imbedded in the bottom sediments ± 1 metre on centre. The lower portion of the structure, below low water levels, will be enclosed with a geogrid (Tensar BX1100) to trap silt and dissipate energy from waves. The upper portion of the structures will be woven with live biotechnical material (modified wattles) to dissipate waves and to present a more natural facade to the structure. Some growth of this material is anticipated in shallow areas, or where silt accumulates below the structure quickly. Ends of biotechnical material will therefore be angled down into the water.

Inside this structure, half (1/3 of the total site) will be left open to test the effects of the wave dissipation barrier along on the re-establishment of vegetation. This will place no effective restrictions on predation, but will protect against wave damage and will contain any floating or dislodged vegetation within this area. It is expected that vegetation reestablishment in this area will be sporadic, but that species diversity will increase significantly.

The second half of the area inside the structure will be completely protected by a full exclosure (see Detail C, Drawing#1). The exclosure will cover a marsh mat seeded with cattail tubers (as described earlier). This will consist of a vertical wall of hardware cloth ± 1 metre high to exclude predators from the water, specifically carp and muskrats, and a chicken wire top to exclude waterfowl from the area. This combination is the most complex and costly and should afford the maximum protection from dislodging by waves, ice or water level variations, as well as the virtual elimination of predation within the rehabilitated area.

Site #3, Site #4 as control (Refer to drawing #2)

At this site, the cattail marsh exists in a very narrow, discontinuous band along the dyke. The dyke is in very poor condition, partially due to its original construction which contains a considerable amount of large, organic material (stumps, branches, etc.), and scrap. Farm storage of machinery and chemical containers has placed further stress on the dyke. In addition, the site is immediately downstream from a discharge pump used to de-water the polder canals behind the dyke. This area could therefore be subject to periodic flushes of water which contain residue from existing agricultural operations.
Rehabilitation Design

Four distinct rehabilitation measures are proposed for this area, as follows:

1. **Dyke Reinforcement**

   The existing dyke is essentially intact and, therefore requires reinforcement, rather than complete reconstruction. To accomplish this, the dyke will be regraded to create an even slope and all debris and rubbish was removed from the surface layer.

   Two live fascines will then be installed, one at the low water line of the dyke and another at the top of the dyke. The lower fascine will protect against toe erosion and reinforce the dyke against wave action at times of low water. The top fascine will be used to reinforce the top of the dyke and raise the elevation of the dyke ± 200 millimetres for added protection of the fields during high water periods. Root growth from both fascines will consolidate the soil in the dyke and thus stabilize the soil mass. The surface of the dyke will be seeded and live stakes will be installed ±1 metre on centre to protect the soil surface from erosion. Shrubby willow and dogwood will be used to maintain a relatively supple, low vegetative cover on the dyke. This will provide protection against wave erosion and prevent long term damage caused by the uprooting of large trees.

2. **Marsh Re-establishment**

   The ultimate protection of the dykes and enhancement of the river ecosystem will be realized through the re-establishment and maintenance of a healthy, diverse marsh fringe along the edges of the river. As mentioned earlier, there are a number of stresses which are placed upon the marsh, both mechanical, chemical and biological, and it is unclear which of these are most critical to control. To help clarify this and to establish the most cost effective methods of counteracting these stresses, a series of three marsh creation techniques has been proposed with varying levels of effort required for their installation. These will be implemented in water depth which does not exceed 500 millimetres, to make certain navigation is not interrupted and that plant material can become successfully established.

   Over approximately 1/3 of the site (± 20 linear metres) a marsh mat will be installed, a maximum distance of 10 metres from the shore (see Detail A, Drawing #1). This will consist of cattail tubers placed ±1 metre on centre and covered with a continuous blanket of chicken wire mesh. This will be held in place on the bottom by metal staples installed ±1 metre on centre. This system will hold the cattail tubers in place on the bottom and prevent their floating away, as well as maintaining the integrity of the entire mat. Some protection from dislodging through wave action will be
provided, however the main protection will be from predation of the tubers and root systems. This is expected to be the least expensive and least obtrusive rehabilitation measure proposed.

The remainder of the site will be enclosed by a wave dissipation barrier (see Detail B, Drawing #1). This will be constructed of a combination of metal T-bars and live plant material imbedded in the bottom sediments ±1 metre on centre. The lower portion of the structure, below low water levels, will be enclosed with a geogrid (Tensar BX1100) to trap silt and dissipate energy from waves. The upper portion of the structures will be woven with live biotechnical material to dissipate waves and to present a more natural facade to the structure. Some growth of this material is anticipated in shallow areas, or where silt accumulates below the structure quickly. Ends of biotechnical material will therefore be angled down into the water.

Inside this structure, half (1/3 of the total site) will be left open to test the effects of the wave dissipation barrier along on the re-establishment of vegetation. This will place no effective restrictions on predation, but will protect against wave damage and will contain any floating or dislodged vegetation within this area. It is expected that vegetation reestablishment in this area will be sporadic, but that species diversity will increase significantly.

The second half of the area inside the structure will be completely protected by a full exclosure (see Detail C, Drawing#1). The exclosure will cover a marsh mat seeded with cattail tubers (as described earlier). This will consist of a vertical wall of hardware cloth ±1 metre high to exclude predators from the water, specifically carp and muskrats, and a chicken wire top to exclude waterfowl from the area. This combination is the most complex and costly and should afford the maximum protection from dislodging by waves, ice or water level variations, as well as the virtual elimination of predation within the rehabilitated area.

Site #5, Site #6 as control (Refer to drawing #3)

At this site there is no dyke or polder development and the marsh is therefore intact for the purposes of this project. It is assumed that the deterioration of the marsh is similar in such areas to those where dyke construction has taken place in the past. It is also assumed that the protection and expansion of an existing marsh will be accomplished with somewhat less effort than where the extra stress of the dyke development occurs.
Rehabilitation Design

Three distinct rehabilitation techniques are proposed for site #1, as follows:

Marsh Re-establishment

Over approximately 1/3 of the site (±20 linear metres) reed rolls will be installed out a maximum distance of 10 metres, 1 metre on centre (see Detail A, Drawing #3). Reed rolls consist of cattail plugs rolled in chicken wire to create a tube 150 -200 millimetres in diameter. These rolls will be staked in place + 1metre on centre, parallel to the shore. This system will hold the cattail tubers in place on the bottom to prevent their floating away, as well as resisting the action of waves. The chicken wire will protect the tubers from predation. It is anticipated that this system may encourage more diversity of vegetative establishment by leaving the spaces between open. This is expected to be the least expensive and least obtrusive rehabilitation measure proposed.

The remainder of the site will be enclosed by a wave dissipation barrier (see Detail B, Drawing #3). This will be constructed of three live stakes, joined together to form triangles 1 metre on centre. The upright stakes will be imbedded in the sediments along with a single vertical T -bar. The T-bar will prevent moving of the structure by ice. The centre of the triangular structure will be filled with recycled christmas trees. The coniferous branches will dissipate wave energy and trap sediments, and the live stakes may potentially take toot if water levels are low or sediments build up quickly. The coniferous branches will also provide natural structure and habitat.

Inside this structure, half (1/3 of the total site) will be left open to test the effects of the wave dissipation barrier alone on the re-establishment of vegetation. This will place no effective restrictions on predation, but will protect against wave damage and will contain any floating or dislodged vegetation within this area. It is expected that vegetation reestablishment in this area will be sporadic, but that species diversity will increase significantly.

The second half of the area inside the structure will be completely protected by a full exclosure (see Detail C, Drawing #3). The exclosure will cover a series of reed rolls, as described earlier. This will consist of a vertical wall of hardware cloth ±1 metre high to exclude predators from the water, specifically carp and muskrats, and a chicken wire top to exclude waterfowl from the area. This combination is the most complex and costly and should afford the maximum protection from dislodging by waves, ice or water level variations, as well as the virtual elimination of predation from within the rehabilitated area.
**Construction Modifications**

Implementation of the rehabilitation project in 1991 was modified by eliminating work on Site #5. As a result, the reed rolls and christmas tree wave dissipation barriers were shifted to Site #3 so that all proposed techniques could be utilized in the first construction season. Christmas tree wave dissipation barriers were changed to tire cluster dissipation barriers which will be installed in 1992.

**Cost Sharing**

Because of the high research component of this initial project it was determined that the construction would be funded entirely through the Authority. The results of the monitoring of these sites will help to pinpoint the major cause or causes of stress on the marsh community and thus help to assess how a cost sharing formula could be determined.

At this time it is assumed that the removal of the cattail fringe has been caused mainly by the recreational use of the waterway, either directly by boat traffic on the river, or indirectly through water level management of the Trent Severn Waterway. It’s degeneration also has a major affect on the recreational use of Lake Simcoe, firstly by a reduction in the natural moderating function of the marsh through nutrient uptake, sediment trapping, flow modification and the maintenance of diverse habitat, and secondly, by the release of stored nutrients and sediment directly into the lake through erosion.

Similarly, at this time it does not appear as though the discharge of surplus agricultural drainage has had a significant effect upon the quantity of vegetation in the river (based upon observations at discharge points). On the basis of this simple assessment, it would seem as though costs for rehabilitation should be paid by recreational users or natural resource managers. However, while the marsh does not protect the dykes from erosion, there are examples of properly constructed and maintained dykes in the marsh which are not eroding. It appears as though the failure of the dykes in other areas can be traced to poor initial construction and/or inadequate maintenance. Based upon this assessment it would seem reasonable that the cost of rebuilding, reinforcing and maintaining the dyke should be paid for by the land owner and that the cost of the marsh rehabilitation be paid for by the recreational users of the river and Lake Simcoe. This could include marina operators, cottagers, angling and hunting organizations, or funds from fishing licences. It is most likely, however I that the funding would be provided through government programs such as "Lake Simcoe Environmental Strategy" (LSEMS) or "Strategic Plan for Ontario Fisheries" (SPOF), or through the federal government Green Plan in recognition of the provincial significance of the resource to be managed.
Monitoring

The purpose of monitoring these projects is to determine the most cost effective method of establishing the marsh and naturally reinforcing the polder dykes. Monitoring should therefore begin with an assessment of the cost of construction of individual structures or combination or structures. Each structure should then be evaluated annually with regard to its:

- structural integrity/durability.
- physical function - erosion control
  - sediment entrapment
- colonization by plant material (cover)
- diversity of species
- aesthetics
- cost of maintenance/management

A monitoring program should be implemented in the summer of 1992 and continue annually for two years. At this time a recommendation should be formulated to guide further work or research on the river. A subsequent review should be undertaken in 5 years to confirm any assumptions or results.
LIST OF APPENDICES

Appendix # 1. Wave Generation Measurements

Appendix # 2. Construction Materials Required, 1991

Appendix # 3. Vegetation Inventory
Appendix # 1

WAVE GENERATION

Lower Holland River September, 1991

Wave amplitude measured at Site #1 in 1 metre of water, ±3 metres from the polder dyke.

<table>
<thead>
<tr>
<th>Boat #</th>
<th>Wave Amplitude (mm)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>fishing boat</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>pleasure boat</td>
</tr>
<tr>
<td>3</td>
<td>140</td>
<td>pleasure boat</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>pleasure boat</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
<td>fishing boat</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>40</td>
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</tr>
<tr>
<td>8</td>
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<td></td>
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<tr>
<td>9</td>
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<td>11</td>
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</tr>
<tr>
<td>12</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

Wave amplitude measured at Site #4 in 1 metre of water, ±6 metres from the polder dyke.

<table>
<thead>
<tr>
<th>Boat #</th>
<th>Wave Amplitude (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>17</td>
<td>250</td>
</tr>
<tr>
<td>18</td>
<td>250</td>
</tr>
</tbody>
</table>

Wave direction and angle to the shoreline appears to vary with boat speed, direction, and hull design, and may be moderated by the distance of the boat from the shore.
LOWERY HOLLAND RIVER EROSION CONTROL

Materials Required:

- Chicken wire 1" mesh, 18" wide 1200 L.F.
- Chicken wire 1" mesh, 48" wide 2000 L.F.
- Chicken Wire 2" mesh, 48" wide 1000 L.F.
- Hardware Cloth 1/4" opening, 36" wide 400 L.F.
- Steel Staples 8" -10" long 800
  (alt.8"staples from Tensar)
- Wood Stakes 1"x2"x18" long (alt. 4" J-Hooks 600
  from Tensar)
- Steel T-Bars 5' long 220
- Tensar BX1100 3 m wide 350 -400 L.M.
- Stove wire ± 300' rolls 5
- Binder Twine ± 300' rolls 5

Tools:
- 2, chain saws
- 2, saw horses
- 1, T-bar drivers
- 1, 5 lb. sledge
- 5, pruning knives
- 3, 4 lb. dead blow hammers
- 5, pairs wire cutters/pliers

Fill:
± 275 m³ clean fill, approximately 29% silt/clay
MEMORANDUM

TO: Chris McGuckin
FROM: Daniel Campbell
DATE: July 30, 1991

SUBJECT: Methodology for Lower Holland River

Here are the detailed methodology for the Lower Holland River project as requested. As well, I have included miscellaneous notes which we gathered.

The data itself has not yet been entered into a Lotus file, but this should be completed soon. I am sending you copies of the data for the meeting. The graphs which I faxed you should also prove to be very useful.

METHODOLOGY

One transect was located in each of the six sites, from a point several meters inland to approximately the lm depth out in Holland River. The lm depth was chosen as a limit since this was the estimate of the maximum depth at which bio-engineering techniques could be utilized.

All transects ran at approximately 900 from the existing shoreline.

Within each of the six sites, there was some variation in some of the parameters, namely vegetative cover and species. Since only one transect was completed for each site, it was determined that the transect should provide a representative cross-section of the vegetation both on-shore and off-shore. Transect locations therefore chosen arbitrarily within each site with this goal in mind. Starting posts for each transect (1" x 2") were placed in the ground at locations where they should remain until next year's sampling time. They are away from roadways and hammered into the ground often with only 2" of the post exposed to avoid having the post broken in the following year. The location of each standing post was measured from existing landmarks.

Measurements along each transect were only taken beginning from a point of at least 6m from the existing shoreline. Although the areas where no engineering methods are going to be applied are right along the shoreline, measurements were taken these distances to be able to determine how far inland the bioengineering methods are successful. Along each transect, parameters were measured in a 1m² quadrat at each meter along the transect. In the quadrates, the following parameters were measured: depth of water column (not including any unconsolidated sediments), thickness of the unconsolidated sediments, depths from the surface of the water to the bottom of the unconsolidated layer, substrate, percent plant coverage, number of plant species, the plant species and any comments.
The location of the surface of the unconsolidated sediment layer was determined using a depth pole and by feeling the river bottom with our feet. The bottom of the unconsolidated layer was determined by pushing the foldable height pole as far down as possible.

The substrate was determined by taking a sample at the surface of the substrate by hand, usually within the first 10 cm, except in peat deposits, where hands could penetrate deeper in the substrate.

The percent coverage by vegetation was estimated. Note that percent coverage was not determined for Site #2.
Site #3
Site #5
Site #6
APPENDIX

MEMBERSHIP ON THE STEERING COMMITTEE FOR THE LAKESIMCOE ENVIRONMENTAL MANAGEMENT STRATEGY IMPLEMENTATION PROGRAM

D. Marquis, Lake Simcoe Region Conservation Authority (Chairman)

J. Barker, Greater Toronto Area District -Maple, Ministry of Natural Resources

E. Cavanagh, York Region, Ministry of Agriculture, Food & Rural Affairs

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

P. Dillon, Dorset Research Centre, Ministry of Environment and Energy

J. Kinkead, Watershed Management Branch, Ministry of the Environment and Energy (past member)

J. Merritt, Director -Central Region, Ministry of the Environment and Energy (past member)

P. Miller, Watershed Management Branch, Ministry of the Environment and Energy (past member)

A. Morton, Lake Simcoe Region Conservation Authority (past member)

B. Noels, Lake Simcoe Region Conservation Authority (Secretary)

G. Rees, Watershed Management Branch, Ministry of Environment and Energy (past member)

J. Richardson, Central Region, Ministry of Environment and Energy
APPENDIX

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

B. Noels, Lake Simcoe Region Conservation Authority (Chainl1an)
J. Beaver, Central Region, Ministry of the Environment and Energy (past member)
I. Buchanan, Greater Toronto Area District -Maple, Ministry of Natural Resources
R. DesJardine, Southern Region, Ministry of Natural Resources (past member)
J. Dobell, Midhurst District, Ministry of Natural Resources (past member)
D. Evans, Greater Toronto Area District -Maple, Ministry of Natural Resources
H. Farghaly, Central Region, Ministry of the Environment and Energy
G. Findlay, Midhurst District, Ministry of Natural Resources, Lake Simcoe Region Conservation
D. Green, Resources Management Branch, Ministry of Agriculture, Food & Rural Affairs (past member)
B. Kemp, Authority
J. Kinkead, Watershed Management Section, Ministry of the Environment and Energy (past member)
R. MacGregor, Southern Region, Ministry of Natural Resources (past member)
M. McMurtry, Lake Simcoe Fisheries Assessment Unit, Ministry of Natural Resources
N. Moore, Victoria-Haliburton County, Ministry of Agriculture, Food & Rural Affairs
K. Nicholls, Water Resources Branch, Ministry of the Environment and Energy
B. Peterkin, Southern Region, Ministry of Natural Resources (past member)
T. Rance, Greater Toronto Area District -Maple, Ministry of Natural Resources (past member)
J. Smitka, Southern Region, Ministry of Natural Resources
B. Stone, Northumberland County, Ministry of Agriculture, Food & Rural Affairs (past member)
M. Toombs, York Region, Ministry of Agriculture, Food & Rural Affairs
M. Walters, Lake Simcoe Region Conservation Authority
C. Willox, Southern Region, Ministry of Natural Resources
K. Willson, Watershed Management Section, Ministry of the Environment and Energy (past member)
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REPORTS

Imp. A.3
Imp. B.5 Duckweed Harvest from Holland River. 1988. Limnos Ltd.

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