The Stratford/Avon River
Environmental Management Project

DEMONSTRATION OF EARTH BERMS AND DROP INLET STRUCTURES

TECHNICAL REPORT R-2

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PREFACE

This report is one of a series of technical reports resulting from work undertaken as part of the Stratford-Avon River Environmental Management Project (S.A.R.E.M.P.).

This two-year Project was initiated in April 1980, at the request of the City of Stratford. The S.A.R.E.M.P. is funded entirely by the Ontario Ministry of the Environment. The purpose of the Project is to provide a comprehensive water quality management strategy for the Avon River Basin. In order to accomplish this, considerable investigation, monitoring and analysis has taken place. The outcome of these investigations and field demonstrations will be a documented strategy outlining the program and implementation mechanisms most effective in resolving the water quality problems now facing residents of the basin. The Project is assessing urban, rural and in-stream management mechanisms for improving water quality.

This report results directly from the aforementioned investigations. It is meant to be technical in nature and not a statement of policy or program direction. Observations and conclusions are those of the authors and do not necessarily reflect the attitudes or philosophy of all agencies and individuals affiliated with the Project. In certain cases the results presented are interim in nature and should not be taken as definitive until such time as additional support data is collected.

Reference to equipment, brand names or supplies in this publication is not to be interpreted as an endorsement of that particular product or supplier.

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This report has been prepared using Imperial measures, as were the plans and specifications attached hereto. This was done purposely for ease of interpretation by contractors, the landowner, and project staff. A metric conversion table has been included in the Appendix.

ABSTRACT

A series of three berms with drop inlet structures leading to a subsurface tile were constructed or improved in the lower end of the Avon River drainage basin during 1981. The purpose of these projects was to demonstrate cost-effective means of controlling soil erosion with minimum interference to the agricultural practices in the area. The structures control rill and gully erosion while causing a portion of the sediment load in the surface runoff to settle out in temporary pounds behind the berms. Landowner acceptance and local reactions have been favourable to the projects. Further surveillance of these structures will reveal the degree to which they have succeeded in controlling soil erosion.

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1.0 INTRODUCTION

1.1 General Introduction

The practice of closing in open drains is a common practice. It increases the area of arable cropland and circumvents problems with open drain maintenance. However, when a drain is closed in and a sub-surface tile installed, provision should be made to control the expected occasional flows which cannot be entirely handled by the tile and consequently flow overland. This, unfortunately, is not yet a common practice in the Avon River basin. Appropriate control techniques are however available in the form of grassed waterways to channel overland flows in a harmless manner and earthen berms to impound surface flows until such time as runoff volumes can be accommodated by subsurface drainage tiles. This report documents the use of some earth berms in a demonstration project.

1.2 Wood Berms 'A' and 'B'

In early April of 1981 a Perth County landowner, Mr. R. Wood, contacted Stratford-Avon River Project staff to discuss the soil erosion he was experiencing on his property. The problem was one of rill and gully erosion caused by concentrated flows of surface water across his field.

The Roxburgh Municipal Drain serves as an outlet for the farmland surrounding Mr. Woods property, and drains an area of approximately 250 acres. The drain was closed in 1968 according to the engineer's report. The existing 16 inch diameter tile running through Lot 9 does not have the capacity to handle the annual peak flows.

The surrounding agricultural land is slightly undulating, with an imperfectly-drained Perth silt loam soil. The land is almost all systematically drained. Agricultural crops grown are predominantly row crops with some cereal grains. There are virtually no woodlot stands which could assist in retaining surface run-off. Likewise, there are no local ponds.

In 1977 Mr. Wood had approached the Upper Thames River Conservation Authority seeking technical and financial help through the Private Land Assistance Program. The Authority granted assistance in carrying out the construction of two earth berm structures with offset drop inlet catch basins leading to the Municipal Drain. The intent was to temporarily pond surface flows behind the berms until the 16" tile had enough capacity to drain the additional water.

However, in the spring seasons of 1980 and 1981, the landowner noted that, due to its position, one of the berms was proving ineffective in ponding the surface flow. In addition, a very poor growth of vegetative cover was established on the berm structures.

Either of the two control alternatives mentioned above could curb the erosion problem on the Wood property. An extensive grassed waterway would move the surface water across the entire farm. Alternatively, the existing berms could be modified and a grassed waterway could be added in the future if it was found to be necessary. There were definite problems associated with the first alternative. Namely: (1) it would be difficult to provide a sufficient outlet without channelling a concentrated flow onto the neighbouring property, (2) the flat topography and existing structures did not lend themselves well to a waterway in terms of cost or acceptable dimensions, and (3) the cost relative to the berm structures was quite high.

Mr. Wood and the project staff agreed to reconstruct berm structures with drop inlets to control soil erosion and to minimize interference with cropping and tillage practices in the field. The temporary ponds and the close spacing of the berm structures would reduce the velocity of the surface flow and thus reduce its erosive potential. The erosion problem would also be minimized if care was taken not to fall plough the natural draw through the field and in the future to establish winter cover crops in the waterway.

1.3 Pethick Berm 'C'

Mr. Wayne Pethick, the owner of Lot 10 adjacent to Mr. Wood's property was also concerned with sheet and rill erosion being caused by concentrated springtime flows across his field. Conditions regarding the Roxburgh Municipal Drain, soil type and surrounding crops are similar to those on the Wood property. At the boundary line of Lots 9 and 10 a distinct change of grade occurs and minor gullying had resulted. The landowners had placed rock in these washouts as a temporary measure to curb erosion. The depth of the draw at this point was 2.13 feet, making it sufficiently deep to accommodate a berm drop inlet structure. A drop inlet would drain surface runoff into the 16" municipal drain, and the berm would temporarily pond runoff which could not be carried by the tile. The volumes of surface flow across Mr. Pethick's field would fall, and erosion would be kept to a minimum. A strip of crop residue below the berm would be left uncultivated to increase soil stability in the draw.

2.0 METHODS

2.1 Wood Property

The location of the proposed berm and offset drop inlet catch basin was chosen to allow a maximum ponding area in the natural draw of the field. This was determined from the survey completed April 10, 1981. A site plan is given in Figure 1.

Berm 'A' is in the same location where it was originally constructed two years previous. The only modifications planned for this berm were to build it up with more topsoil to increase the ponded area, and to protect the surface outlet around the drop inlet with stone rip-rap (See Appendix D). This berm would create the larger of the two ponded areas.

The re-location of Berm 'B' served to create an additional ponded area and also acted as a barrier to reduce the velocity of surface flows across the property. The co-operator had experienced major erosion problems associated with the drain between Berms 'A' and 'B'. The slope is slightly greater here than below Berm 'B' (0.5% compared to 0.35% respectively), and the draw is somewhat more defined.

Following Mr. Wood's acceptance of the terms stated in the Engineering Practice Agreement (see Appendix 2), the work was scheduled to be carried out in late April of 1981. In this way the work would not greatly interfere with the spring tillage and planting of the surrounding field.

The co-operator made arrangements to have topsoil delivered to the site, and obtained a backhoe and the required lengths of plastic drain tile to make the connections with the Municipal Drain.

Staff offered assistance and supervision in carrying out the work. By April 27 both Berms 'A' and 'B' had been modified or re-located as required. A concrete catch basin was

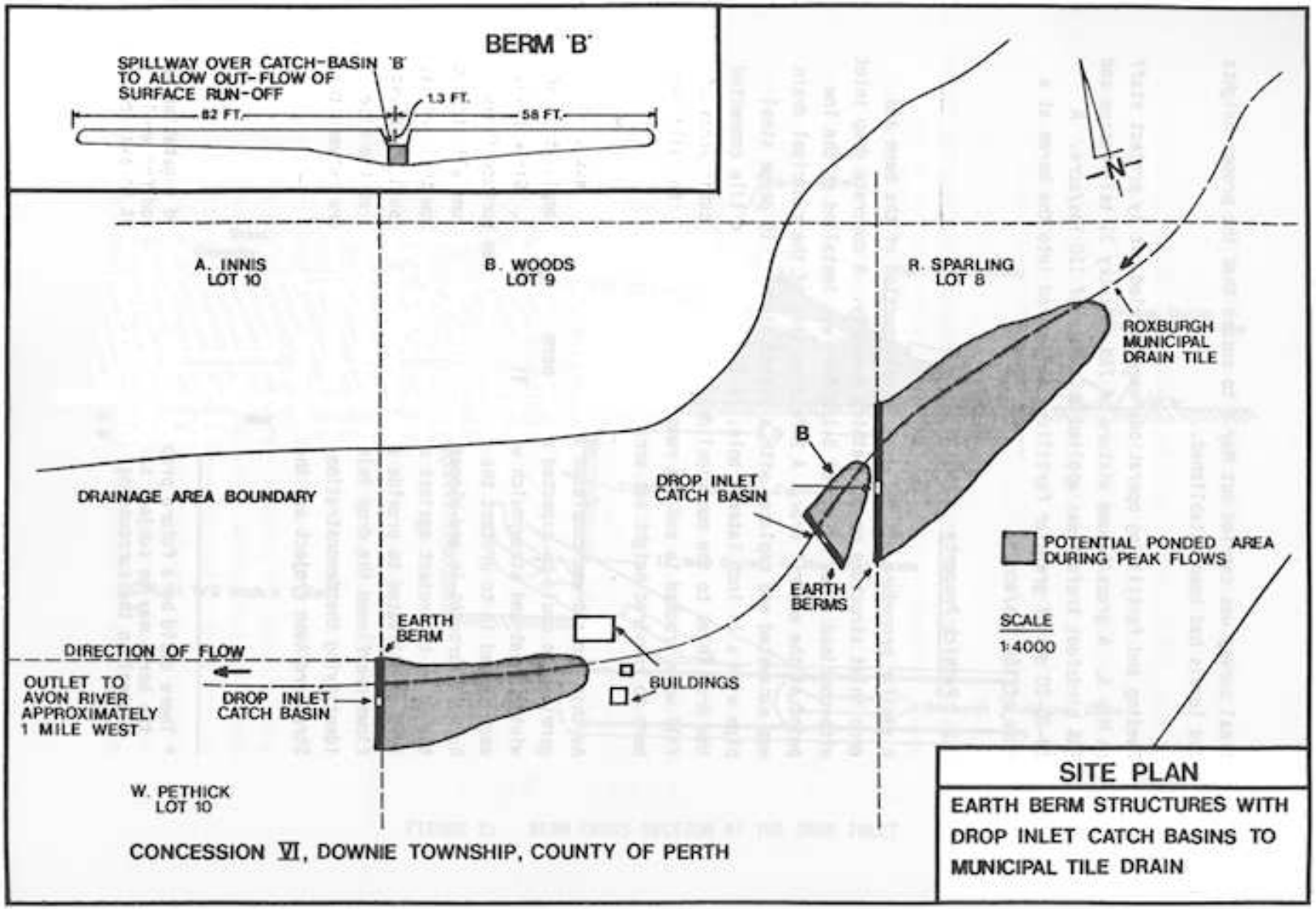
BERM 'B'
SPILLWAY OVER CATCH-BASIN 'B' TO ALLOW OUT-FLOW OF SURFACE RUN-OFF
82 FT.
1.3 FT.
58 FT.
A. INNIS LOT 10
B. WOODS LOT 9
R. SPARLING LOT 8
ROXBURGH MUNICIPAL DRAIN TILE
B
DROP INLET CATCH BASIN
DRAINAGE AREA BOUNDARY
POTENTIAL PONDED AREA DURING PEAK FLOWS
EARTH BERMS
SCALE
1:4000
EARTH BERM
DIRECTION OF FLOW
OUTLET TO AVON RIVER APPROXIMATELY 1 MILE WEST
DROP INLET CATCH BASIN
BUILDINGS
W. PETHICK LOT 10
CONCESSION VI, DOWNIE TOWNSHIP, COUNTY OF PERTH
SITE PLAN
EARTH BERM STRUCTURES WITH DROP INLET CATCH BASINS TO MUNICIPAL TILE DRAIN

Figure 1:

positioned in Berm 'B'. A final survey was carried out May 4 to ensure that the proper heights and levels had been established.

Seeding and fertilizing operations were carried out by project staff on May 5. A grass/legume mixture of 76% Kentucky 31 tall fescue and 24% birdsfoot trefoil was applied at a rate of 110 lbs/acre. A 10-20-20 mix of granular fertilizer was worked into the berms at a rate of 150 lbs/acre*.

2.2 Pethick Property

A similar procedure was followed in construction of the berm and drop inlet structure on the Pethick property. A concrete drop inlet with combined riser height of 5-½ feet was installed at the low point of the natural draw. A 2 foot section of the municipal drain was excavated and replaced with a fitted piece of 16 gauge steel pipe with a 14 inch lateral hole. A 12 inch plastic tile connected the drop inlet to the municipal drain. Thirty (30) cubic yards of fill were trucked in and the remaining topsoil needed to build the berm to required height was scraped off the field.

As this project was completed in the fall of 1981 no grass seed germination could be expected on the berm. A heavy application of winter wheat and straw mulch was applied to the berm. Straw bales were staked in to protect the toe of the berm from surface flows. Rock was brought in and placed over filter cloth around all sides of the inlet to protect against scouring. The draw below the berm was left uncultivated to provide some protection to the soil if excess flows overflowed the drop inlet. A sign was erected at the site identifying the demonstration as a cooperative venture between the Stratford/Avon Project and the landowner.

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* There could be a future problem in that the desired vegetation on the berms may be subject to some harmful sprays used for weed control in the surrounding field. This risk cannot be avoided.

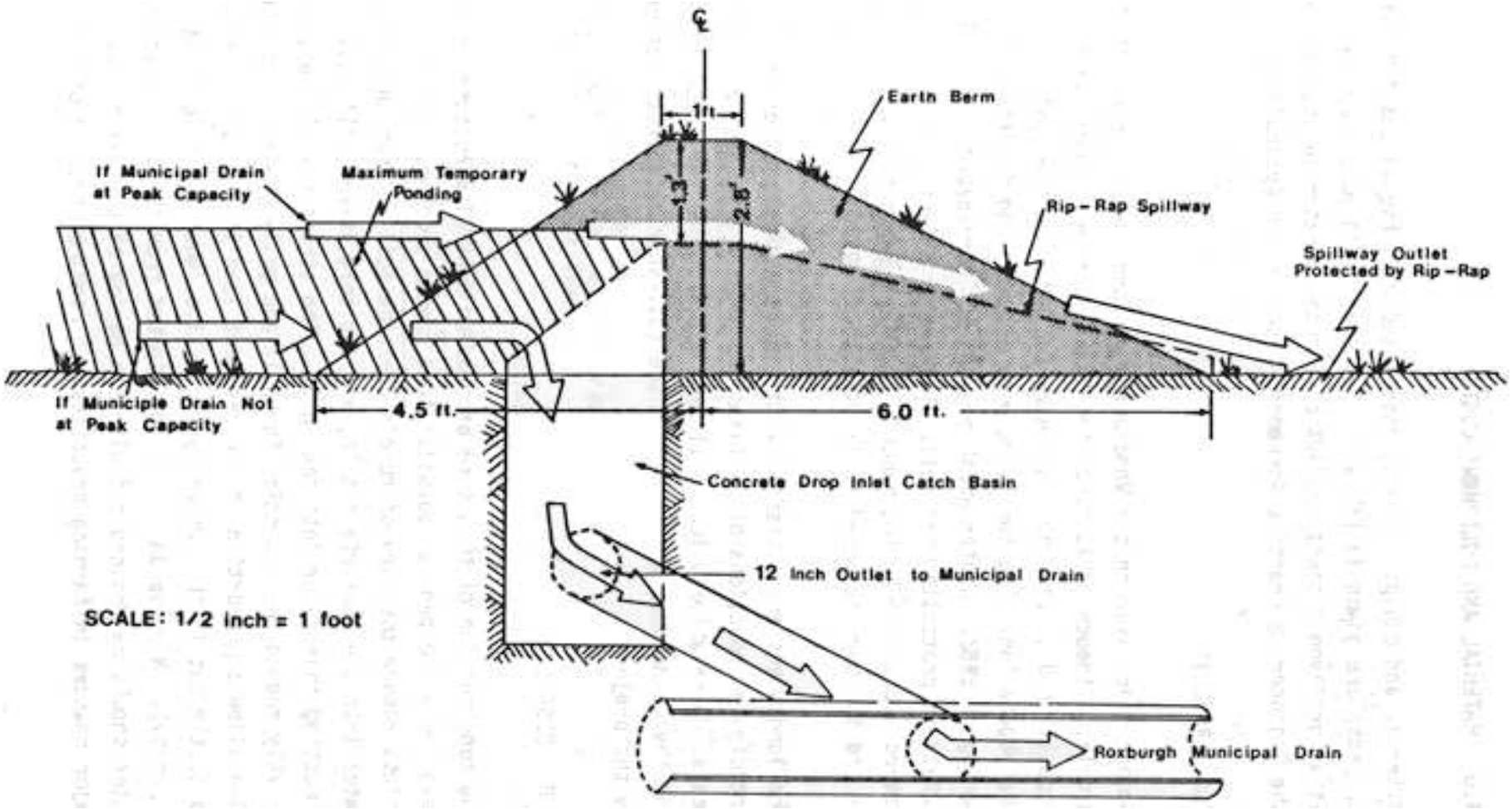

FIGURE 2: Berm Cross Section At The Drop Inlet

3.0 MATERIAL AND EQUIPMENT COSTS

Material and equipment costs associated with the Wood and Pethick projects are given in Table 1. Costs were shared 60% by the Stratford/Avon Project and 40% by the co-operator in accordance with the Engineering Practice Agreement appearing in Appendix C.

4.0 RESULTS

Same winter cover on the Wood berms was provided by grass and legume growth, although it is suspected that atrazine residues in the topsoil used on the berms may have inhibited full establishment of the vegetation. The two berms were reseeded and fertilized in the spring of 1982. Winter wheat on berm 'C' germinated but had little effect in protecting the soil. The center 8 feet of the berm was washed out by the Spring runoff. Rock and earth fill were brought in and the berm reseeded in the summer of 1982.

The landowners are satisfied with project implementation and anticipate reductions of drainage and erosion problems in subsequent years. A relatively low total cost was incurred for these projects, and the landowners profited from the cost-sharing approach offered by the project.

5.0 DISCUSSION AND CONCLUSIONS

The construction of this type of erosion control structure is a relatively inexpensive solution to a common problem. The drop inlets reduce the flow of runoff over the soil by dropping this water into the subsurface tile, and the berm itself will assist in directing this water into the inlet. The structures will not only greatly reduce the potential for rill and gully erosion, but will also allow a proportion of the sediment load in the surface runoff to settle out in the temporary ponds (i.e. when the tile is at capacity). No crop damage is anticipated from the ponding as the water should be drained off within a period of several hours. No major

TABLE 1: MATERIAL AND EQUIPMENT COSTS

Quantity		UNIT	UNIT COST	TOTAL COST
	W. Pethick Berms			
1.5	Catch Basin with Riser	m	$79.00	$118.56
1	Slant Top Inlet		66.00	66.00
30	Top Soil	yd^3	6.30	189.00
20	12-inch Perforated Tubing	ft.	2.50	50.00
1.5	Backhoe Rental	hr.	30.00	45.00
78	100-08 Nicolon Filter Cloth	ft^2	23	18.00
10	Straw Bales		75	7.50
	TOTAL			$494.00
SAREMP 60% Total Capital Costs - $296.40				
Co-operator 40% Total Capital Costs - $197.60				
	B. Wood Berm			
12	12" diam. Perforated Tubing	m	8.20	103.49
1	Coupling		3.50	3.50
8	Backhoe Rental	hr	25.00	214.00
32	Topsoil	yd^3	6.25	200.00
1	10-20-20 Fertilizer	Bag	8.83	8.83
	Seed Mixture:			
13	K-31 Tall Fescue/Bromegrass Mix	lb.	1.15	n/c
4	Leo Birdsfoot Trefoil	lb.	4.70	n/c
	TOTAL			$529.82
SAREMP 60% Total Capital Costs - $317.89				
Co-operator 40% Total Capital Costs - $211.93				

changes in farming practices are required because of the structures as only a small area was taken out of production; two of the berms are situated on property boundary lines.

These structures are simple to install if one has the use of a level and a backhoe or front-end loader. Factors such as depth of draw, ponding area, and finished berm and riser height must be accurately determined. Tile hook-up should be carried out with care to ensure sufficient slope and to provide proper connections. The lip of the catch basin may be positioned slightly above the surface to allow for settling of sediment prior to its entering the subsurface drain.

Excess water which the berms cannot pond will flow over the top of the inlets. Rocks placed around these inlets will dissipate the erosive energy of the water and prevent scouring. Provision of soil stabilization measures below the berms should be considered, such as leaving unploughed strips of crop residue or planting cover crops. Should these measures not prove sufficient in the long-term to control erosion, other improvements may be made to maximize soil protection and reduce sediment loadings to downstream watercourses. Adopting conservation tillage will reduce runoff and sedimentation. Constructing a grassed waterway along these natural draws is a more expensive solution to the sheet and rill erosion problems, however some adaptation of this measure can be used to compliment the berms and drop inlets if necessary.

APPENDICES

APPENDIX 1

METRIC EQUIVALENTS

LENGTH

inch	= 2.54 cm	millimetre	= 0.039 in.
foot	= 0.3048 m	centimetre	= 0.394 in.
yard	= 0.914 m	decimetre	= 3.937 in.
mile	= 1.609 km	metre	= 3.28 ft

AREA

square inch	= 6.452 cm^2	cm^2	= 0.155 sq in.
square foot	= 0.093 m^2	m^2	= 1.196 sq yd
square yard	= 0.836 m^2	km^2	= 0.386 sq mile
square mile	= 2.59 km^2	ha	= 2.471ac

VOLUME (DRY)

cubic inch	= 16.387 cm^3	cm^3	= 0.061 cu in.
cubic foot	= 0.028 m^3	m^3	= 31.338 cu ft
cubic yard	= 0.765 m^3	hectolitre	= 2.8 bu
bushel	= 36.368 litres	m^3	= 1.308 cu yd
board foot	= 0.0024 m^3		

VOLUME(LIQUID)

fluid ounce(imp)	= 28.412 ml	litre	= 35.2 fluid oz
pint	= 0.568 litre	hectolitre	= 22 gal
gallon	= 4.546 litres		

WEIGHT

ounce	= 28.349 g	gram	= 0.035 oz avdp
pound	= 453.592g	kilogram	= 2.205 lb avdp
hundredweight(imp)	= 45.359 kg	tonne	= 1.102 short ton
ton	= 0.907 tonne		

PROPORTION

1 gal/acre	= 11.232 litres/ha	1 litre/ha	= 14.24 fluid oz/acre
1 lb/acre	= 1.120 kg/ha	1kg/ha	= 14.5 oz avdp/acre
1 lb/sq in.	= 0.0702 kg/cm^2	1 kg/cm^2	= 14.227lb/sq in.
1 bu/acre	= 0.898 hl/ha	1 hl/ha	= 1.112 bu/acre

APPENDIX 2: ENGINEERING PRACTICE AGREEMENT

This agreement between:

Wayne Pethick, Lot 10, Conc. VI, Downie Twp.

Co-operator

and

Stratford-Avon Environmental Management Project (SAREMP)

1. The Co-operator agrees to assist the with implementation of the following soil conservation practices on his property as noted below:

   Construction of earthen berm with catch basin and rock spillway to pond surface flow over Roxburgh Municipal Drain

2. The Co-operator agrees that for the purposes of demonstration, practices shall be accessible for viewing by others, that photographs may be taken for documenting the success of the practice, and that a sign may be installed identifying the practice as part of a Project.
3. The **SAREMP** and the Co-operator. jointly agree to undertake the above-noted demonstration in accordance with this Agreement and the plans and specifications attached hereto.
4. Modifications to the demonstration specifications and/or Agreement may be made in the future, subject to the approval of both Co-operator and **SAREMP**
5. The **SAREMP** agrees to have a staff member or representative at the site to oversee the implementation of the demonstration, according to the demonstration specifications. If none are available, the Co-operator agrees to keep detailed records on all activities at the site during that period.
6. The Co-operator agrees to have at the demonstration site, in working order, those machines to be provided by him, as stated in the demonstration specifications. The Co-operator should be available to operate such tractors and/or machinery.
7. The **SAREMP** agrees to document changes in each project (eg. grass establishment on grassed waterways), throughout the life of the demonstration.
8. The Co-operator agrees to maintain the demonstration according to the specifications, for at least 3 years from the time of installation.
9. Should the **SAREMP** staff or the Co- operator note any problems that could jeopardize the success of the demonstration, both parties will be notified, and mutually acceptable, appropriate, corrective measures undertaken.
10. The Co-operator agrees not to undertake any cultural practices in the demonstration area without the consent of the **SAREMP** staff.
11. The **SAREMP** agrees to inform the Co-operator when a tour stop is to be made at the site, and will invite, on occasion, the Co-operator to attend the site while the tour is being conducted.
12. The **SAREMP** agrees to pay 60% of the total cost (exclusive of project staff and Co-operator labour), of the engineering practices noted above, subject to the satisfactory completion of the project and the provision of acceptable invoices.
13. Financial assistance will be made available by **SAREMP** in the following manner:
    - **Total charge to be initially billed to the SAREMP**
    - **Once the Conservation Project is complete, 40% of the cost will be paid by the Co-operator to the SAREMP.**

14. The Co-operator agrees to release the project, its staff and associated agencies from all liability which might arise as a result of the activity proposed.

_____ _____

Co-operator Program Co-ordinator

Date: _____

STRATFORD-AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT
LIST OF TECHNICAL REPORTS

S-1 Impact of Stratford City Impoundments on Water Quality in the Avon River
S-2 Physical Characteristics of the Avon River
S-3 Water Quality Monitoring of the Avon River - 1980, 1981
S-4 Experimental Efforts to Inject Pure Oxygen into the Avon River
S-5 Experimental Efforts to Aerate the Avon River with Small In-stream Dams
S-6 Growth of Aquatic Plants in the Avon River
S-7 Alternative Methods of Reducing Aquatic Plant Growth in the Avon River
S-8 Dispersion of the Stratford Sewage Treatment Plant Effluent into the Avon River
S-9 Avon River In-stream Water Quality Modelling
S-10 Fisheries of the Avon River
S-11 Comparison of Avon River Water Quality During Wet and Dry Weather Conditions
S-12 Phosphorus Bioavailability of the Avon River
S-13 A Feasibility Study for Augmenting Avon River Flow by Ground Water
S-14 Experiments to Control Aquatic Plant Growth by Shading
S-15 Design of an Arboreal Shade Project to Control Aquatic Plant Growth

U-1 Urban Pollution Control Strategy for Stratford, Ontario - An Overview
U-2 Inflow/Infiltration Isolation Analysis
U-3 Characterization of Urban Dry Weather Loadings
U-4 Advanced Phosphorus Control at the Stratford WPCP
U-5 Municipal Experience in Inflow Control Through Removal of Household Roof Leaders
U-6 Analysis and Control of Wet Weather Sanitary Flows
U-7 Characterization and Control of Urban Runoff
U-8 Analysis of Disinfection Alternatives

R-1 Agricultural Impacts on the Avon River - An Overview
R-2 Earth Berms and Drop Inlet Structures
R-3 Demonstration of Improved Livestock and Manure Management Techniques in a Swine operation
R-4 Identification of Priority Management Areas in the Avon River
R-5 Occurrence and Control of Soil Erosion and Fluvial Sedimentation in Selected Basins of the Thames River Watershed
R-6 Open Drain Improvement
R-7 Grassed Waterway Demonstration Projects
R-8 The Controlled Access of Livestock to Open Water Courses
R-9 Physical Characteristics and Land Uses of the Avon River Drainage Basin
R-10 Strip cropping Demonstration Project
R-11 Water Quality Monitoring of Agricultural Diffuse Sources
R-12 Comparative Tillage Trials
R-13 Sediment Basin Demonstration Project
R-14 Evaluation of Tillage Demonstration Using Sediment Traps
R-15 Statistical Modelling of In-stream Phosphorus
R-16 Gully Erosion Control Demonstration Project
R-17 Institutional Framework for the Control of Diffuse Agricultural Sources of Water Pollution
R-18 Cropping-Income Impacts of Management Measures to Control Soil Loss
R-19 An Intensive Water Quality Survey of Stream Cattle Access Sites