Severn Sound

Remedial Action Plan

URBAN STORMWATER MANAGEMENT STRATEGY

December 1998

Canada Ontario

Canada-Ontario Agreement Respecting Great Lakes Water Quality
L’ Accord Canada-Ontario relatif à la qualite de l’eau dans les Grand Lacs

Town of Midland

Town of Penetanguishene

Township of Tay

Township of Severn

Simcoe County District Health Unit

SEVERN SOUND REMEDIAL ACTION PLAN
URBAN STORMWATER MANAGEMENT STRATEGY

Severn Sound Remedial Action Plan
Great Lakes 2000 Cleanup Fund
Ontario Ministry of the Environment
Corporation of the Town of Midland
Corporation of the Town of Penetanguishene
Corporation of the Township of Tay
Corporation of the Township of Severn
Simcoe County District Health Unit

December, 1998

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Severn Sound Remedial Action Plan

FOREWORD

This report has been prepared under the auspices of the Canada-Ontario Great Lakes Remedial Action Plan Program. Financial support for the study was provided by Environment Canada (The Great Lakes 2000 Cleanup Fund), the Ontario Ministry of the Environment (Standards Development Branch, Environmental Monitoring and Reporting Branch), the Town of Midland, the Town of Penetanguishene, the Township of Tay and the Township of Severn. In-kind services were also provided by the above mentioned participants as well as the Simcoe County District Health Unit and the Severn Sound Remedial Action Plan.

Please note that the Technical Steering Committee for this study has reviewed this report and approved its publication. Approval does not necessarily signify that the contents reflect the views and policies of individual agencies, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This report is part of a series of technical investigations conducted in support of the Severn Sound Remedial Action Plan (RAP). For additional technical reports or information on the RAP, please contact the Severn Sound Environmental Association Office.

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EXECUTIVE SUMMARY

Urban stormwater discharges have traditionally been regarded as relatively benign inputs into our lakes and rivers. However, recent studies indicate that urban runoff can contribute significantly to pollutant loadings to lakes and rivers (Schroeter and Associates, 1993; Marsalek et al., 1987; Maunder and D'Andrea, 1995). In the Severn Sound Area of Concern (AOC), in southeastern Georgian Bay, stormwater discharges could contribute to the following problems:

- nutrient enrichment which can lead to nuisance algae growths and oxygen depletion;
- degradation of aesthetics through discharge of turbid or oily water;
- elevated bacterial densities in excess of the Ontario Ministry of Health's Beach Management Protocol (OMOH 1992) that could lead to impairment of quality at bathing areas; and
- discharge of elevated levels of heavy metals and organic chemicals that could contribute to the contamination of sediments and aquatic life.

The Stage 2 Report of the Severn Sound Remedial Action Plan (RAP) identified urban stormwater as a significant controllable source of phosphorus to Severn Sound. In addition, bacterial contamination and waste from stormwater during wet weather, and possible illegal connections to the storm sewers during dry weather, were thought to be affecting recreational bathing areas within the Sound. Initial planning estimates at the time of the Stage 2 Report indicated that a 20% reduction in phosphorus loading was achievable through existing stormwater management practices without requiring chemical additions. However, an initial 'broad brush' cost estimate of $35,000,000 for urban stormwater treatment resulted in the RAP Team recommending further study before proceeding with any implementation.

A cooperative study of urban stormwater impacts was initiated in the Severn Sound AOC through a joint partnership that included Environment Canada (Great Lakes 2000 Cleanup Fund), the Ontario Ministry of the Environment, the Town of Midland, the Town of Penetanguishene, the Township of Tay and the Township of Severn. The study was designed and conducted during 1995 and 1996 with the following objectives:

1. Measure runoff quantity and quality at selected catchments during dry and wet weather to:
   a) establish a baseline by which the effectiveness of remedial options can be evaluated after implementation; and
   b) identify those catchments requiring additional source identification of dry and wet weather pollutant loads.

2. Monitor a selected urban bathing area impacted by stormwater discharges.
3. Conduct a planning level analysis of options for stormwater control and/or treatment in existing urbanized catchments to achieve the RAP target of 20% reduction of stormwater phosphorus load and to reduce other pollutant loadings to meet water quality objectives.

The scope of work involved the following components of study:

1. characterization of urban stormwater runoff quantity and quality going into Severn Sound;
2. application of a planning level model to examine potential retrofit remedial measures for existing storm catchments in the urban municipalities in Severn Sound;
3. the development of pollution control plans for the participating urban municipalities in the Severn Sound watershed; and
4. monitoring of an urban bathing to examine the effects of urban stormwater runoff on the bacteriological quality of the water and to determine if it is possible to predict impairment of the bathing area based on precipitation events.

The first component of the study, field monitoring, consisted of measuring flow and collecting quality samples of rain event runoff, snowmelt runoff and baseflow during dry weather periods. The purpose of this sampling was to establish a baseline by which the effectiveness of remedial options could be evaluated and identify those catchments requiring source identification. Seven representative stations were installed to collect runoff from rain and snowmelt events, and nineteen outfalls were sampled during dry weather periods. In addition, two monitoring stations were installed in a drainage ditch situated in the Community of Coldwater, Ontario, one upstream on the outskirts of the Community, and one at the confluence of the ditch and the Coldwater River.

The runoff quantity and quality data collected were analysed statistically to determine Event Mean Concentrations (EMCs) and probability distributions of the results. These EMCs provided the basis by which annual pollutant loads were calculated through the Retrofit Stormwater Management Practices (RSWMP) model utilized for this study. In addition, local long-term historical records of precipitation were analysed to determine average rainfall and snowfall amounts for input into this model. This was essential for calculating annual runoff from the urban areas. Table 1 illustrates the EMCs and the associated 95% confidence intervals of the variables monitored.

In addition to collecting baseline contaminant and flow information, the field monitoring program involved the collection of information required for the application of the RSWMP model.

Table 1 Summary of Contaminant Concentrations by Monitoring Phase

Parameter	Units	PWQO	Rain Event N = 19			Dry Weather N = 27			Snow Events N = 8			Coldwater N = 9		
			Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval	
				LL	UL		LL	UL		LL	UL		LL	UL
Metals														
Aluminum	mg/L	0.075	0.388	0.107	1.408	0.036	0.022	0.059	0.430	0.271	0.684	0.358	0.684	0.358
Barium	mg/L	—	0.052	0.040	0.069	0.091	0.069	0.120	0.057	0.039	0.085	0.049	0.085	0.049
Beryllium	mg/L	0.011	0.00006	0.00005	0.00007	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Cadmium	mg/L	0.0002	0.00074	0.00048	0.00115	0.00009	0.00006	0.00013	0.00102	0.00037	0.00280	0.00026	0.00280	0.00026
Chromium	mg/L	0.1	0.006	0.004	0.009	0.00118	0.00057	0.00242	0.008	0.005	0.012	0.00076	0.012	0.00076
Cobalt	mg/L	0.0004	0.00142	0.00099	0.00203	0.00023	0.00013	0.00042	0.00048	0.00025	0.00094	0.00037	0.00094	0.00037
Copper	mg/L	0.005	0.0333	0.0204	0.0543	0.0032	0.0021	0.0049	0.0145	0.0098	0.0216	0.0022	0.0216	0.0022
Iron	mg/L	0.3	0.546	0.145	2.058	0.154	0.078	0.308	0.685	0.396	1.185	0.415	1.185	0.415
Lead	mg/L	0.005	0.0296	0.0158	0.0553	0.0025	0.0025	0.0025	0.0163	0.0038	0.0699	0.0025	0.0699	0.0025
Manganese	mg/L	—	0.198	0.134	0.292	0.050	0.027	0.092	0.095	0.061	0.147	0.025	0.147	0.025
Molybdenum	mg/L	0.01	0.0012	0.0004	0.0032	0.0030	0.0011	0.0087	0.0007	0.0002	0.0023	0.0002	0.0023	0.0002
Nickel	mg/L	0.025	0.0040	0.0030	0.0054	0.0004	0.0002	0.0005	0.0070	0.0032	0.0151	0.0012	0.0151	0.0012
Strontium	mg/L	—	0.218	0.153	0.311	0.215	0.146	0.317	0.221	0.154	0.317	0.434	0.317	0.434
Titanium	mg/L	—	0.0183	0.0125	0.0269	0.0007	0.0005	0.0010	0.0113	0.0049	0.0264	0.0108	0.0264	0.0108
Vanadium	mg/L	0.0007	0.0035	0.0025	0.0048	0.0008	0.0005	0.0014	0.0012	0.0007	0.0023	0.0011	0.0023	0.0011
Zinc	mg/L	0.03	0.1233	0.0813	0.1868	0.0088	0.0049	0.0161	0.0654	0.0466	0.0919	0.006	0.0919	0.006
General Chemistry														
Chlorides	mg/L	—	21.7	15.27	81.47	434.6	118.7	1591.0	178.7	74.7	8704.4	6.9	6.3	7.5
Sodium	mg/L	—	14.5	10.18	49.01	68.3	42.0	111.1	111.6	88.6	5000.1	6.1	5.7	6.5
Potassium	mg/L	—	2.26	1.881	2.728	3.878	3.194	4.709	2.8	2.155	3.659	2.455	2.199	2.741
Ammonia/um	mg/L	—	0.043	0.200	2.026	0.116	0.041	0.327	0.026	0.022	0.174	0.016	0.011	0.025
Nitrites	mg/L	—	0.033	0.0286	0.1262	0.0395	0.0218	0.0718	0.027	0.0211	0.0549	0.0255	0.0173	0.3761
Nitrates	mg/L	—	0.806	0.5972	1.9723	2.1134	1.5268	2.9253	0.596	0.4130	1.7307	0.2044	0.1279	0.3267
DRP	mg/L	—	0.025	0.0154	0.2412	0.0310	0.0138	0.0699	0.019	0.0127	0.0722	0.0165	0.0116	0.0233
TSS	mg/L	—	138.4	113.63	389.93	84.52	36.97	193.21	44.2	33.89	217.47	19.07	14.90	24.41
TP	mg/L	0.01	0.257	0.187	0.5631	0.0692	0.0392	0.1221	0.125	0.1024	0.2208	0.0614	0.0515	0.0732
TKN	mg/L	—	1.325	1.1083	2.3744	0.3146	0.2500	0.3960	0.788	0.6497	1.2245	0.6771	0.6027	0.7607
DOC	mg/L	—	5.6	4.9621	7.9131	2.103	1.506	2.937	3.366	2.7623	5.5219	8.3163	7.5436	9.1681
DIC	mg/L	—	20.2	18.046	26.847	56.458	46.120	69.113	25.8	21.818	34.874	42.181	40.229	44.228

Note: CI = Confidence Intervval LL = Lower Limit of 95% Confidence Interval UL = Upper Limit of 95% Confidence Interval

This information included drainage/sewershed areas, land use composition, soils and groundwater information, and storm sewer/ditch locations. ArcView®, a Geographical Information System (GIS), was utilized for the compilation and graphical representation of this information. The GIS was used to calculate drainage/sewershed areas, land use composition of an area, the total area covered by a each land use and to identify appropriate stormwater retrofit measures.

The second component of the study involved the input of collected data and baseline information into the RSWMP model. The model utilizes analytical probabilistic and multi-efficiency models in a LOTUS 1-2-3® spreadsheet to determine the following for each drainage/sewershed area:

1. the existing annual runoff volume (m^3/yr) and solids loading (kg/yr);
2. the runoff volume and solids concentration reduction efficiencies (%) of RSWMPs;
3. the cumulative runoff volume and solids load reduction efficiencies (%) of RSWMPs;
4. the average annual runoff volume and solids loading after the application of each RSWMP;
5. the cost of runoff volume and solids loading reduction for each RSWMP;
6. the marginal cost of runoff volume and solids load reduction for each RSWMP;
7. the cumulative cost of runoff and solids loading reduction for a series of RSWMPs; and
8. phosphorus loading reduction based on the phosphorus concentrations measured in this study.

A summary of the model results for the study area is outlined in Table 2.

Table 2 Model Results

Urban Area	Area (ha)	Annual Runoff (m^3)	Annual Suspended Solids Loading (kg)	Annual Phosphorus Loading (kg)	Potential Phosphorus Removal Efficiency	Predicted Total Cost
Town of Midland	2,477	9,217,303	168,800	420.4	19.1%	$842,387
Town of Penetanguishene	610	2,032,580	118,600	273.9	16.2%	$1,008,417
Community of Victoria Harbour	390	1,166,538	61,570	141.2	20.0%	$1,072,346
Community of Port McNicoll	270	853,927	44,420	100.6	43.2%	$1,221,316
Community of Waubaushene	145	486,892	32,630	75.3	19.5%	$416,843
Community of Coldwater	241	654,855	31,820	71.3	4.9%	$42,951
Total	**4,133**	**14,412,095**	**457,840**	**1082.7**	**19.8%**	**$4,604,260**

The third component of the study involved the production of detailed stormwater management plans for each of the participating municipalities. The information was presented on a catchment by catchment basis outlining the potential phosphorus reduction, the capital cost, the amortized capital cost/year and the operations and maintenance cost/year of the various RSWMP options.

The final component of the study involved establishing a monitoring regime for an urban bathing area thought to be impacted by urban stormwater runoff in terms of the bacteriological quality of the water (Peterson Park, Midland). Nine sampling sites were established where grab water quality samples were obtained at regular intervals during and after rain events. These samples were obtained in conjunction with flow monitoring to determine quantity of stormwater discharging to the bathing area.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study provide important insight into the characteristics of wet and dry weather stormwater discharges and snowmelt originating from small urban centers, and more specifically, the characteristics of annual pollutant loadings into Severn Sound. The emphasis on potential retrofit remediation of stormwater contaminant loading has also led to the development of detailed retrofit stormwater management plans for municipalities based on local cost functions.

The following conclusions were drawn from this study:

- The average annual volume of flows from urban outfalls discharging into Severn Sound was estimated to be approximately 14.4 million cubic meters.

- Based on seasonal water quality sampling performed for this study, urban stormwater contributes to contaminant loadings into Severn Sound. These findings support initial assumptions outlined in the Stage 2 RAP report indicating that reductions of phosphorus loadings originating from urban stormwater must be remediated to achieve open water levels in accord with the Provincial Water Quality Objectives.

- The original baseline loading estimate for phosphorus of 3,300 kg/year from urban sources has been revised to 1,083 kg/year. This reflects the consideration of existing treatment in the form of in place stormwater management practices, lakes and ponds, and natural ponding areas such as beaver ponds and man-made structures associated with drinking water reservoir recharge areas.

- The study has shown that a 19.8% reduction of phosphorus loading is achievable with the stormwater management practices considered for this study. This effectively meets the original 20% reduction target.

- The original cost estimate of $35,000,000 to achieve the target of 20% reduction in phosphorus has been revised to $4,604,260.

- Although mean contaminant concentrations are generally lower than those found in other studies, the order of magnitude by which they surpass the Provincial Water Quality Objectives (PWQO) is the same. Some metals concentrations ranged in the order of 3 to 7 times greater than the PWQO compared to the Toronto study where the same metals ranged from 2 to 11 times greater than the PWQO.

- Total phosphorus concentrations were not significantly different for urban areas of differing land use (residential, commercial, industrial). An average total phosphorus concentration of 0.26 mg/L was measured. This concentration was slightly lower than that found in the Toronto study but in the same order of magnitude. The phosphorus loadings estimated for areas of residential, commercial or industrial land uses were different due to differing runoff volume estimates.

- The study has determined that there is a connection between stormwater and water quality at the bathing area sampled during rain events. Water quality sampling suggested impingement of water with elevated E. coli counts at the bathing area within 6 hours of the onset of a rain event.

The following recommendations are made.

1. The draft Drainage Policy and Protocol for Implementation of Infrastructure Improvement Projects should be adopted as policy documents by the Towns of Midland and Penetanguishene, and by the Townships of Tay and Severn. The documents should then be utilized by Engineering and Public Works staff for developing roads or drainage strategies.

2. Individual urban stormwater retrofit projects listed for each municipality should be implemented over the next 25 years as resources and timing allow. Wherever possible, the retrofit projects should be combined with new development stormwater treatment projects to optimize the treatment provided and maximize cost efficiencies.

3. As a condition for approval for all new developments, the design and construction of such new developments shall include stormwater management facilities designed to address both the control of the quantity of stormwater runoff and the control of the quality of stormwater runoff.

4. The Simcoe County District Health Unit should consider a protocol for posting the Pete Peterson Park bathing area following rain events of greater than 20 mm falling within six hours in order to avoid bather contact with bacteriologically contaminated water.

5. A follow-up study should be undertaken to further identify and trace illegal connections to storm sewers, and to track and correct these sources.

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1.0 INTRODUCTION

1.1 Significance of Urban Stormwater Discharges

Urban stormwater discharges have traditionally been regarded as relatively benign inputs into our larger water bodies. However, recent studies indicate that urban runoff can contribute significantly to pollutant loadings into nearby lakes and streams (Schroeter and Associates, 1993; Marsalek *et al.*, 1987; Maunder and D'Andrea, 1995). Lawn fertilizers, pesticides, automobile emissions, oil and chemical spills in industrial areas and fecal droppings from animals all contribute to nutrient and contaminant loadings in urban stormwater runoff. Contaminant loadings associated with stormwater originating from many sources over a wide area are termed 'non-point sources'.

Urban stormwater runoff results from rainfall and snowmelt draining from paved roadways, parking lots and roofs which cannot absorb water. Water runs off into storm sewers or ditches and washes contaminants into lakes and streams. Surfaces such as lawns, which usually absorb water, can also contribute a significant amount of runoff during storm events when the ground gets saturated and during winter when the ground is frozen.

The contaminants associated with overland runoff in urban settings have various impacts on the receiving waters into which it flows. In the Severn Sound area, storm water discharges could contribute to the following problems:

- nutrient enrichment which can lead to nuisance algae growth and oxygen depletion;
- degradation of aesthetics through discharge of turbid water and oil slicks;
- elevated bacterial densities in excess of the Provincial Water Quality Guidelines that could lead to impairment of water quality at bathing areas; and
- discharge of elevated levels of heavy metals and organic chemicals that could contribute to the contamination of sediments and aquatic life.

Given these concerns, the Severn Sound Remedial Action Plan (RAP) team recommended study of this source of pollution (SSRAP, 1993).

1.2 Study Rationale

Severn Sound is a group of bays in southeast Georgian Bay, Lake Huron which has been designated as one of 17 Areas of Concern (AOC) in Ontario by the Great Lakes Water Quality Board of the International Joint Commission (IJC). Problems stemming mainly from nutrient enrichment and been developed by the provincial and federal governments for the restoration of the Severn Sound ecosystem. The goals of the plan are:

1. to improve water quality in Severn Sound; and
2. to maintain a healthy ecosystem in Severn Sound.

The Great Lakes Water Quality Agreement (IJC, 1987) (as amended by protocol in 1997) calls for plans to address pollution from non-point sources such as urban runoff. The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA) (1994) set a target of undertaking 25 stormwater quality projects in AOCs. The COA also focused on toxic chemical pollution and runoff from both urban and agricultural lands, indicating that urban runoff pollution control is one of the government's initiatives for restoring water quality in the AOCs within the Great Lakes Basin.

The Severn Sound RAP Stage 2 report identified urban stormwater as a significant controllable source of phosphorus to Severn Sound. In addition, bacterial contamination and waste from stormwater during wet weather, and possible illegal connections to the storm sewers during dry weather, were thought to be affecting recreational areas within the Sound (i.e. bathing, fishing and outdoor recreation). Examination of stormwater management practices at the time indicated that a 20% reduction in phosphorus loading was the best achievable target without requiring treatment by chemical additions. However, an initial 'broad brush' cost estimate of $35,000,000 for urban stormwater treatment resulted in the RAP team recommending further study before proceeding with any implementation (SSRAP, 1993). As a result, a cooperative study effort between Environment Canada (Great Lakes 2000 Cleanup Fund), the Ministry of the Environment (MOE), the RAP and local municipalities was undertaken to examine potential actions by which to achieve this reduction.

1.3 Study Objectives and Scope

The primary objectives of this study were to determine quantity and quality of flow from stormwater sources into Severn Sound from the urban areas of the watershed. Contaminant concentrations and contaminant mass loadings were characterized, and remedial actions developed based on these findings. More specifically, the objectives of the project were as follows:

1. Measure runoff quantity and quality at selected catchments during dry and wet weather to:
   a) establish a baseline by which the effectiveness of remedial options can be evaluated after implementation; and
   b) identify those catchments requiring additional source identification of dry and wet weather pollutant loads.

b) identify those catchments requiring additional source identification of dry and wet weather pollutant loads.

2. Monitor a selected urban bathing area impacted by stormwater discharges.
3. Conduct a planning level analysis of options for stormwater control and/or treatment in existing urbanized catchments to achieve the RAP target of 20% reduction of stormwater phosphorus load and to reduce other pollutant loadings to meet water quality objectives.

It is anticipated that the results of this study will assist in the development of urban stormwater pollution control plans in small municipalities. Although the scope of this study overlaps with previous studies examining dry and wet weather storm discharges from urban areas, it represents a significant departure in that the focus is on urban areas with populations of less than 20,000.

It is intended that the information presented in this study be used as a basis for remedial actions towards new and retrofit stormwater management in local municipalities with an ultimate goal of delisting the Severn Sound AOC. In addition, it is intended that the information be transferred to other similar AOCs with small municipalities and augment existing databases for stormwater quality and management techniques.

1.4 Study Area Characteristics

The Severn Sound AOC is unique from most other RAP sites due to its relatively low proportion of urban areas. The largest urban area is the Town of Midland but concerns have also been noted for stormwater discharges in the Town of Penetanguishene, and in the Communities of Victoria Harbour, Port McNicoll, Waubaushene and Coldwater.

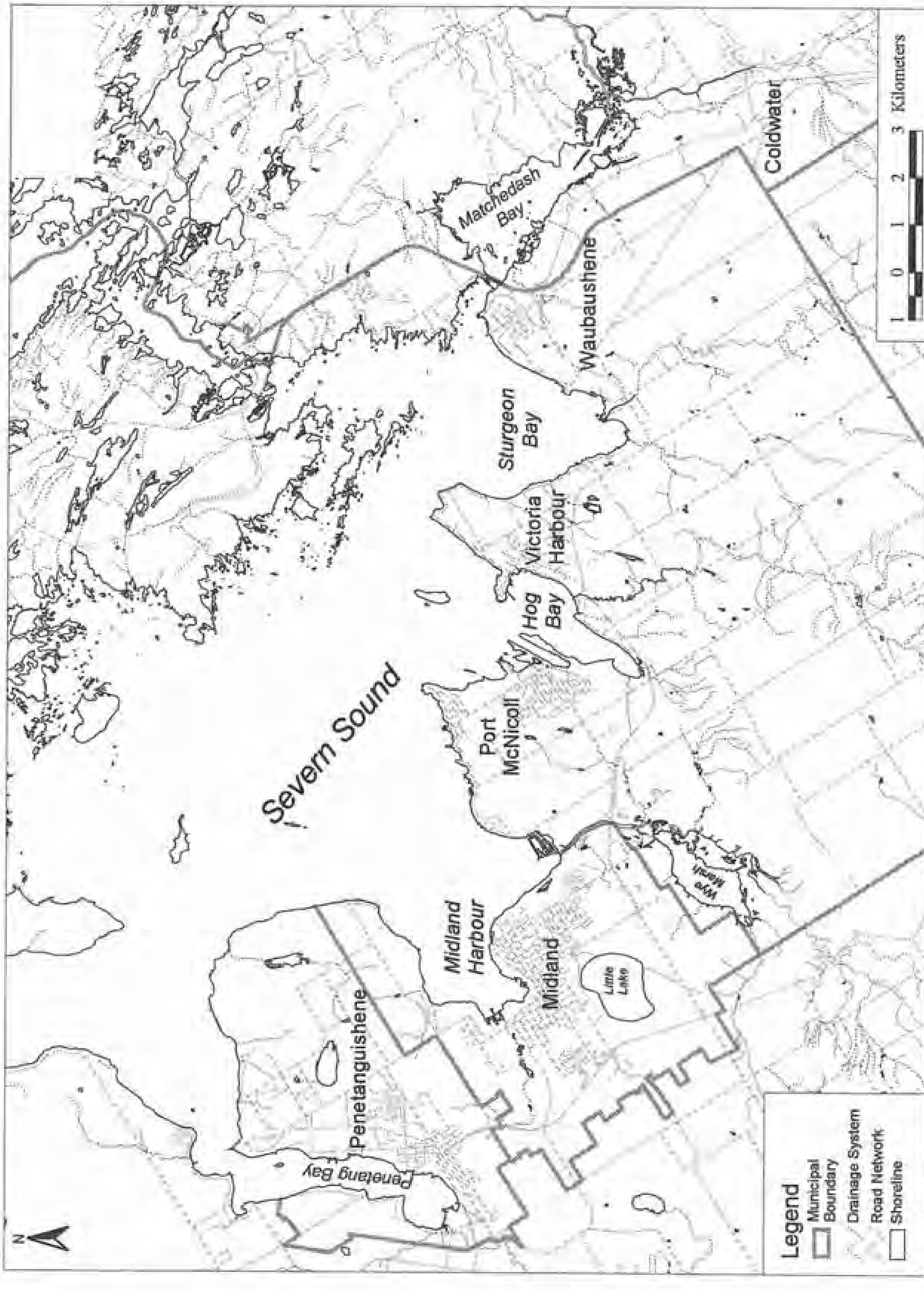
Stormwater studies in other AOCs have tended to focus on large scale and often high cost remediation activities that would not necessarily be practical or economically feasible in smaller municipalities. As such, the study has been structured to recognize the uniqueness of this area.

The urban areas of concern within the Severn Sound watershed encompass 41 km^2 or 4% of the land area in the watershed (Table 1.1, Figure 1.1).

Town of Midland	16,500	32	2,477 ha	*Existing CSO/Bypass 1,216 kg/y
Town of Penetanguishene	7,000	19	610 ha	
Township of Tay				
Community of Victoria Harbour	1,700	16	390 ha	
Community of Port McNicoll	1,800	9	270 ha	*Storm Water 3,133 kg/y
Community of Waubaushene	1,000	9	145 ha	
Township of Severn				
Community of Coldwater	800	11	241 ha	

* Note: These numbers represent the initial planning estimate from the RAP Stage 2 Report.

Figure 1.1 Urban Areas of Severn Sound



2.0 STUDY APPROACH

2.1 Field Program for Runoff Quantity and Quality Measurements

The primary objectives of the field monitoring program were to collect runoff quantity and quality measurements representative of the urban catchment areas draining into Severn Sound. In designing the field program, the following factors were considered:

- runoff volumes and pollutant concentrations from storm sewers will vary based on land use;
- runoff volumes and pollutant concentrations will vary between events; and
- runoff volumes and associated pollutant concentrations may vary seasonally.

The collection and analysis of flow quantity and quality data from each of the approximately 90 storm sewer and ditch outfalls would be labour intensive and cost prohibitive. For this reason, a field program was designed to monitor flows and collect samples from representative outfalls which could then be used to extrapolate flow volumes and contaminant concentrations to the entire study area.

2.2 Monitoring Approach

To establish baseline loading conditions for the urban areas of Severn Sound, the following monitoring approach was developed:

1. Collect grab water quality samples and spot flow measurements at dry weather locations (19 sites). Note: 'dry weather' is operationally defined as 3 preceding days of no precipitation.
2. Measure flow resulting from rain events (at least 5 sites) over 3-5 events.
3. Collect flow weighted composite water quality samples of rain events (>5 mm precipitation).
4. Estimate catchment characteristics and wet and dry weather load for selected pollutants.
5. Use dry and wet weather results as input to model annual pollutant loads to Severn Sound, from all urban catchments, monitored and unmonitored.

The monitoring component of the study provided the necessary data for determining seasonal pollutant loadings from individual catchments of differing land uses. This information was essential as input to the Retrofit Stormwater Management Practices (RSWMP) model developed by Li (1997) for the City of Scarborough and which has been utilized for the planning level analysis component of this study.

The first phase of the field sampling program was initiated September 22, 1995 and completed

The first phase of the field sampling program was initiated September 22, 1995 and completed December 7, 1995. Due to significant accumulations of snow and cold temperatures, the monitoring equipment was removed for the winter season. The second phase of the field sampling program took place from April 15, 1996 to August 31, 1996 to assist in characterizing spring/summer flows and contaminant concentrations.

2.2.1 Wet Weather Monitoring

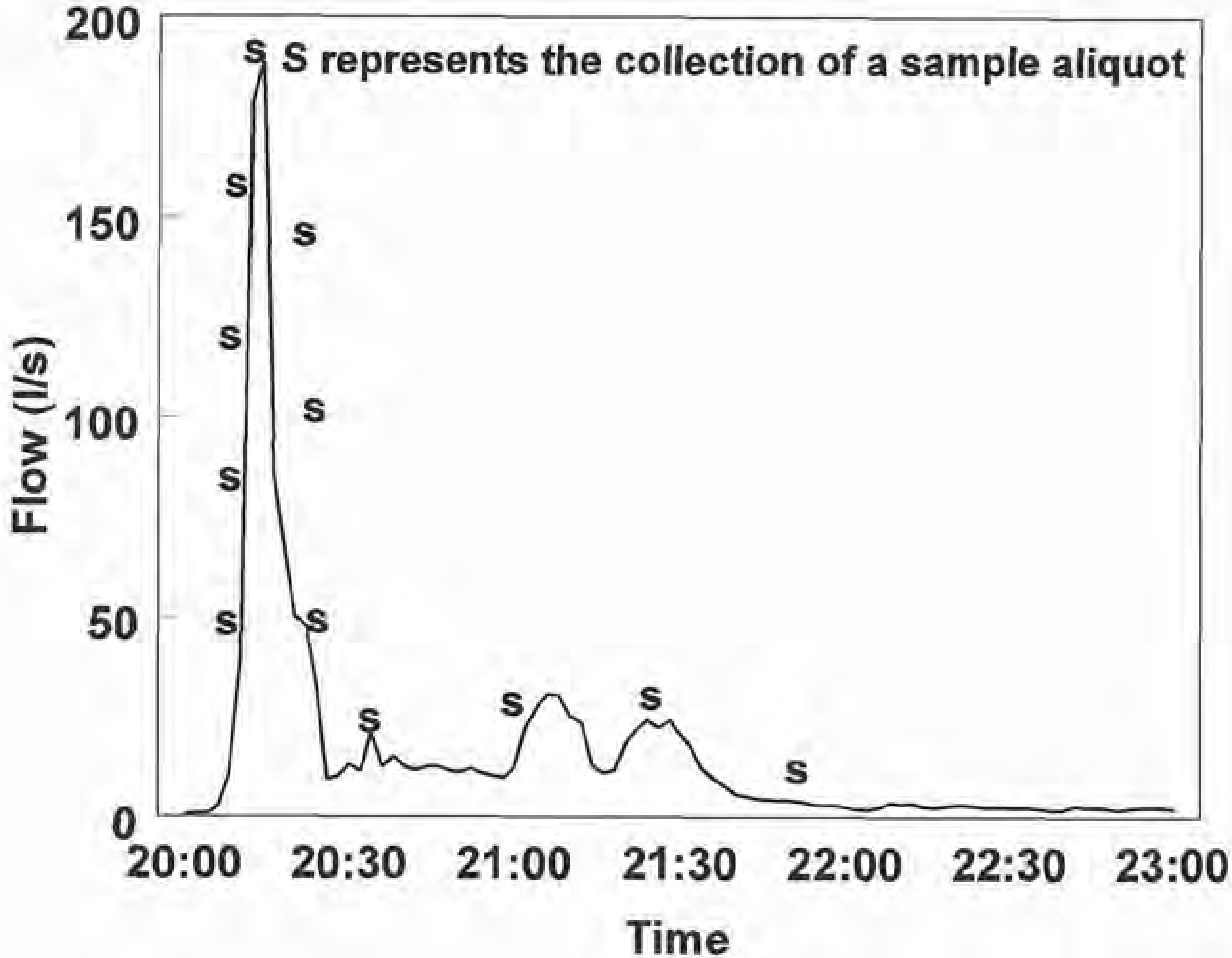
The wet weather sampling protocol was structured to collect composite samples of storm events (>5 mm precipitation) to determine pollutant concentrations of runoff with non-uniform washoff rates. Montedoro Whitney Q-Logger flow monitoring equipment was used to continuously record flow depth and velocity. The depth and velocity sensors are both contained within a single probe which is installed at the bottom of the sewer as close to the outfall as possible. Velocity is measured by a Doppler ultrasonic sensor and depth is measured by a pressure transducer. A laptop computer was used to program the unit and collect recorded data.

The flow monitoring equipment was programmed to measure flow at 2 minute intervals. This time interval was chosen to ensure that short duration/high intensity events would be monitored. Figure 2.1 illustrates the flow-weighted sampling regime of the Q-Logger during a rain event (See Appendix A for flow logger setups).

The flow monitoring equipment was interfaced with an automatic wastewater sampler that would collect flow weighted composite samples. The Q-Logger sampler trigger works from two settings. The first setting is the threshold depth, which when surpassed in the pipe, will initiate the sampling cycle. The second setting is a volume totalizer, which when surpassed, will trigger the sampling device. As flow volume increases in the pipe, the Q-Logger will trigger the sampler more frequently, resulting in a larger number of sample aliquots with the higher rates of flow. This regime provides a flow weighted composite sample of the storm event because more samples are taken during higher flows.

The automatic samplers employed for this study were ISCO Model 2700 samplers. These samplers work with peristaltic pumps where the only material in contact with the pump system is surgical grade silicone tubing. Teflon lined polyethylene tubing was employed for the intake line and a standard prewashed 9.5 litre glass container was employed to collect the composite samples. This system minimizes cross-contamination of samples (Maunder and D'Andrea, 1995).

Figure 2.1 Storm Event Proportional Sampling Regime



2.2.2 Flow Monitoring and Quality Sampling for the Coldwater Drain

An upstream/downstream difference approach to quantity and quality of flow was used in the Community of Coldwater as the urban area receives upstream drainage from an agricultural drain.

Environment Canada was contracted to monitor the streamflow of the Coldwater Drain upstream and at the Community of Coldwater. The two sites were installed on March 26, 1996 and operated continuously to June 7, 1996 (Environment Canada, 1996).

The instrumentation at each site consisted of a Campbell Scientific CR10X data logger, a Tavis water level sensor, and a dry bubble unit with a nitrogen gas cylinder. The CR10X was programmed to sample and log water levels every 5 minutes and ambient air temperature every 15 minutes with an attached thermocouple. The equipment was installed in a 'dog-house' structure mounted on a corrugated pipe pedestal.

Seventeen flow surveys were manually conducted over the monitoring period. These measurements were used to establish a water level-stream discharge rating curve. An average water level was computed for each day and a hydrograph was produced for the period of record.

Due to the fact that the CR10X datalogger did not have a flow actuator for triggering an automatic sampler, 24 hour composite samples of 72 aliquots were obtained. The automatic samplers were disassembled and installed in the 'dog-house' structure housing the other equipment. Whenever there was a chance of precipitation, the sampler was started and samples were taken at 20 minute intervals. In addition, 4 grab samples were taken at both sites to assist in baseline loading determination.

2.2.3 Dry Weather Monitoring

The dry weather sampling was structured for collecting water samples from the various outfalls during dry weather periods (operationally defined as 3 preceding days of no precipitation), making flow measurements and then determining contaminant concentrations and loadings (mass discharges).

Grab samples of flowing storm sewer water were taken from predetermined outfall locations. When the outfall was submerged or inaccessible, samples were taken at manholes close to the outfall using a reach pole from the ground surface. A total of three sampling runs were performed in an attempt to obtain representative samples during different seasons (Fall 1995, Spring 1996 and Summer 1996). This data was used to determine loadings during dry weather periods and to identify any potential illegal connections to the system.

At the initiation of the study, nineteen outfalls were identified as discharging significant dry-weather flow (>.5 litre/second). However, in a few instances the outfalls were dry or the flow was such that sampling was not possible.

2.3 Site Selection

The flow quantity and quality monitoring station sites were selected based on:

- drainage area;
- land use;
- geographic location; and
- ease of accessibility.

In total, seven monitoring sites were chosen for the wet weather monitoring program, four in the Town of Midland, two in the Town of Penetanguishene and one in the Community of Victoria Harbour. Table 2.1 provides information concerning the physical characteristics of each of the sites monitored for wet weather events and Figure 2.2a and Figure 2.2b illustrates their locations.

Table 2.1 Wet Weather Monitoring Sites Land Use Characteristics

Location	Total Area (ha)	Res/Inst Area (ha)	Com Area (ha)	Ind Area (ha)	Com/Ind Road Area (ha)	Vacant/Open Space (ha)
1.Penetanguishene	24.4	8.3	11	0	3.3	1.8
2. Midland	19.4	17.54	0.8	0	0.46	0.6
3. Midland	166.15	133.34	1.1	13.21	10.22	8.28
4. Midland	27.61	16.13	6.32	0	3.1	2.06
5. Victoria Harbour	19.48	11.79	3.23	0	1.72	2.74
6. Midland	67.74	52.89	4	0	2.57	8.28
7. Penetanguishene	46.68	42.23	0	0	0	4.45

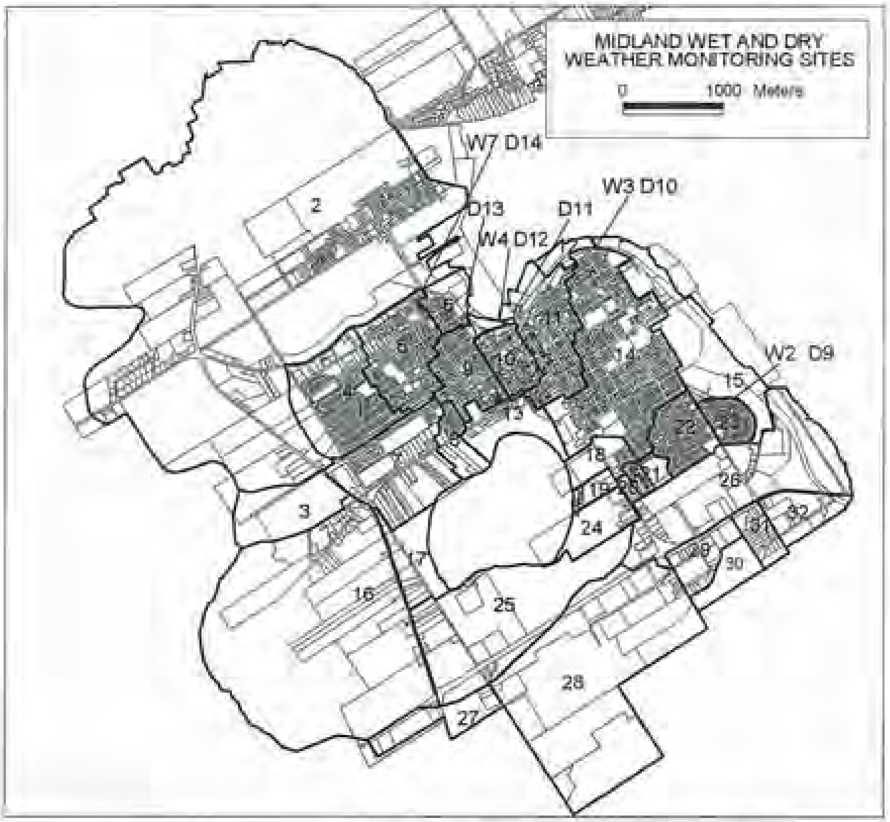
Dry weather monitoring sites were chosen based on similar criteria as wet weather sites. However, an additional criterion of baseflow >.5 L/s was also included. These sites and their land use characteristics are outlined in Table 2.2 and Figure 2.2a and Figure 2.2b illustrate their locations.

Table 2.2 Dry Weather Monitoring Sites Land Use Characteristics

Location	Total Area (ha)	Res/Inst Area (ha)	Com Area (ha)	Ind Area (ha)	Com/Ind Road Area (ha)	Vacant/ Open Space (ha)
1. Victoria Harbour	76.52	26.48	0.43	0	2.74	46.87
2. Victoria Harbour	61.56	18.81	4.63	3.87	1.84	32.41
3. Victoria Harbour	57.95	25.09	3.84	0	2.5	26.52
4. Victoria Harbour	19.48	11.79	3.23	0	1.72	2.74
5. Victoria Harbour 6. Victoria Harbour	30.26	22.91	0.38	0	0.08	6.89
7. Port McNicoll	7.89	6.56	0	0	0	1.33
8. Port McNicoll	36.83	17.88	0.06	0	3.69	15.2
9. Midland	19.4	17.54	0.8	0	0.46	0.6
10. Midland	166.15	133.34	1.1	13.21	10.22	8.28
11. Midland	68.65	32.72	18.5	5.36	7.92	4.15
12. Midland	27.61	16.13	6.32	0	3.1	2.06
13. Midland	45.64	37.42	0.56	0.08	0.6	6.98
14. Midland	67.74	52.89	4	0	2.57	8.28
15. Penetanguishene	74.22	58.05	0	0	0	16.17
16. Penetanguishene	14.5	10.91	0.31	0	0.14	3.14
17. Penetanguishene	24.4	8.3	11	0	3.3	1.8
18. Penetanguishene	10.25	8.15	0	0	0.7	1.4
19. Penetanguishene	2.08	0.21	0	0	0	1.87

Figure 2.2a Wet Weather and Dry Weather Monitoring Sites
W - Wet Weather Site, D - Dry Weather Site, C - Coldwater Site

Figure 2.2 b Wet Weather and Dry Weather Monitoring Sites



2.4 Sample Handling and Analytical Methods

Sample bottles (pre-cleaned) from the Ministry of the Environment were used for the submission of all samples. The Ontario Ministry of the Environment Laboratory Services Branch performed the chemical analysis for all conventional parameters, microbiological parameters and heavy metals as listed below:

1. *Basic Chemistry* - chloride, sodium, potassium, conductivity, pH, turbidity, ammonia & ammonium, nitrite, nitrate+nitrite, phosphate, suspended solids, total phosphorus, total kjeldahl nitrogen, dissolved organic carbon, dissolved inorganic carbon, reactive silicate.

2. *Microbiology* - E. coli, faecal streptococci, Pseudomonas aeruginosa (dry weather and bathing area sampling only).

3. *Heavy Metals* - Copper, Nickel, Zinc, Cadmium, Cobalt, Chromium, Lead, Iron, Manganese, Aluminum, Vanadium, Molybdenum, Barium, Beryllium, Strontium, Titanium.

Analytical methodologies described by the M0E (1988) were used in these analyses.

2.5 Catchment Characterization and Baseline Data Collection

The implementation of the Retrofit Stormwater Management Practices (RSWMP) model applied for this study requires the collection of baseline data to calculate runoff quantity and quality, and to determine the suitability of RSWMP options on a site specific basis. ARCVIEW®, a Geographic Information System (GIS), was utilized to assist in the compilation and graphical representation of these baseline data requirements in the form of maps.

For all the municipalities involved, digitized basemaps of all properties were made available by the municipal partners. By applying standard digital tax assessment information, the land use and size of individual lots were determined. Once the drainage/sewershed areas were delineated and digitized onto the basemaps, total area by land use was calculated through the GIS.

The RSWMP model also requires other data to calculate stormwater pollutant loadings and the effectiveness and costs of the various RSWMP options. These baseline data requirements are outlined in Table 2.3.

Table 2.3 Data Required To Evaluate The Control Effectiveness And Cost Of RSWMPs (Li, 1996)	
Baseline Calculation	residential, commercial, industrial, and institutional drainage areas (ha), runoff coefficient, depression storage (mm), percent of impervious area of various land uses, average rainfall event volume (mm), average annual number of rainfall events (#/yr), average runoff event pollutant concentration (mg/L)
Downspout Disconnection	total number of lots, total roof area, residential area qualified for the disconnection, resident participation percentage (%), unit cost ($/ha/% participation)
Infiltration Trenches	area qualified (ha), length of road qualified (m), percent application (%), runoff reduction efficiency (%), unit cost ($/m)
Oil/Grit Separators	impervious area of various land uses (ha), treatment efficiency (%), percent of application (%), unit cost ($/ha)
Exfiltration Systems	area qualified (ha), length of road qualified (m), percent application (%), runoff reduction efficiency (%), unit cost ($/m)
Quantity Pond Retrofit	drainage area of various land uses (ha), storage requirement (m^3/ha), treatment efficiency (%), unit cost ($/$m^3$)
New Quality Ponds	drainage area of various land uses (ha), storage requirement (m^3/ha), treatment efficiency (%), unit cost ($/$m^3$)

2.6 Urban Bathing Area Monitoring Program

Excessive algal growth in Severn Sound has been of public concern since the mid 1960s. The algae growth forms unsightly scum and layers of turbid water that discourage recreational uses such as bathing and boating. Severn Sound has many sheltered bays that are popular bathing areas. Bacteriological analyses of water samples taken by the Simcoe County District Health Unit and the Severn Sound RAP suggest that some of these bathing areas have elevated bacteria that periodically exceed Ontario Ministry of Health's (OMOH) Beach Management Protocol (1992) for bathing areas. In 1992, the indicator organism tested for by the OMOH laboratory was set as Escherichia coli (E. coli), with a maximum allowable density of 100 organisms per 100 ml of test water (OMOH, 1992). As such, this organism and respective density was used as the bench mark for this study.

2.6.1 Bathing Area Sampling Program

Previous sampling of bathing areas in the Severn Sound AOC was not related to storm events. Other studies (St. Catharines Pollution Control Plan (PCP), Peterborough PCP) have found a close relationship between bacteria counts at bathing areas and storm events. This implies that sampling design must include coordination of source monitoring and bathing area monitoring during rain events in order to establish a cause/effect relationship. However, bathing area sampling methodologies have been problematic for posting warnings regarding bathing water quality because:

- *Variability of Bacteriological Results* - Indicator bacteria densities in water are known to be highly variable under natural conditions (MOEE, 1994b). In addition, results of individual tests require care in sampling, timely transport to labs and analysis.

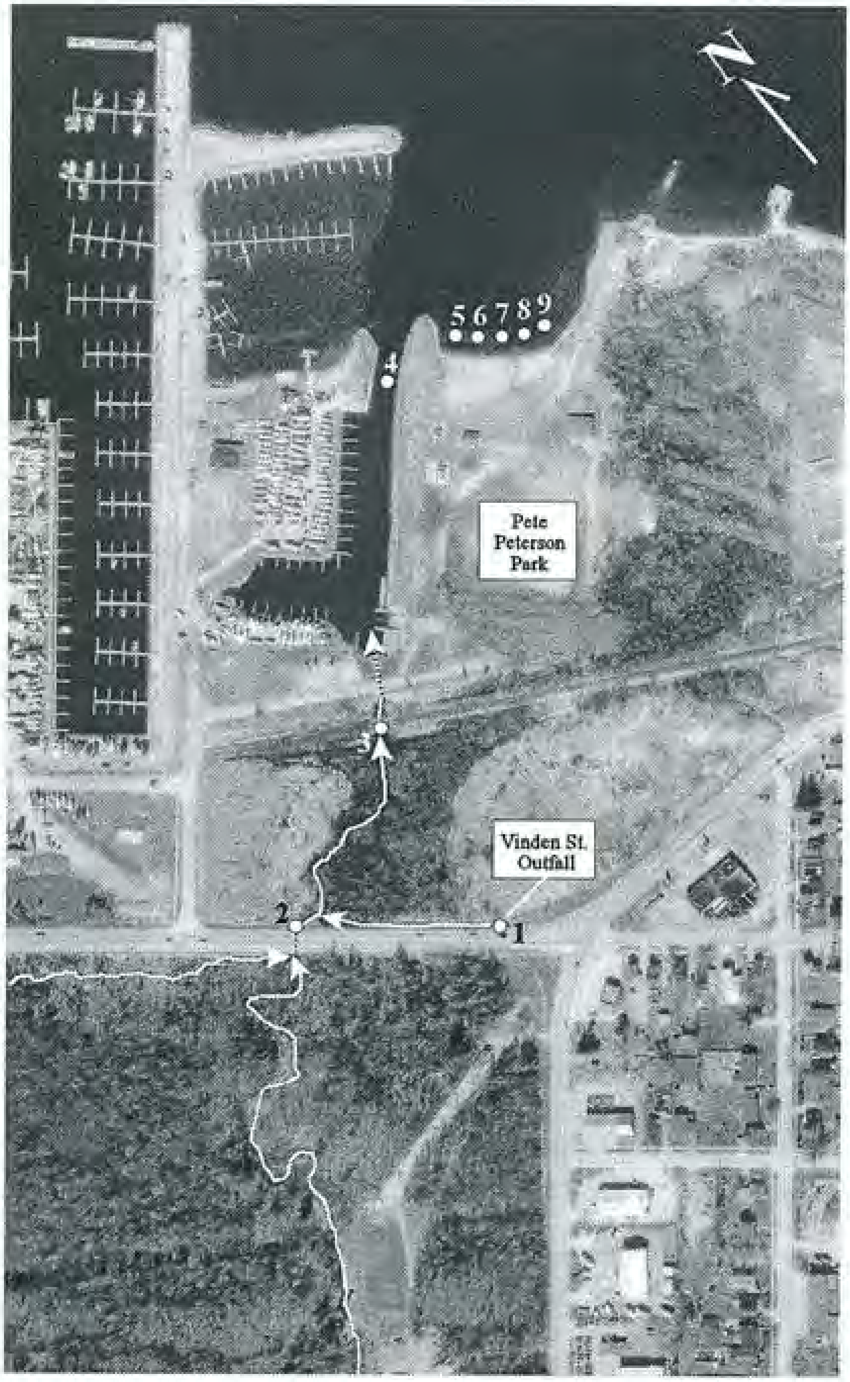
- *Insufficient Resources to Sample Frequently Enough*- The Simcoe County District Health Unit performs routine sampling of local bathing areas but logistical considerations (available personnel and lab services) prevent intensive evaluation. The time lag between sampling, reporting of results and resampling to confirm results often spans changed weather conditions, allowing for die-off of bacteria following rain events and time for exchange of storm water flows with open water.

Due to the rather large number of potential bathing areas in the urban areas of Severn Sound, a focused approach to monitoring bathing areas was adopted. Instead of taking weekly samples at all urban bathing areas during the summer months, a single urban bathing area was identified for more intensive study. This site, Pete Peterson Park, is located in Midland Bay, adjacent to a marina and subject to input of stormwater discharge from multiple large urban catchments (Figure 2.3).

Factors considered in the analysis of the bacteriological quality of this bathing area include:

1. configuration of the bathing area;
2. wind and currents;
3. precipitation;
4. proximity to discharges; and
5. structures in the area.

Figure 2.3 Pete Peterson Park Bathing Area Location



Note: Diagram not to scale. Flow Path ○ Sampling Site

As per Figure 2.3, the discharge from the Vinden Street storm outfall flows through a ditch to a creek (a distance of approximately 200 m). This flow then mixes with the creek flow as well as local drainage along Fourth Street and travels approximately 150 m through a small wetland before discharging into the marina basin. The discharge then flows through the marina (a distance of approximately 220 m) before reaching Midland Bay and the bathing area at Pete Peterson Park. Based on water current modelling in Severn Sound (Gore and Storrie, 1996) the ambient current speeds expected along the bathing area should typically be quite small or negligible. Measurements of temperature in the marina basin indicate that the basin is thermally stratified at the point of discharge, with the cooler discharge sinking immediately upon entering the basin. The stratification becomes less evident 50 m from the point of discharge, suggesting that the discharge is dispersed vertically through the water column as it travels toward Midland Bay.

Water quality time series measurements were taken at nine sites located from the Vinden Street outfall to the bathing area at Pete Peterson Park (Figure 2.3). Water flow time series measurements were made at points along the flow path. These flow measurements were conducted with a Montedoro-Whitney Q-Logger installed at the Vinden Street outfall and dye tracing at the outlet into the marina basin. In addition to wet weather monitoring, measurements were made during dry weather to document low flow conditions and the physical and temperature characteristics of the marina basin and bathing area.

A hydraulic and quality model developed by the Standards Development Branch of the Ministry of Environment and Energy was used to model the estimated time of travel and measurements of bacteria density from the outfall to the bathing area. The model simulates an inflow-storage-outflow segment or reservoir linked series. Contaminant transport between the reservoirs is assumed to be flow induced (i.e. no significant lake currents were present).

3.0 MODELLING APPROACH

3.1 Retrofit Stormwater Management Practices (RSWMP) Modelling

Retrofit stormwater quality/quantity management in existing urbanized areas poses significant problems to municipalities and regulators alike. Unlike stormwater management strategies associated with new developments, stormwater management in existing urbanized areas typically involves rehabilitation, retrofitting and redevelopment of infrastructure, often through capital intensive undertakings.

Realizing the limitations of traditional new development stormwater management practices in existing urbanized areas, Li (1997) developed a planning strategy that takes into consideration new technologies, maintenance plans, road need studies and capital budget plans of municipalities. This was accomplished in cooperation with the Great Lakes 2000 Cleanup Fund, the Ministry of the Environment and the City of Scarborough, and focused on the Centennial Watershed in Scarborough. Issues such as basement flooding, baseflow augmentation, stream rehabilitation, physical space restriction and spill control are particularly important in this approach to developing stormwater management strategies for existing urbanized areas. In addition, the approach examines retrofit options in a hierarchial fashion, with source controls a priority and more costly conveyance system and downstream options being considered only where source controls are not feasible.

The Retrofit Stormwater Management Practices (RSWMP) model developed for the Centennial Watershed study follows five steps:

1. Identify ecosystem/economic goals and objectives.
2. Identify feasible RSWMP for the study area.
3. Formulate alternative management strategies.
4. Evaluate alternative strategies with respect to ecosystem/economic objectives.
5. Select preferred alternatives for stormwater management, integrating installation with municipal capital works and operations.

In Severn Sound, the urban areas are relatively small in size and not as densely populated as in larger centers. Stormwater studies in other AOCs have focused on large scale and often high cost remediation activities that would not necessarily be practical or feasible for application in smaller municipalities. As a result, the five steps of RSWMP modelling were applied with consideration for local conditions and needs.

3.1.1 RSWMP Goals and Objectives

In relation to the urban stormwater management component of the RAP, the general principles of the ecosystem approach and sustainable development can be applied as follows:

1. maintain and rehabilitate the hydrologic cycle;
2. maintain and rehabilitate runoff and surface water quantity and quality; and,
3. maintain and rehabilitate the physical, chemical and biological relationships of the water ecosystem.

The economic goals of the RSWMP approach to stormwater management can be defined as:

1. integrate a stormwater quality management strategy with municipal capital works and operation and maintenance programs;
2. minimize the capital and operation and maintenance costs of RSWMPs; and
3. rationalize and streamline the approval process of stormwater related capital works and operations and maintenance programs.

Consideration of both the ecosystem and economic goals results in the following site-specific measurable objectives:

1. reduce runoff volume;
2. improve water quality with the removal of pollutants from runoff (20% reduction of phosphorus loading);
3. incorporate RSWMPs in municipal stormwater related capital works projects;
4. locate RSWMPs preferably on municipally owned sites and right-of-ways; and
5. promote the use of innovative and cost-effective technologies.

The measurable objectives above have been used to continuously evaluate the effectiveness of the stormwater management strategy in the various urban areas of Severn Sound.

3.1.2 Identification of Feasible RSWMPs

The identification of feasible RSWMPs should take into consideration the ecosystem and economic goals and objectives outlined above. In addition, the physical and financial constraints associated with potential sites within the AOC have to be recognized. As a result, the categories of RSWMPs being examined in this study are as follows:

i. Non-Structural Management Controls
ii. Source Controls
iii. Local Drainage Controls
iv. Inlet Controls
v. System Controls
vi. Outlet Controls

It is important to note that the list of stormwater management practices examined for this study should not be considered exhaustive. The practices included were chosen because efficiencies associated with them are generally agreed upon and there was an existing model in place to determine potential loading reductions.

i. Non-Structural Management Controls

Non-structural management control measures are pollution prevention techniques that focus on public education and by-law enforcement. Such measures include:

- Encourage and educate homeowners to reduce fertilizer and pesticide/herbicide use.
- Modify municipal practices of fertilizer and pesticide/herbicide use in parks, including allowing more areas to revert to natural vegetation.
- Establish household hazardous waste disposal programs.
- Establish and enforce sewer use bylaws for industrial and commercial areas.
- Institute and enforce 'poop-and-scoop' bylaws.
- Ensure that catch basin water and solids are disposed of properly when cleaned.
- Promote programs such as the 'Yellow Fish Road' where school children paint fish on catch basins to warn against using them to dispose of toxic chemicals or waste.

Although it is impossible to quantify the benefits of such activities, public education with regards to environmental stewardship are generally considered necessary for successful pollution reduction/control strategies.

ii. Source Controls

Source controls involve measures to reduce and/or treat stormwater before it reaches the local conveyance systems (storm sewer, swales). Since source controls are lot-level measures, the implementation of these practices requires the participation and cooperation of the building lot landowners. Source control measures are designed solely to reduce the volume of stormwater entering the storm sewer. The source control considered in this study is downspout disconnection.

a. Downspout Disconnection

In many urban areas, the precipitation that falls on roofs is conveyed through the building's eaves troughs directly to the storm sewer or to impervious surfaces such as driveways. Disconnecting the roof leader from the storm sewer system is often a cost-effective source control measure. By returning the roof runoff to soils through infiltration, the runoff volume and solids loadings are reduced (Li, 1997). The Ministry of the Environment (MOEE, 1994a) has identified two downspout disconnection systems that have shown to be effective control measures. This RSWMP is suitable for a site where the local lot grading is gentle and sufficient lawn areas are available. It is also desirable to have a sandy soil and a low groundwater table on site so that the diverted runoff will not be detained on the lawn over an extended period of time. Methods include downspout connection to yard ponding areas and to soakaway pits (Figure 3.1).

Ponding areas can be created in backyards where feasible. Downspouts are connected to the ponding area via a splash pad and an overland flow route. The water is detained in the shallow ponding area until it evaporates or infiltrates into the ground below. In addition to ponding in the yard area, rain barrels can be incorporated which have the added benefit of promoting water conservation as the captured water can be used for watering gardens or washing cars.

If ponding is unwanted, a soakaway pit can be installed. A soakaway pit is a trench which can be created on the building lot. By connecting the roof leader to a perforated pipe extending the full length of the trench, roof water can flow into the pit and be detained until it infiltrates (Figure 3.1).

For the purposes of baseline data collection, a ground survey of residential areas was performed to identify houses with downspouts draining onto impervious surfaces. In addition, residential areas that possessed good lot grading (<3% slope) were identified. Based on this information, the most likely suitable areas for implementation were identified. The percent participation (50%) and unit cost of the disconnections (capital cost of $50/lot for the first 40% of participating households, $300/lot for the remainder; no operations and maintenance costs) was assumed to be equal to that in the Centennial Watershed study. It was also assumed that this RSWMP would not contribute to loading reductions during winter months due to ground saturation or frozen state.

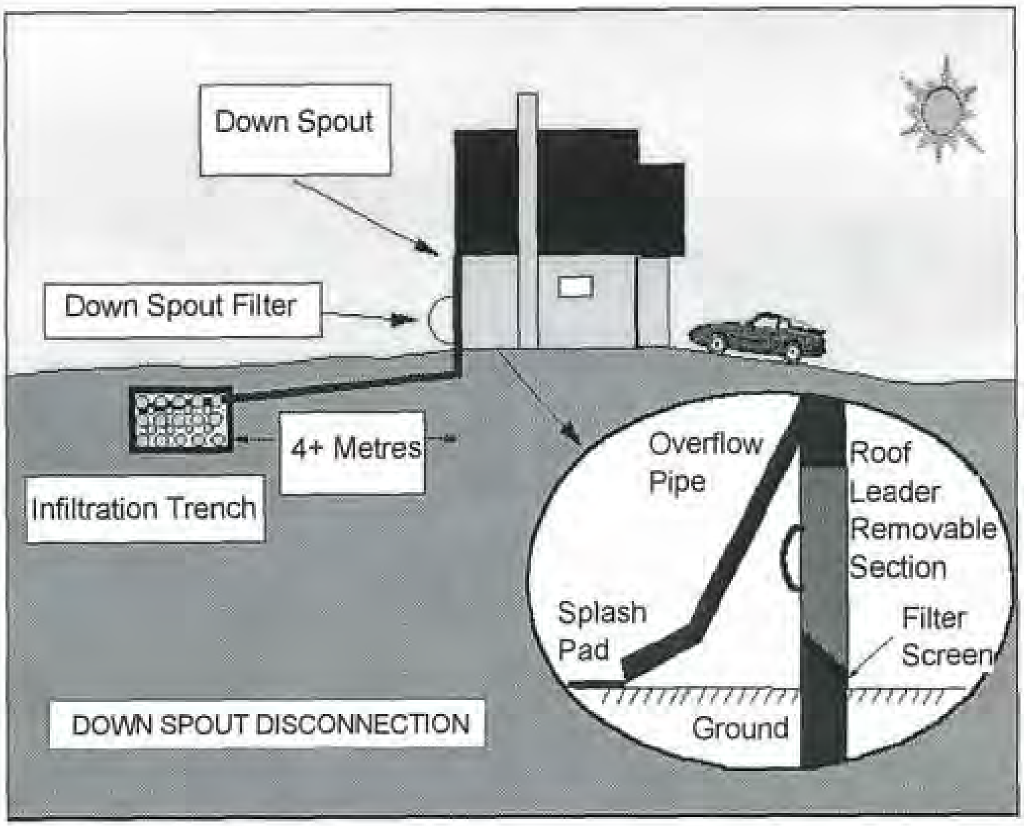


Figure 3.1 Downspout Disconnection Detail (MOEE, 1994a)

Table 3.1 Downspout Disconnection Assumptions

Assumption	Rationale
Cost First 20%-$50/household Remainder-$300/household	$50 represents the cost of materials required for a downspout disconnection (concrete splash pad, elbow, overflow pipe, etc.). The cost assumes that the first 40% of participating households will be willing to install the equipment themselves. The remainder of participating households will require Town employees to install the equipment.
Participation 50%	Based on the Centennial Watershed Study, a participation rate of 50% was assumed for all suitable properties for downspout disconnection.

iii. Local Drainage Controls

Local drainage controls are used primarily to treat stormwater runoff from several properties, as opposed to source controls that are utilized primarily for a single building and lot. The local drainage controls being considered in this study include infiltration trenches and swales and ditches.

a. Infiltration Trench

Infiltration trenches are systems with stormwater storage below the surface of the soil. The trenches are comprised of a clear stone storage layer and a sand or peat filter layer (MOEE, 1994a) (Figure 3.2). The trench system is often used in residential areas to enhance infiltration in ditch drainage systems. The enhanced infiltration decreases both the volume of runoff and the amount of suspended solids and associated nutrients reaching the receiving body of water .

Due to the predominance of curb and gutter stormwater conveyance structures in major urban centres, focus for the potential trench implementation remained on the smaller municipalities that are presently utilizing ditches and on vacant undeveloped lands.

Because infiltration trenches were not considered for the Centennial Watershed study, cost functions and suitability criteria had to be developed. Storage, design, capital and operations and maintenance information were all obtained from the Ministry of the Environment's Stormwater Management Practices Planning and Design Manual (MOEE, 1994a). For this study, a treatment efficiency of 70% (10% for snowmelt runoff in winter) and a cost of $10,000/ha of treatment has been assumed (capital cost of $6,500/ha treatment and operational and maintenance cost of $3,500 over 25 years).

b. Swales and Ditches

Swales and ditches are open stormwater conveyance systems constructed of soil. The soil base of these conveyance systems makes them well suited for stormwater infiltration. Improved infiltration can be achieved by retrofitting a ditch or swale with an infiltration trench or similar structure. In addition, the soil base of swales and ditches can be planted with appropriate species of vegetation that promote flow resistance/detention and the uptake of nutrients and other contaminants.

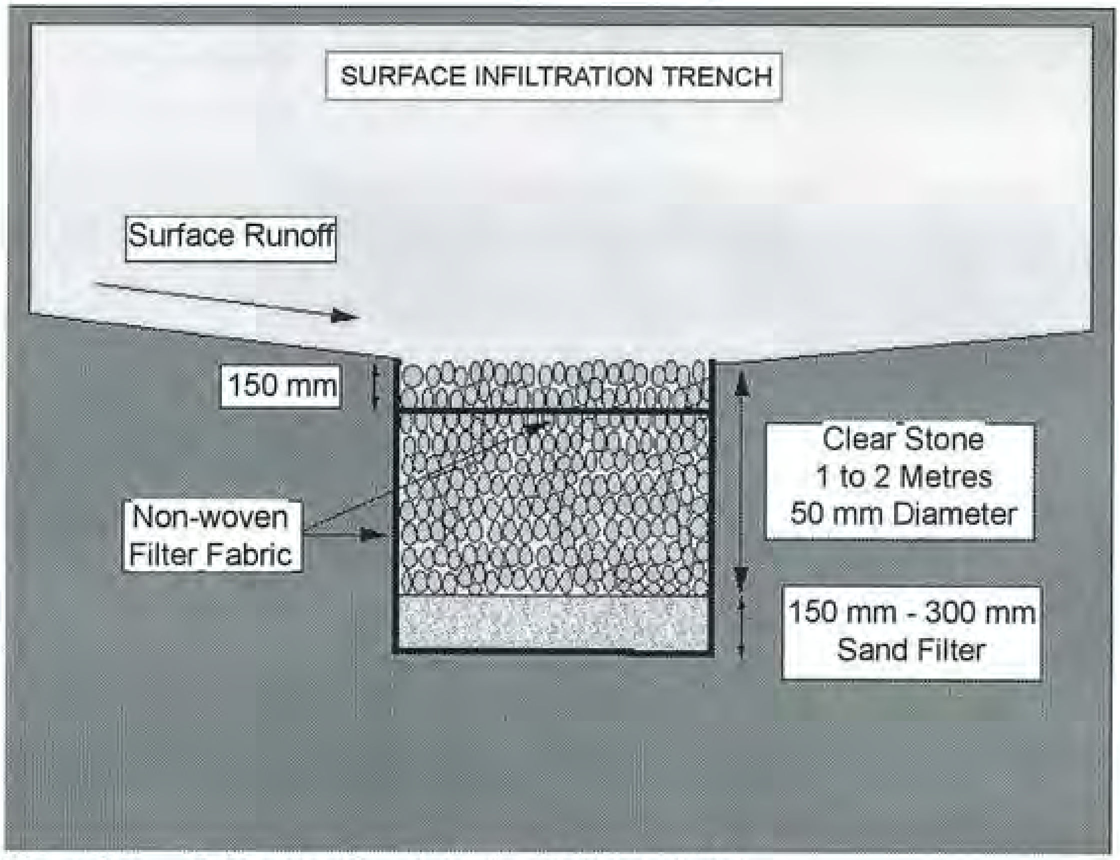


Figure 3.2 Infiltration Trench Design (MOEE, 1994a)

Table 3.2 Infiltration Trench Assumptions	
Assumption	**Rationale**
Runoff Reduction Efficiency 70%	Due to the fact that infiltration trenches were not considered in the Centennial Watershed Study, the efficiency and cost of this stormwater management practice were developed based on local conditions and Figures 4.2 to 4.5 in the MOE Stormwater Management Practices Planning and Design Manual. Based on the typical soil conditions of the area, a runoff reduction efficiency of 70% was assumed.
Cost $10,000/ha	A capital cost of $6,500/ha was calculated with an O&M cost of $140/yr/ha.

iv. <u>Inlet Controls</u>

Inlet controls are treatment devices which are designed to remove sediments, oil and other pollutants in runoff before they enter a storm sewer system. The inlet control to be considered in this study is the oil/grit separator.

a. Oil/Grit Separators

Oil/grit separators are generally installed at commercial and industrial parking lots to capture spills and small runoff events. This RSWMP can also be installed in municipal roads when a sewer system is undergoing reconstruction/rehabilitation.

In most designs, a typical oil/grit separator is comprised of three chambers (MOEE, 1994a) (Figure 3.3). The first chamber is designed to trap sediment, grit, and floatable debris, while the second chamber is designed to trap oil. The third chamber contains a permanent pool to further trap the fine sediments.

Generally, it has been noted that older separators were unable to provide protection against the scouring action of high flows, allowing accumulated oil and sediments to be flushed out of the separator during higher magnitude rain events. The overall pollutant removal efficiency is reported to be about 10 to 20%. Li (1997) has indicated that several alternative designs have incorporated a scour protection mechanism for high flows and a large storage tank for the trapped oil and sediments. Under low flow conditions, storm runoff is captured and treated before it enters the sewer. Under high flow conditions, the excess storm runoff passes the scour protection mechanism which prevents resuspension of the trapped sediments and oil.

As per the Scarborough study (Li, 1997), a treatment efficiency of 30% and a unit cost of $20,000/ha of impervious area were assumed for oil/grit separators (capital cost of $17,000/ha and operational and maintenance cost of $3,000/ha over 25 years). In addition, a 30% treatment efficiency was applied for snowmelt runoff during winter months.

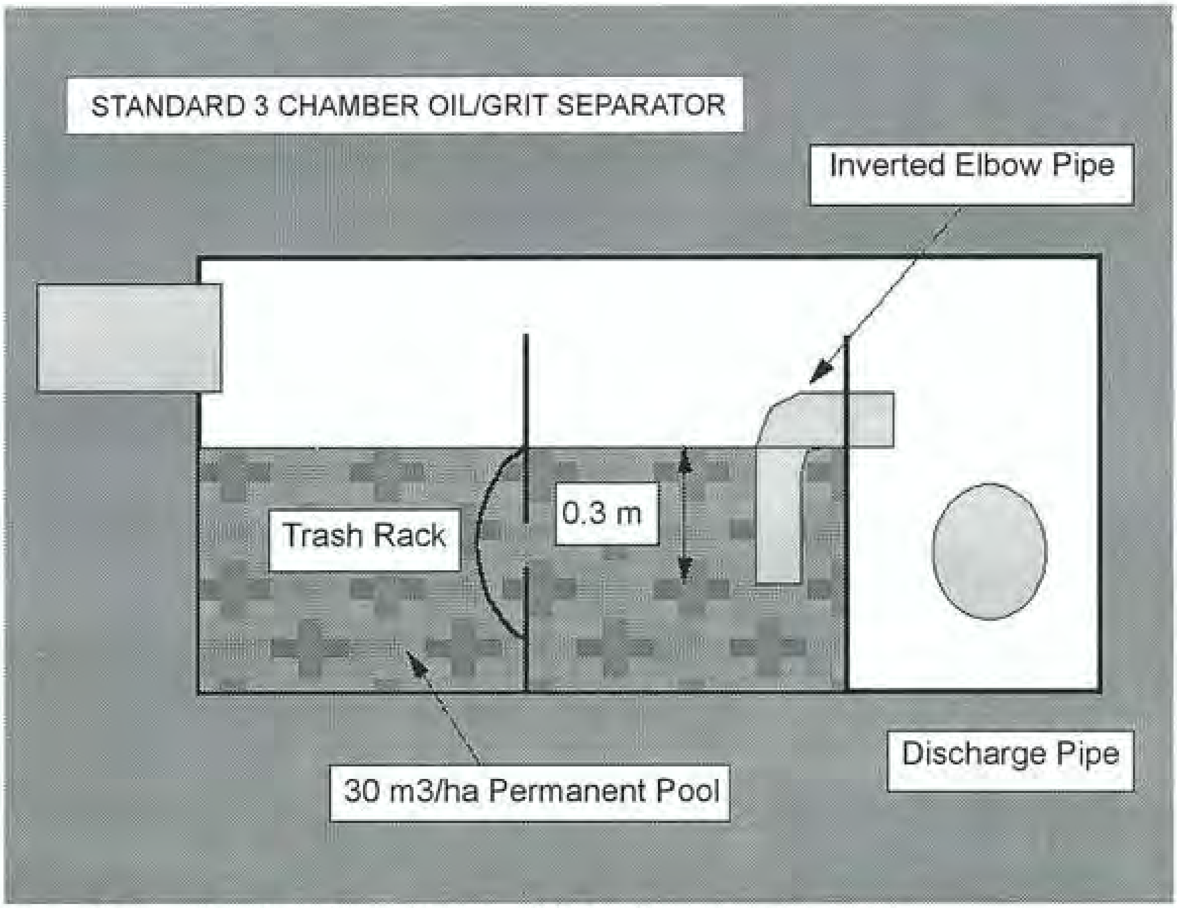


Figure 3.3 Standard Three Chamber Oil/Grit Separator (Li, 1997)

Table 3.3 Oil/Grit Separator Assumptions	
Assumption	**Rationale**
Treatment Efficiency 30%	Due to conflicting reports regarding the treatment efficiency of oil/grit separators, a 30% treatment efficiency was adopted as per the Centennial Watershed Study (efficiency developed by G.M. Sernas and Associates, Mississauga, Ontario).
Cost $20,000/ha impervious area	Capital Cost - $18,000/ha impervious area O&M Cost - $80/yr

v. System Controls

System controls are those practices used to retrofit the stormwater conveyance system. The stormwater exfiltration system is the only system control considered in this study.

a. Stormwater Exfiltration Systems

A stormwater exfiltration system is comprised of two perforated pipes, plugged at the downstream end. The two pipes are attached to and installed below the storm sewer. During a runoff event, the first flush is directed to the perforated pipes. For a large runoff event, excess runoff bypasses the perforated pipes and travels through the storm sewer. With a surrounding granular bedding, this pipe-trench system is usually designed to store the runoff of a 15 mm rainfall event and allow exfiltration within 2 or 3 days (Li, 1997) (Figure 3.4). The exfiltration system can be constructed within the right-of-way and is best integrated with storm sewer replacement or road rehabilitation projects. However, Li (1997) indicates that the exfiltration system is not suitable for sites where there is concern with groundwater contamination by urban runoff and spills, and/or damage to road beds by infiltrated water.

Using a continuous simulation model, the long-term average runoff control effectiveness of a 2.5 km section of exfiltration pipe installed in three fully developed areas of the City of Etobicoke has been found to vary between 80% and 95% (Li, 1997). As such, a 90% runoff reduction efficiency has been assumed for both rainfall runoff and snowmelt runoff in this study. For the Scarborough study, a unit cost of exfiltration systems on roads in poor and good condition was assumed to be $60/m. This value has been decreased to $53/m based on local costing information.

Existing Road Needs studies produced by the local municipalities provided one component of the suitability criteria for determining suitable locations for both oil/grit separators and exfiltration systems. Any roads slated for replacement in the next 25 years were favourable locations for these RSWMPs.

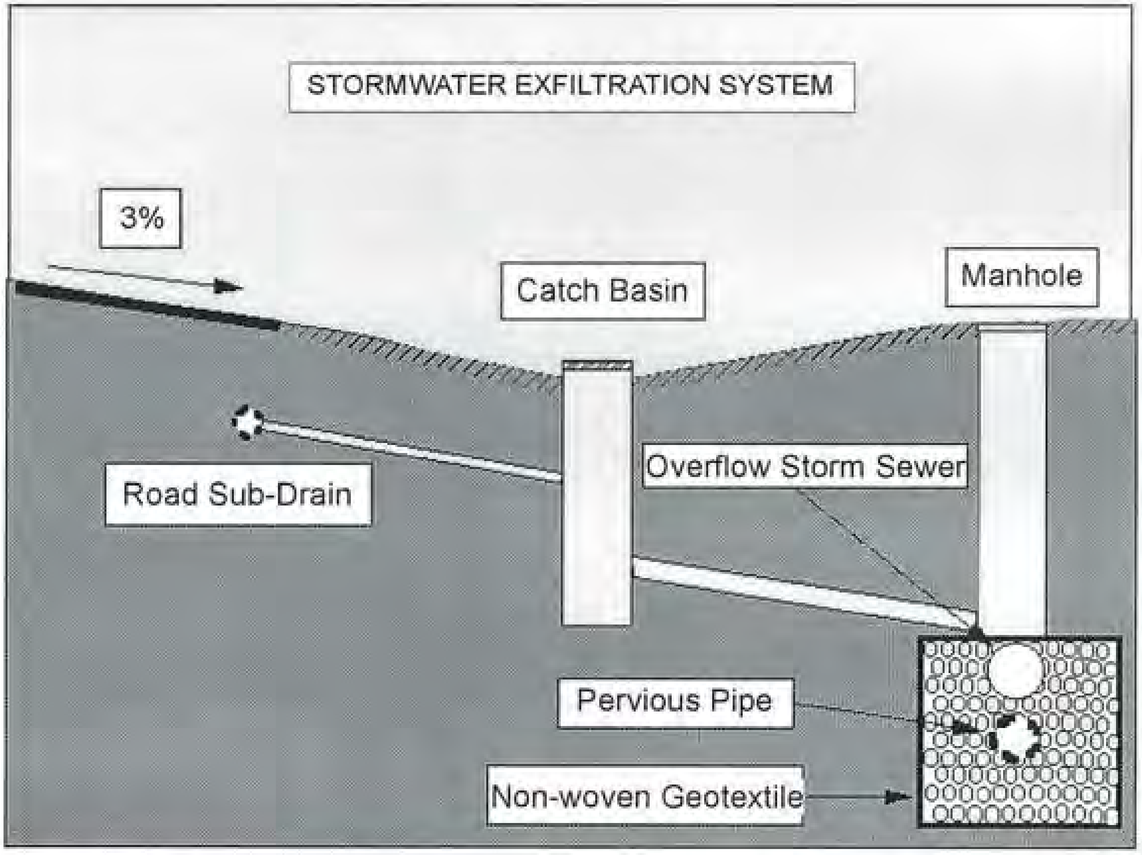


Figure 3.4 Stormwater Exfiltration System and Pervious Pipe Detail (MOEE, 1994a)

Table 3.4 Exfiltration System Assumptions

Assumption	Rationale
Runoff Reduction Efficiency 90%	As per the Centennial Watershed Study, a runoff reduction efficiency of 90% has been assumed (based on long-term simulation using STORM).
Cost $53/m of sewer	As per the Centennial Watershed Study, a cost of $53/m of sewer length was assumed

vi. Outlet Controls

Outlet controls are end-of-pipe stormwater management facilities used to treat stormwater following its collection in the conveyance system. Quantity Pond Retrofits and New Quality Ponds are the outlet controls being considered in this study.

a. Stormwater Quantity Pond Retrofit

Stormwater quantity ponds can be retrofitted to provide a water quality treatment function with:

1. the construction of a shallow sediment forebay at the pond entrance;
2. the construction of wetlands for nutrient removal;
3. the creation of storage area by excavating below the current pond bottom or sides;
4. the construction of a restrictive riser pipe outlet; and,
5. the construction of a barrier to lengthen the flow path between inlets and outlets.

It is important, when considering this alternative, that the storage capacity for flood control be maintained and that the public be informed of the water quality function of the pond (MOEE, 1994a).

The Ministry of the Environment (MOEE, 1994a) reports computer model simulations that indicate a 60% (dependant upon % imperviousness) solids concentration reduction efficiency in quantity pond retrofits with 60 m^3 of storage per hectare of drainage area. This value has been assumed for this study. In addition, a capital cost of \$21/m^3 and an operational and maintenance cost of \$4/m^3 over 25 years has been developed based on local land and construction costs.

b. Stormwater Quality Ponds

Quality ponds are the most reliable end-of-pipe stormwater management facility for pollutant removal (MOEE, 1994a). New stormwater quality ponds can be considered as RSWMPs if they can be retrofitted to an existing storm drainage system (Li, 1997). Space for construction and available maintenance are also important considerations. Quality ponds are comprised of a sediment forebay area followed by a pond area containing wetland and submerged plants for pollutant removal (Figure 3.5). The permanent pool of a quality pond provides an area where stormwater can be detained for long periods of time. The detention of the stormwater allows the settling of sediments to the pond bottom. In addition, the permanent pool prevents the re-suspension of settled sediment, provides an area for biological removal of pollutants and provides an area for infiltration to the ground below.

Li (1997) cites a number of design criteria to consider in order for a stormwater quality pond retrofit to be efficient and cost-effective. The criteria include: a drainage area greater than 5 hectares; an elevation greater than the 100 year flood level to prevent flooding, and minor and major drainage system outfalls discharging at different locations so only the first flush from the minor drainage system is captured and treated.

Li (1997) cites a MOE computer simulated treatment efficiency of 60% to 90% for suspended solids in a quality pond. For the purposes of this study, a treatment efficiency of 60% was assumed for both rainfall runoff and snowmelt runoff. In addition, a capital cost of $\$31/m^3$ and an operational and maintenance cost of $\$4/m^3$ over 25 years of storage created was assumed based on local land and construction costs.

For each of the RSWMP options considered for this study, many of the assumptions applied for the Scarborough study were applied. In terms of the cost functions associated with the RSWMP options, the same values have been adopted unless local municipal experiences have warranted a change. In addition, the runoff volume and solids concentration reduction efficiencies of these RSWMPs have been assumed to be the same.

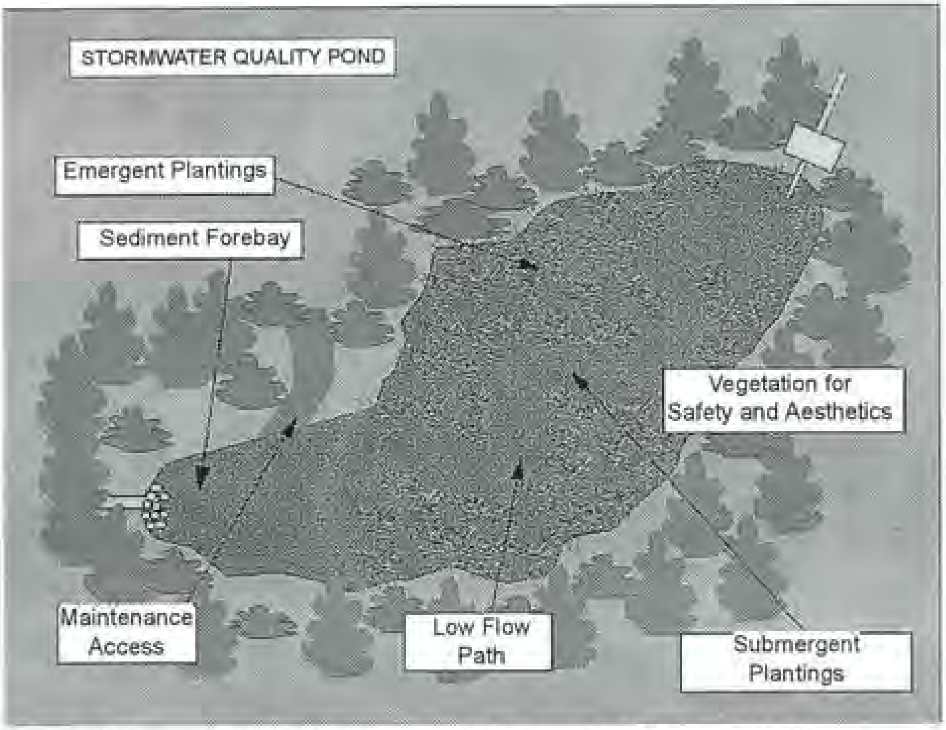


Figure 3.5 Extended Detention Wet Pond (MOEE, 1994a)

Table 3.5 Quantity Pond Retrofit Assumptions	
Assumption	**Rationale**
Treatment Efficiency 60%	As per the Centennial Watershed Study, a treatment efficiency of 60% was assumed for quantity pond retrofits.
Cost $\$25/m^2$	Based on local experiences, a capital cost of $\$21/m^2$ with an O&M cost of $\$4/m^2$.

Table 3.6 New Quality Pond Assumptions	
Assumption	**Rationale**
Treatment Efficiency 60%	As per the Centennial Watershed Study, a treatment efficiency of 60% was assumed for new water quality ponds.
Cost $\$35/m^2$	Similar to quantity pond retrofits, a capital cost of $\$21/m^2$ with an O&M cost of $\$4/m^2$. However, due to the lack of municipally owned lands, it was necessary to factor in land costs for new ponds. Based on local information, an additional $\$10/m^2$ was incorporated to take into account land costs ($120,000/ha for industrial lands).

3.1.3 Formulation of Alternative Stormwater Management Strategies

There is a preferred hierarchy associated with stormwater management measures (Li, 1997) (Figure 3.6). Control of runoff at the source (or as close as possible) is always a preferred strategy, minimizing the capital expenditures required for infrastructure and maintaining the spatial and temporal characteristics of the natural hydrologic features of an area. In addition, by emphasizing low cost source and drainage system controls, the RSWMP measures can be integrated effectively with municipal capital and operating programs on a gradual basis (Li, 1997).

Alternative stormwater quality management strategies are formulated, combining the various RSWMPs in accordance with the hierarchy. This approach allows analysis of the most cost effective approaches to stormwater management first, with the examination of progressively more capital intensive projects until the overall loading reduction objective is achieved. For the purposes of this study, an overall loading reduction goal for phosphorus of 20% has been assumed. In addition, a staged implementation plan has been developed to assist the local municipalities with budgeting and planning information. Strategies of 0-10 and 10-25 years (where applicable) indicate locations of potential RSWMP projects and their associated capital and operational and maintenance costs. Following are some examples of alternatives for stormwater management strategies based on this hierarchy:

1. Downspout disconnection, ditch rehabilitation, exfiltration systems.
2. Downspout disconnection, exfiltration systems, quantity pond retrofit.
3. Oil/grit separators, exfiltration systems, quantity pond retrofits, new quality ponds.

3.1.4 Evaluation of Alternative Strategies

The alternative stormwater management strategies considered for Severn Sound were evaluated based on their achievement of the ecosystem and economic objectives identified in Section 3.1.1. For the purposes of this study, a similar approach as that taken for the Scarborough study has been followed. Analytical probabilistic models (Adams and Bontje, 1983; Li, 1991) and a multi-efficiency model (Weatherbe, 1995) were applied because they are suited to a planning level analysis of RSWMPs (See Appendix C for a description of these models).

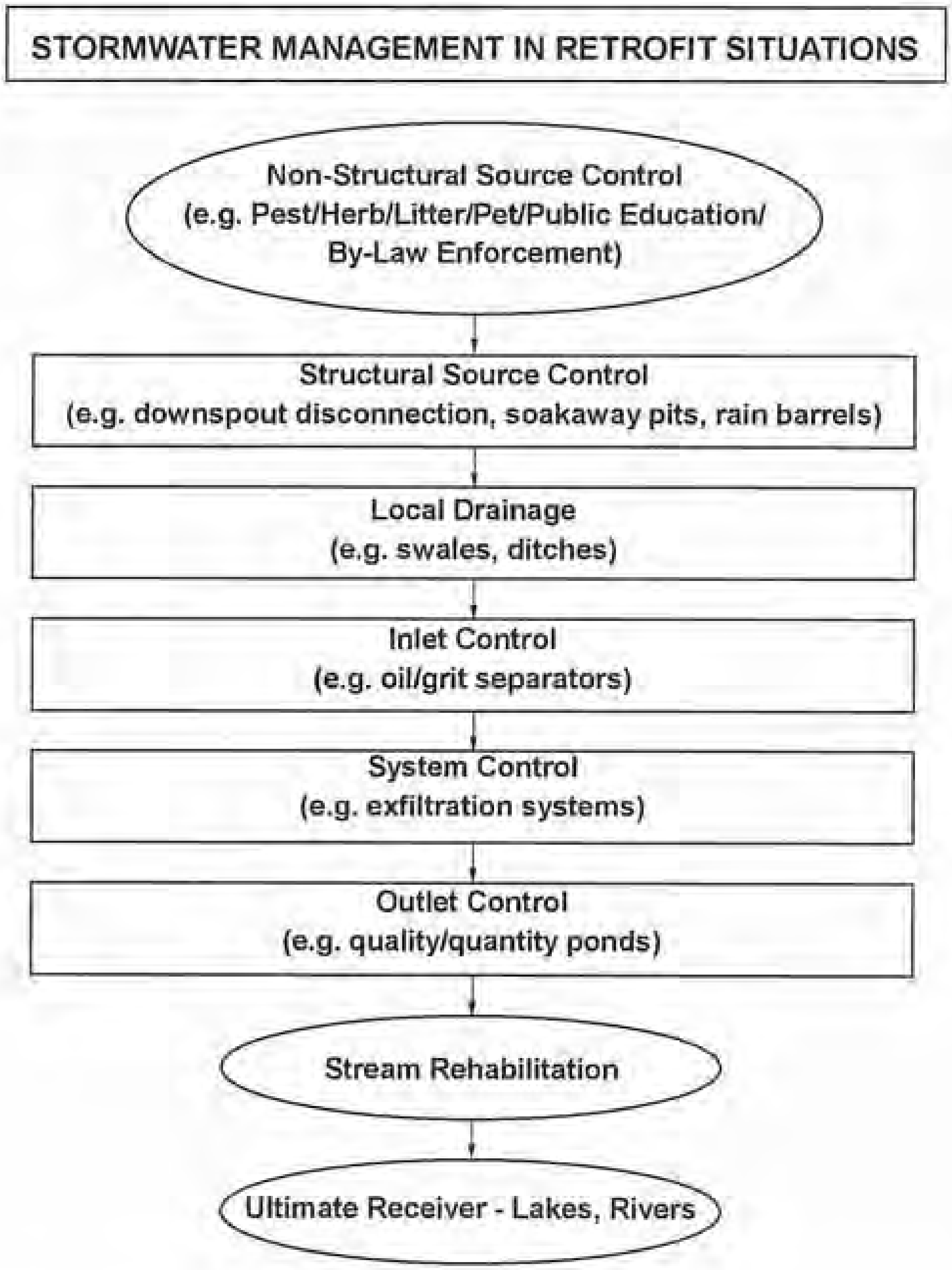


Figure 3.6 Preferred Hierarchy of Retrofit Stormwater Management Practices

These models were combined into a LOTUS 1-2-3® spreadsheet program by Li (1997) to determine the following for each catchment:

1. the existing annual runoff volume (m^3/yr) and solids loading (kg/yr);
2. the runoff volume and solids concentration reduction efficiencies (%) of RSWMPs;
3. the cumulative runoff volume and solids load reduction efficiencies (%) of RSWMPs;
4. the average annual runoff volume and solids loading after the application of each RSWMP;
5. the cost of runoff volume and solids loading reduction for each RSWMP;
6. the marginal cost of runoff volume and solids load reduction for each RSWMP;
7. the cumulative cost of runoff and solids loading reduction for a series of RSWMPs; and
8. phosphorus loading reduction based on the phosphorus concentrations measured in this study.

3.1.5 Recommendation of the Preferred Strategy

After the evaluation of alternative strategies has been undertaken, the preferred strategy should be chosen based on the following principles developed by Li (1997):

1. Environmental and economic objectives are to be achieved by the least expensive strategy.
2. Strategies which can integrate effectively with sewer/road system rehabilitation and redevelopment and lot level source control should have high priority.
3. RSWMPs which are cost-effective (i.e., low marginal costs) should have high priority.
4. RSWMPs which receive subsidies from other levels of government should have high priority.

3.2 Suitability Matrix of Retrofit Stormwater Management Practices

There are three categories of criteria that are used to assess the suitability of a site for RSWMP implementation as follows:

1. Drainage Catchment Characteristics
   - poor/good lot grading
   - clayey/sandy soil
   - low/high groundwater table
   - small/large upstream drainage area
   - small/large lot size
   - low/high density land use

2. Drainage System Characteristics
   - accessible/inaccessible for maintenance
   - ditch/curb-gutter-sewer road
   - high sewer-road system rating (needs repair)/low sewer-road system rating (good condition)
   - space/no space for storage
   - above 100-year flood level/below 25 year flood level

3. Receiving Water Characteristics
   - large lakes with/without embayment
   - small lakes with/without embayments
   - concern/no concern for fish habitat

Each criterion listed above is assigned a rating from low to high potential for each of the RSWMP options. The evaluation procedure consists of a series of questions which are set up in a hierarchial fashion. All Priority One questions must be answered positively without remediation measures while Priority Two Questions can be answered acceptably with remediation measures (Stirpe, 1995). If site specific conditions indicate that there is low potential for a given option, it is excluded from future consideration. Figure 3.7 illustrates the suitability matrix developed by Li (1997) for this modelling program.

3.3 Consideration of Winter Snowmelt Runoff

The Severn Sound area receives a substantial amount of precipitation in the form of snowfall. The runoff from the accumulation of this snowfall over the winter period is considered significant in terms of pollutant loading on an annual basis. Because the model developed for the Centennial Watershed study did not consider winter runoff and winter performance of RSWMPs, significant modifications have been made to the RSWMP model to account for these loadings.

Currently, very little is known about the performance of traditional and retrofit stormwater management performance during winter. As a result, the Technical Steering Committee has assumed performance values for winter of all applicable RSWMPs as described in Section 3.1.2.

Figure 3.7 Suitability Matrix for Determining Potential for RSWMP Options

	Catchment Characteristics													Drainage Sewer Characteristics						Receiving Water Characteristics											
BMP Type	Poor Lot Grading	Good Lot Grading	Clayey Soil	Sandy Soil	Water Supply Aquifer	High Water Table	Low Water Table	Large Upstream Area	Small Upstream Area	Small Lot Size	Large Lot Size	High Density I/C/R Area	Low Density Residential Area	Access Road Available	Access Road Not Available	Ditch Road	Curb-Gutter-Sewer Road	Sewer/Road System Rating = 4	Sewer/Road System Rating = 3	Combined Major/Minor Outfalls	Separate Major/Minor Outfalls	Space For Storage	No Space For Storage	Facility Above 100-Year Level	Facility Below 25-Year Level	Large Lakes Without Embayment	Large Lakes With Embayment	Small Lakes Without Embayment	Small Lakes With Embayment	Fish Habitat Concern	No Fish Habitat Concern
Down Spout Disconnection	⊕	●	⊘	●		⊘	●			⊕	●	⊕	●			⊘	●														
Oil/Grit Separator								⊘	●			●	⊘			⊕	●	●	⊕												
Stormwater Exfiltration			⊘	●	○	○	●					○	●			⊘	●	●	⊕												
Infiltration Trench																															
Quantity Pond Retrofit																				⊘	●	●	⊘							●	●
New Quality Pond								●	⊕											⊘	●	●	○	●	⊕					⊘	●

● High Potential ⊘ Medium Potential ⊕ Low Potential ○ Not Applicable ☐ Blank Cells Do Not Affect Potential

4.0 RUNOFF QUANTITY AND QUALITY CHARACTERISTICS

4.1 Precipitation Review

In order to estimate existing conditions and test the potential effectiveness of RSWMP options, typical hydrologic conditions were analysed. Long term records of hourly and/or daily precipitation from the closest Atmospheric Environment Service (AES) meteorological stations were obtained and analysed to determine the average number of rainfall events, the average amount of rainfall per event and the average amount of snowfall.

4.1.1 Average Annual Precipitation Determination

Traditionally, stormwater impact assessments have examined ice-free periods to determine long term average loadings. This generally corresponds to the period April 1 through October 31 of each year for which long term hourly precipitation data are available. In order to estimate an annual average precipitation value, the Technical Steering Committee agreed that it would be necessary to consider the additional contribution from snowfall. As a result, long-term daily snowfall data were obtained for the period November 1 through March 31 (a water equivalent of 10:1 was assumed). Although the combination of the rainfall and snowfall values was considered to represent the annual precipitation, it is important to note that rainfall precipitation during the winter period was not included, resulting in a conservative annual precipitation value.

The two closest AES meteorological stations that recorded hourly rainfall precipitation were located in the Community of Honey Harbour (15 km from Midland) and the Town of Orillia (45 km from Midland). The following outlines the length of record analysed for the determination of average rainfall and the number of events per year for both stations:

Honey Harbour (AES Stn # 6113490)	
Length of Record -	1977/4/1 - 1992/9/1
Average Number of Rain Events/Year-	90
Average Amount of Precipitation/Event -	4.82 mm
Orillia (AES Stn # 6115820)	
Length of Record -	1965/4/1 - 1992/5/30
Average Number of Rain Events/Year -	90
Average Amount of Precipitation/Event -	5.19 mm

For the purposes of the modelling exercise, a conservative estimate of 100 events/year and 5 mm of precipitation/event were applied as typical values for the modelling exercise.

Due to the fact that long-term daily (not hourly) data were required for snowfall, the snowfall data collected at the Midland Wastewater Treatment Centre was applied. The following outlines the length of record analysed for the determination of average snowfall:

Midland (AES Stn # 6115127)

Length of Record -	1974/1975 - 1994/1995
Average Amount of Snowfall -	3.2 m

Figure 4.1 illustrates the average snowfall selection.

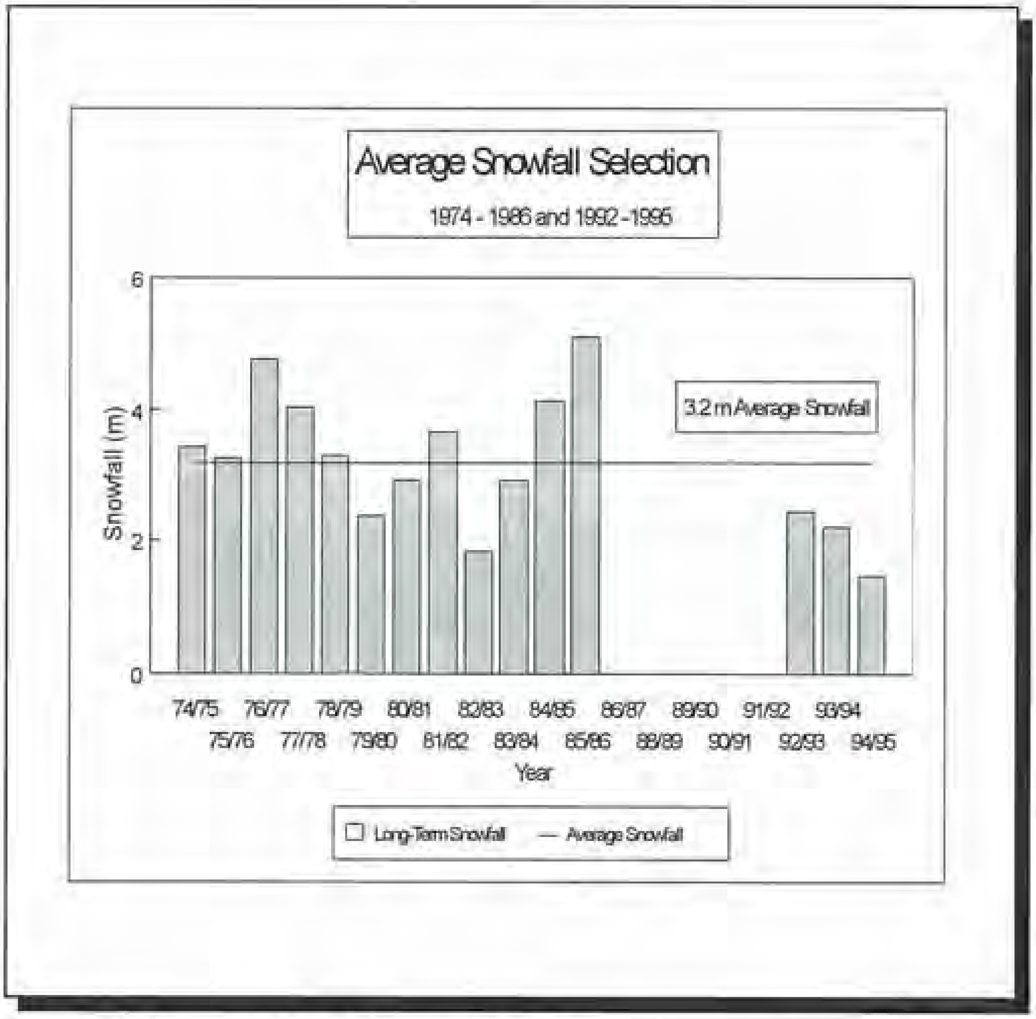


Figure 4.1 Average Annual Snowfall Selection

4.1.2 Collected Precipitation Data

In addition to obtaining long term precipitation records from AES meteorological stations close to Severn Sound, an AES/Wetzer recording (5 minute) tipping bucket rain gauge was installed at the Wastewater Treatment Center in the Town of Midland in August, 1995. The data collected from this rain gauge was used to correlate actual monitored runoff with the model results. Figure 4.2 illustrates the monitored precipitation during the course of this study. In addition, see Appendix C for graphical summaries of individual precipitation events during which sampling occurred.

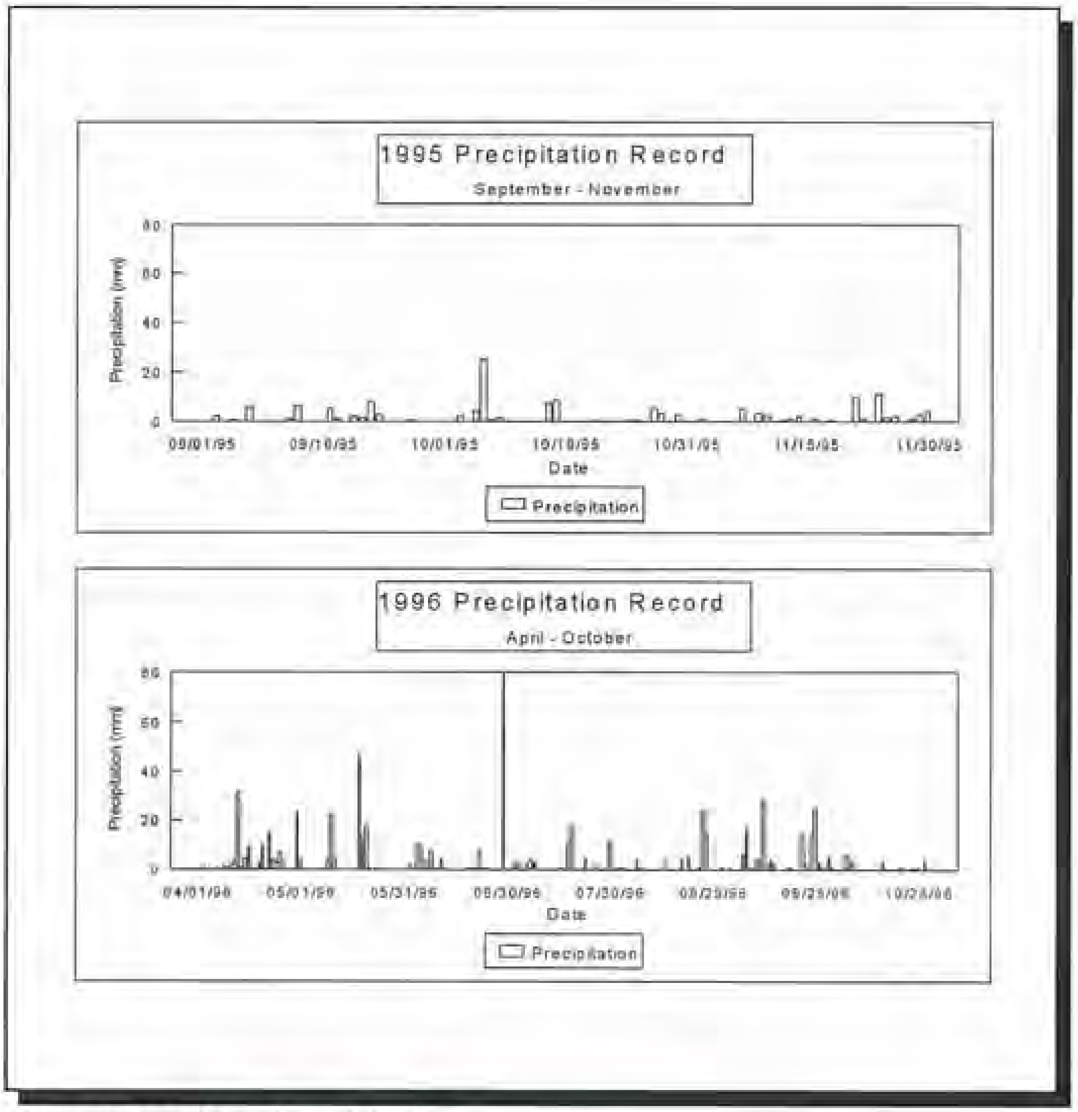


Figure 4.2 Monitored Precipitation

4.2 Runoff Quantity Analysis

Throughout the monitoring phase of this study, a total of 21 composite samples were collected, of which 19 provided good results. Although a target of 3-5 samples per site was originally set, only three samples per site were obtained on average. This was due to adverse weather conditions (snow) and malfunctioning equipment. Table 4.1 provides a summary of flow measurements obtained during dry weather sampling runs and Table 4.2 illustrates the dates, locations, flow and precipitation characteristics, and the concentrations of selected parameters for each rain event during which a sample was taken.

Table 4.1 Dry Weather Flow Measurements

Outfall ID	Fall 1995 Flow	Spring 1996 Flow	Summer 1996 Flow	Total Baseflow
1	not sampled	4.90 m^3/day	no flow	441.0 m^3/yr
2	not sampled	8.02 m^3/day	no flow	721.8 m^3/yr
3	not sampled	11.58 m^3/day	no flow	1,042.2 m^3/yr
4	not sampled	12.47 m^3/day	11.13 m^3/day	2,124.0 m^3/yr
5	not sampled	4.45 m^3/day	no flow	400.5 m^3/yr
6	not sampled	44.54 m^3/day	no flow	4008.6 m^3/yr
7	not sampled	22.65 m^3/day	11.13 m^3/day	3,040.0 m^3/yr
8	not sampled	18.71 m^3/day	4.90 m^3/day	2,124.9 m^3/yr
9	no flow	44.54 m^3/day	4.8 m^3/day	4,440.6 m^3/yr
10	114.47 m^3/day	349.66 m^3/day	26.70 m^3/day	44,174.7 m^3/yr
11	8.9 m^3/day	24.05 m^3/day	4.90 m^3/day	3,406.5 m^3/yr
12	no flow	10.69 m^3/day	14.70 m^3/day	2,285.1 m^3/yr
13	12.47 m^3/day	10.25 m^3/day	14.70 m^3/day	3,367.8 m^3/yr
14	no flow	3.12 m^3/day	2.22 m^3/day	480.6 m^3/yr
15	50.00 m^3/day	63.90 m^3/day	44.54 m^3/day	14,259.6 m^3/yr
16	8.91 m^3/day	31.45 m^3/day	8.01 m^3/day	4,353.3 m^3/yr
17	6.68 m^3/day	11.14 m^3/day	11.13 m^3/day	2,605.5 m^3/yr
18	26.73 m^3/day	456.48 m^3/day	39.96 m^3/day	47,085.3 m^3/yr
19	8.91 m^3/day	not sampled	4.45 m^3/day	1,202.4 m^3/yr

Table 4.2 Rain Event Summaries

Station ID	Event ID	Date	Precipitation (mm)	Total Flow (m3) (Measured)	Total Flow (m3) (Modelled)	Total Runoff (mm) (Measured)	Total Runoff (mm) (Modelled)	Duration of Precipitation (hrs)	Event Intensity (mm/hr)	Maximum 1 Hour Intensity (mm)	Maximum 5 Minute Intensity (mm)	Event Composite Concentration (mg/L)			
												Cl	SS	TP	TKN
1	PCP0200	05-Oct-95	30.6	1,707	3,756	7.0	15.4	15.0	2.0	6.8	0.8	2.8	44	0.164	0.68
1	PCP0202	27-Oct-95	5.6	297	542	1.2	2.2	11.5	0.5	1.8	0.4	26.4	123	0.61	2.7
2	PCP0201	20-Oct-95	0.6	175	3	0.9	0.01	2.0	0.3	0.6	0.4	2.2	71	0.23	1.3
2	PCP0217	13-Apr-96	30.4	2,493	2,204	12.9	11.36	13.5	2.3	7.2	0.8	65.2	651	0.65	1.8
2	PCP0221	20-Apr-96	8.8	483	532	2.5	2.7	4.3	2.1	4.4	0.6	65.2	202	0.2	1.16
3	PCP0203	27-Oct-95	5.6	690	2,643	0.4	1.6	11.5	0.5	1.8	0.4	11.2	31	0.35	1.5
3	PCP0216	13-Apr-96	32	13,068	20,500	7.9	12.4	13.5	2.4	7.2	0.8	117	304	0.32	1.7
3	PCP0218	15-Apr-96	13.4	6012	7,838	3.6	4.7	19.0	0.7	2.4	0.8	82.6	20	0.064	0.52
3	PCP0232	30-Apr-96	23.4	14,347	14,630	8.6	8.8	8.0	2.9	7.4	1.2	49.6	96	0.27	1.36
3	PCP0252	06-Jun-96	5.6	1,337	2,643	0.8	1.6	18.0	0.3	1.8	0.4	28.2	88	0.224	1.44
4	PCP0253	06-Jun-96	5.2	260	476	0.9	1.7	18.0	0.3	1.8	0.4	13.2	147	0.276	1.96
4	PCP0254	08-Jun-96	7.6	590	773	2.1	2.8	6.3	1.2	3.0	0.4	5.6	109	0.184	1.8
4	PCP0255	22-Jun-96	7.6	300	773	1.1	2.8	1.5	5.0	7.2	2.6	11.6	303	0.61	3.16
4	PCP0257	29-Jun-96	79.8	4,205	10,060	15.2	36.4	8.0	10.0	28.6	7.0	N/A	N/A	N/A	N/A
5	PCP0231	30-Apr-96	23.4	1,269	1748	6.5	9.0	8.0	2.9	7.4	1.2	56.6	73	0.024	0.002
5	PCP0237	03-May-96	0.0	350	0	1.8	0.0	0.0	0.0	0.0	0.0	20.8	1,080	0.54	0.088
5	PCP0251	18-May-96	76.6	2,714	6,052	13.9	31.0	45.0	1.7	25.0	9.2	5.6	508	0.77	1.51
7	PCP0258	18-Jul-96	28.8	1,807	6,813	2.7	10.1	12.0	2.4	9.8	2.0	28.4	245	0.16	0.09
7	PCP0259	29-Jul-96	11.6	876	2,456	1.3	3.6	21.0	0.6	5.8	0.6	94.4	344	0.45	0.198
7	PCP0260	07-Aug-96	4.2	264	644	0.4	6.95	3.5	1.2	3.6	1.8	132	198	0.58	0.216
8	PCP0256	29-Jun-96	79.8	3,310	10,020	4.5	21.5	8.0	10.0	28.6	7.0	11.8	63	0.17	0.224

Cl - Chlorides
SS - Suspended Solids
TP - Total Phosphorus
TKN - Total Kjeldahl Nitrogen

4.3 Runoff Quality Analysis

4.3.1 Statistical Techniques

Concentration characteristics and flow volumes of monitored wet weather runoff are variable by storm events and sites in urban settings (Maunder and D'Andrea, 1995). To evaluate concentration characteristics, an approach similar to that undertaken for the Metro Toronto Waterfront Wet Weather Outfall Study has been adopted. An event mean concentration (EMC) based on flow weighted composite samples was chosen as the primary water quality statistic. The EMC can be defined as the total contaminant mass discharge divided by the runoff volume for a storm event (U.S.EPA, 1983).

The following statistical analyses were performed on the data collected:

- identification of frequency of detection;
- determination of the mean and variability of EMCs by location and season; and
- comparison of EMCs by location.

Probability Distribution Estimation (PDE) techniques were used for calculating the mean and associated confidence interval for the data sets. These techniques use the probability distribution of the data above detection limits to estimate the statistical properties of the entire data set using a method known as maximum likelihood estimation (MLE). The statistical summaries provided in this report include the mean, geometric mean, standard deviation and the 95% confidence interval. Appendix D summarizes and graphically illustrates the mean contaminant concentrations with the 95% confidence interval indicated for all conventional parameters.

4.3.2 Rain Event Contaminant Concentration Characteristics

Table 4.3 illustrates a comparison of the rain event mean concentrations developed during this study with those reported by the Metropolitan Toronto Waterfront Wet Weather Outfall Study - Phase II (MTWOS), Nationwide Urban Runoff Program (NURP), the Upper Great Lakes Connecting Channels Area Study (UGLCC) and the Ontario Provincial Water Quality Objectives.

Table 4.3 Comparison of Rain Event Mean Concentrations With Other Studies

Parameter	Units	MDL[1]	PWQO[2]	SSRAP Event Samples (N = 19)					Mean Values (Others)		
				% Det[3]	%>PWQO	Geo Mean	L.CI[4]	U.CI[5]	Metro[6]	UGLCC[7]	NURP[8]
Metals											
Aluminum	mg/L	0.005	0.075	100%	100%	0.388	0.107	1.408	1.4	—	—
Barium	mg/L	0.005	—	100%	—	0.052	0.040	0.069	0.041	—	---
Beryllium	mg/L	0	0.011	5.3%	0%	0.00006	0.00005	0.00007	0.00013	—	---
Cadmium	mg/L	0.0001	0.0002	100%	84.2%	0.00074	0.00048	0.00115	0.00094	—	---
Chromium	mg/L	0.0002	0.1	100%	0%	0.006	0.004	0.009	0.007	0.006	0.014
Cobalt	mg/L	0.0002	0.0004	100%	89.5%	0.00142	0.00099	0.00203	—	—	—
Copper	mg/L	0.0001	0.005	100%	94.7%	0.0333	0.0204	0.0543	0.045	0.009-0.087	0.10
Iron	mg/L	0.01	0.3	100%	94.7%	0.546	0.145	2.058	2.83	3.0-11.4	—
Lead	mg/L	0.005	0.005	68.4%	68.4%	0.0296	0.0158	0.0553	0.057	0.06-0.45	0.006-0.46
Manganese	mg/L	0.001	—	100%	—	0.198	0.134	0.292	0.160	—	—
Molybdenum	mg/L	0.0002	0.01	42.1%	0%	0.0012	0.0004	0.0032	—	---	—
Nickel	mg/L	0.0005	0.025	100%	0%	0.0040	0.0030	0.0054	0.01	0.003-0.039	0.001-0.18
Strontium	mg/L	0.01	—	100%	—	0.218	0.153	0.311	—	---	---
Titanium	mg/L	0.001	—	100%	—	0.0183	0.0125	0.0269	—	---	---
Vanadium	mg/L	0.0002	0.0007	100%	5.3%	0.0035	0.0025	0.0048	—	---	---
Zinc	mg/L	0.0005	0.03	100%	94.7%	0.1233	0.0813	0.1868	0.15	0.16-0.48	0.01-2.40
General Chemistry											
Chlorides	mg/L	0.2	---	100%	—	21.7	15.27	81.47	—	---	---
Sodium	mg/L	0.1	—	100%	—	14.5	10.18	49.01	—	—	—
Potassium	mg/L	—	—	100%	—	2.26	1.881	2.728	—	---	—
Ammonia/um	mg/L	0.002	—	73.7%	—	0.043	0.200	2.026	0.08	---	---
Nitrites	mg/L	0.001	—	94.7%	—	0.033	0.0286	0.1262	1.96	---	57-73
Nitrates	mg/L	0.01	—	100%	—	0.806	0.5972	1.9723	0.14	---	—
DRP	mg/L	0.0005	—	100%	—	0.025	0.0154	0.2412	—	---	—
TSS	mg/L	0.1	—	100%	—	138.4	113.63	389.93	238	—	67-101
TP	mg/L	0.0005	0.01	100%	100%	0.257	0.187	0.5631	0.82	0.16-0.37	0.2-0.38
TKN	mg/L	0.05	—	100%	—	1.325	1.1083	2.3744	4.11	—	1.18-1.9
DOC	mg/L	—	—	100%	—	5.6	4.9621	7.9131	—	---	---
DIC	mg/L	---	—	100%	—	20.2	18.046	26.847	—	---	—

[1] Minimum Detectable Limit
[2] Provincial Water Quality Objectives (MOEE, 1994)
[3] % of Samples Above Detection Limit
[4] Lower Limit of 95% Confidence Interval
[5] Upper Limit of 95% Confidence Interval
[6] Metro Toronto Wet Weather Outfall Study Phase II (Aquafor Engineering Limited, 1993)
[7] Upper Great Lakes Connecting Channels Area Study (Marsalek and Ng, 1993)
[8] Nationwide Urban Runoff Program (U.S. EPA, 1983)

In general, the mean concentrations developed in this study lie either within the range or below those reported by MTWOS, NURP and UGLCC. It is important to note, however, that although the absolute concentrations are slightly lower than those found in the other studies, the exceedences of the PWQO are still in the same magnitude. For example, several metals concentrations found in the Severn Sound area are in the range of 3 to 7 times greater than the PWQO while in the Toronto study the same metals ranged from 2 to 11 times greater than the PWQO. In addition, total phosphorus exceeds the PWQO in all samples by 13 times (compared to 41 times for Toronto).

Further analysis of the EMCs showed that there was no significant relationship between contaminant concentration and total flow, event precipitation intensity, maximum one hour precipitation intensity, duration of precipitation, total precipitation and land use. Figure 4.3 illustrates these relationships for total phosphorus, which was characteristic for all parameters.

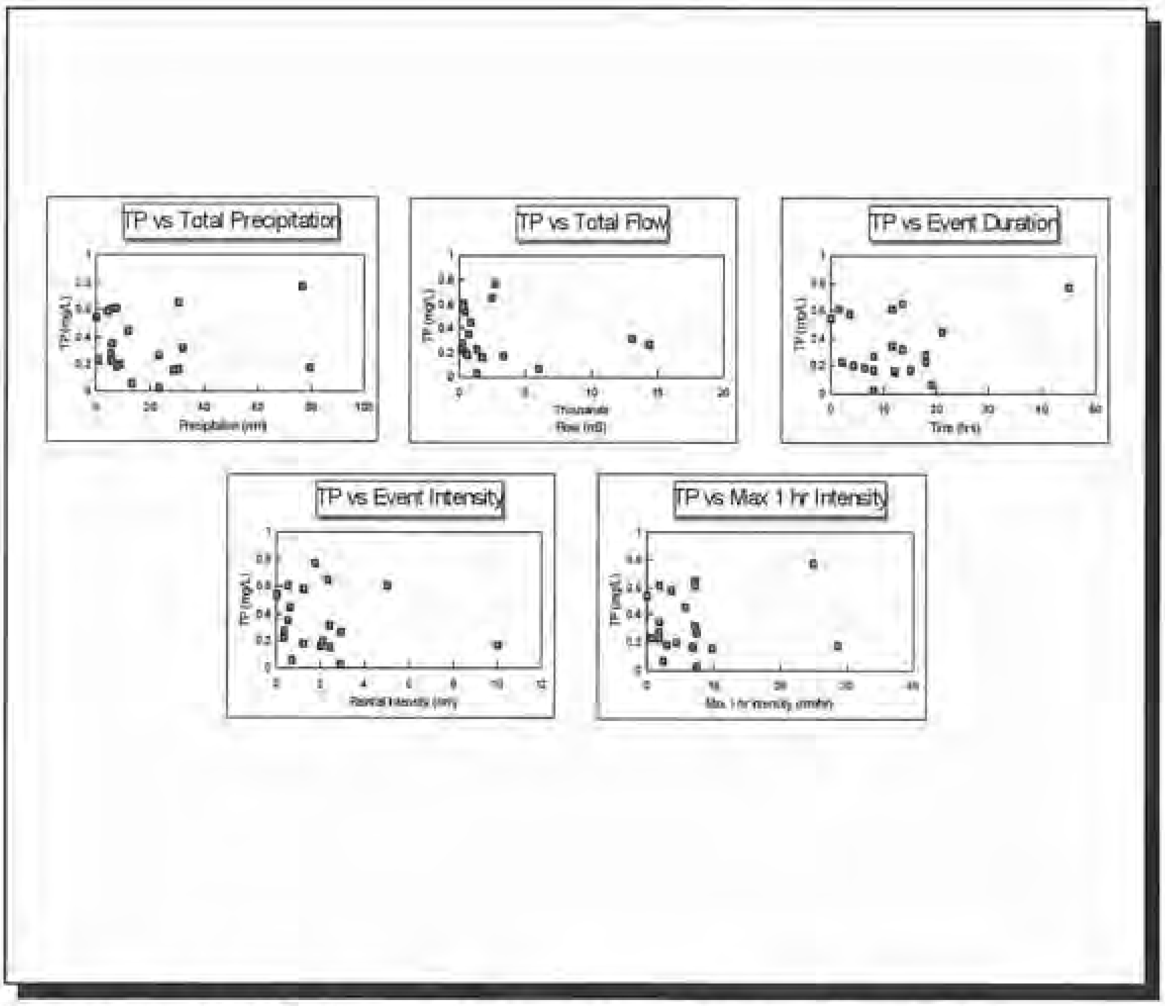


Figure 4.3 Relationships Between Total Phosphorus and Event Characteristics

4.3.3 Dry Weather Characteristics

Table 4.4 illustrates a comparison of the dry weather mean concentrations developed during this study to those reported in the Dry Weather Discharges to the Metropolitan Toronto Waterfront report. In general, the concentrations developed in this study lie below those reported in the Toronto report. Phosphorus exceedences of the PWQO still remain high at 76.6%.

Table 4.4 Comparison of Dry Weather Mean Concentrations With Other Studies

Parameter	Units	MDL[1]	PWQO[2]	SSRAP Dry Weather Samples (N = 16, * Denotes 30 Samples)					
				% Det[3]	%>PWQO	Mean	L.CI[4]	U.CI[5]	Metro[6]
Metals									
Aluminum	mg/L	0.005	0.075	87.5%	12.5%	0.036	0.022	0.059	0.500
Barium	mg/L	0.005	—	100%	—	0.091	0.069	0.120	0.109
Beryllium	mg/L	0	0.011	100%	0%	0.00005	0.00005	0.00005	—
Cadmium	mg/L	0.0001	0.0002	12.5%	12.5%	0.00009	0.00006	0.00013	0.0003
Chromium	mg/L	0.0002	0.1	75%	0%	0.00118	0.00057	0.00242	0.0166
Cobalt	mg/L	0.0002	0.0004	31.3%	12.5%	0.00023	0.00013	0.00042	---
Copper	mg/L	0.0001	0.005	100%	6.3%	0.0032	0.0021	0.0049	0.0878
Iron	mg/L	0.01	0.3	75%	6.3%	0.154	0.078	0.308	1.344
Lead	mg/L	0.005	0.005	0%	0%	0.0025	0.0025	0.0025	0.0163
Manganese	mg/L	0.001	—	100%	—	0.050	0.027	0.092	0.231
Molybdenum	mg/L	0.0002	0.01	68.8%	12.5%	0.0030	0.0011	0.0087	---
Nickel	mg/L	0.0005	0.025	6.3%	0%	0.0004	0.0002	0.0005	0.0003
Strontium	mg/L	0.01	—	100%	—	0.215	0.146	0.317	---
Titanium	mg/L	0.001	—	6.3%	—	0.0007	0.0005	0.0010	—
Vanadium	mg/L	0.0002	0.0007	75%	56.3%	0.0008	0.0005	0.0014	---
Zinc	mg/L	0.0005	0.03	93.8%	6.3%	0.0088	0.0049	0.0161	0.0875
General Chemistry									
Chlorides	mg/L	0.2	—	87.5%	—	434.6	118.7	1591.0	—
Sodium	mg/L	0.1	—	100%	—	68.3	42.0	111.1	—
Potassium	mg/L	—	—	100%	—	3.878	3.194	4.709	—
Ammonia/um	mg/L	0.002	—	70.6%	---	0.116	0.041	0.327	---
Nitrites	mg/L	0.001	—	100%	—	0.0395	0.0218	0.0718	—
Nitrates	mg/L	0.01	—	100%	—	2.1134	1.5268	2.9253	4.5625
DRP	mg/L	0.0005	—	94.1%	—	0.0310	0.0138	0.0699	—
TSS*	mg/L	0.1	—	96.8%	—	84.52	36.97	193.21	25.47
TP*	mg/L	0.0005	0.01	93.3%	76.6%	0.0692	0.0392	0.1221	0.3125
TKN*	mg/L	0.05	—	100%	—	0.3146	0.2500	0.3960	1.9688
DOC	mg/L	---	—	100%	—	2.103	1.506	2.937	—
DIC	mg/L	—	—	100%	—	56.458	46.120	69.113	---

[1] Minimum Detectable Limit
[2] Provincial Water Quality Objectives (MOEE, 1994)
[3] % of Samples Above Detection Limit
[4] Lower Limit of 95% Confidence Interval
[5] Upper Limit of 95% Confidence Interval
[6] Metro Toronto Wet Weather Outfall Study Phase II (Maunder and D'Andrea, 1995)

In addition to the above mentioned parameters, bacteriological quality samples were also taken at many of the dry weather monitoring sites (Table 4.5). Samples were analysed for Escherichia coli, Fecal streptococci and Pseudomonas aeruginosa at the MOE laboratory in Toronto, Ontario and at MDS labs of London, Ontario during the period of a labour dispute.

In general, when high counts were discovered, investigations were undertaken in conjunction with the respective public works/engineering departments and corrections were made where necessary.

Table 4.5 Dry Weather Bacteriological Results

Date	Stn ID	EC	FS	PA
October 12, 1995	10	208	600	300
	11	4	16	2
	13	16	12	32
	16	4	4	2
	17	56,000	1,380	32
	18	16	12	2
	19	76	60	2
May 27, 1996*	1	37	110	40
	2	26	20	18
	3	62	14	20
	4	1	38	8
	5	2	6	1
	6	3,500	170	2,400
	7	14	34	70
	8	9	18	32
	9	45	36	290
	10	185	52	1,000
	11	3	2	1
	12	240	2	84
	13	340	180	160
	14	190	130	76
	15	300	680	370
	16	4	19	2
	17	75,000	4,200	2,400
	18	6	32	4
August 12, 1996	4	2,820	220	600
	7	870	160	4
	8	12	42	1
	9	184	166	6
	10	22	266	3
	11	8	36	1
	12	620	590	9
	13	830	720	23
	14	640	1,920	104
	15	162	300	23
	16	16	252	0
	17	220	40	7
	18	22	94	0
	19	8	78	0

EC - E. Coli
FS - Fecal Streptococci
PA - Pseudomonas aeruginosa
* MDS lab analyses

4.3.4 Comparison of Water Quality Results From all Monitoring Phases

In addition to the Wet and Dry monitoring components of this study, sampling of snowmelt runoff and sampling of the Coldwater drain were performed. The snowmelt sampling provided the basis for winter loading estimations which were necessary for determining annual loading. Monitoring of the Coldwater Drain, a predominantly rural/agricultural catchment, provided a basis for loading estimations from rural cultivated and abandoned/forest areas. Table 4.6 illustrates a comparison of the mean concentrations of all phases of monitoring.

Seasonal differences in water quality were noted. Much higher chloride, sodium and conductivity were observed during snow melt sampling, likely due to road salting operations. This corresponds with other studies indicating that significant portions of the saline runoff from roads eventually finds its way to nearby surface waters (Jones et.al., 1986).

The Coldwater Drain had lower concentrations of chlorides and nutrients than rain produced runoff of the other urban catchments. The influence of the proportionately larger flow from the rural areas of the catchment probably dampened the impact of the relatively small proportion of urban runoff.

The dry weather quality of the urban catchments was characterized by higher chloride concentrations than during rain events, but lower suspended solids and total phosphorus concentrations. Dry weather bacteria indicator results were generally low indicating little potential for sanitary sewage discharge through the storm sewers in the area.

4.3.5 Summary of Quality Assessment

Based on the mean contaminant concentrations developed through this study, it is evident that pollutant loadings from urban stormwater sources to Severn Sound pose a problem in causing exceedences of the PWQO in the receiving waters. Total phosphorus is especially elevated in storm water discharges during rain events as was found to be the case in other similar studies.

Table 4.6 Summary of Contaminant Concentrations by Monitoring Phase

Parameter	Units	PWQO	Rain Event N = 19			Dry Weather N = 27			Snow Events N = 8			Coldwater N = 9		
			Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval	
				LL	UL		LL	UL		LL	UL		LL	UL
Metals														
Aluminum	mg/L	0.075	0.388	0.107	1.408	0.036	0.022	0.059	0.430	0.271	0.684	0.358	0.684	0.358
Barium	mg/L	—	0.052	0.040	0.069	0.091	0.069	0.120	0.057	0.039	0.085	0.049	0.085	0.049
Beryllium	mg/L	0.011	0.00006	0.00005	0.00007	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Cadmium	mg/L	0.0002	0.00074	0.00048	0.00115	0.00009	0.00006	0.00013	0.00102	0.00037	0.00280	0.00026	0.00280	0.00026
Chromium	mg/L	0.1	0.006	0.004	0.009	0.00118	0.00057	0.00242	0.008	0.005	0.012	0.00076	0.012	0.00076
Cobalt	mg/L	0.0004	0.00142	0.00099	0.00203	0.00023	0.00013	0.00042	0.00048	0.00025	0.00094	0.00037	0.00094	0.00037
Copper	mg/L	0.005	0.0333	0.0204	0.0543	0.0032	0.0021	0.0049	0.0145	0.0098	0.0216	0.0022	0.0216	0.0022
Iron	mg/L	0.3	0.546	0.145	2.058	0.154	0.078	0.308	0.685	0.396	1.185	0.415	1.185	0.415
Lead	mg/L	0.005	0.0296	0.0158	0.0553	0.0025	0.0025	0.0025	0.0163	0.0038	0.0699	0.0025	0.0699	0.0025
Manganese	mg/L	—	0.198	0.134	0.292	0.050	0.027	0.092	0.095	0.061	0.147	0.025	0.147	0.025
Molybdenum	mg/L	0.01	0.0012	0.0004	0.0032	0.0030	0.0011	0.0087	0.0007	0.0002	0.0023	0.0002	0.0023	0.0002
Nickel	mg/L	0.025	0.0040	0.0030	0.0054	0.0004	0.0002	0.0005	0.0070	0.0032	0.0151	0.0012	0.0151	0.0012
Strontium	mg/L	—	0.218	0.153	0.311	0.215	0.146	0.317	0.221	0.154	0.317	0.434	0.317	0.434
Titanium	mg/L	—	0.0183	0.0125	0.0269	0.0007	0.0005	0.0010	0.0113	0.0049	0.0264	0.0108	0.0264	0.0108
Vanadium	mg/L	0.0007	0.0035	0.0025	0.0048	0.0008	0.0005	0.0014	0.0012	0.0007	0.0023	0.0011	0.0023	0.0011
Zinc	mg/L	0.03	0.1233	0.0813	0.1868	0.0088	0.0049	0.0161	0.0654	0.0466	0.0919	0.006	0.0919	0.006
General Chemistry														
Chlorides	mg/L	—	21.7	15.27	81.47	434.6	118.7	1591.0	178.7	74.7	8704.4	6.9	6.3	7.5
Sodium	mg/L	—	14.5	10.18	49.01	68.3	42.0	111.1	111.6	88.6	5000.1	6.1	5.7	6.5
Potassium	mg/L	—	2.26	1.881	2.728	3.878	3.194	4.709	2.8	2.155	3.659	2.455	2.199	2.741
Ammonia/um	mg/L	—	0.043	0.200	2.026	0.116	0.041	0.327	0.026	0.022	0.174	0.016	0.011	0.025
Nitrites	mg/L	—	0.033	0.0286	0.1262	0.0395	0.0218	0.0718	0.027	0.0211	0.0549	0.0255	0.0173	0.3761
Nitrates	mg/L	—	0.806	0.5972	1.9723	2.1134	1.5268	2.9253	0.596	0.4130	1.7307	0.2044	0.1279	0.3267
DRP	mg/L	—	0.025	0.0154	0.2412	0.0310	0.0138	0.0699	0.019	0.0127	0.0722	0.0165	0.0116	0.0233
TSS	mg/L	—	138.4	113.63	389.93	84.52	36.97	193.21	44.2	33.89	217.47	19.07	14.90	24.41
TP	mg/L	0.01	0.257	0.187	0.5631	0.0692	0.0392	0.1221	0.125	0.1024	0.2208	0.0614	0.0515	0.0732
TKN	mg/L	—	1.325	1.1083	2.3744	0.3146	0.2500	0.3960	0.788	0.6497	1.2245	0.6771	0.6027	0.7607
DOC	mg/L	—	5.6	4.9621	7.9131	2.103	1.506	2.937	3.366	2.7623	5.5219	8.3163	7.5436	9.1681
DIC	mg/L	—	20.2	18.046	26.847	56.458	46.120	69.113	25.8	21.818	34.874	42.181	40.229	44.228

Note: CI = Confidence Intervval LL = Lower Limit of 95% Confidence Interval UL = Upper Limit of 95% Confidence Interval

4.4 Model Evaluation

Although the main function of the data collected through the wet and dry weather monitoring phases of this study was to establish a baseline by which to evaluate the effectiveness of remedial measures, a secondary function was to contribute to a sensitivity analysis of the RSWMP model applied for this study. In its development, the RSWMP model was tested against the Storage, Treatment, Overflow, Runoff Model (STORM) (HEC, 1974) for runoff volume and the results of both models were generally found to be in good agreement (Kauffman, 1987; Li, 1991). However, the model had not been compared to actual monitored conditions until application for this study. By comparing the actual monitored flow and precipitation to the model output, the following conclusions can be made.

In general, the model predicts higher runoff volume than measured (with the exception of residential catchments, where runoff was reasonably predicted). However, the relationship between measured flows and modelled flows is quite good ($r^2 = .84$, $p<.05$). This indicates that the model is predicting consistently, but with an error most likely associated with localized factors. These factors could include:

- The model was originally calibrated outside of the Severn Sound watershed. Localized differences in soils, slope and rainfall patterns may have introduced some errors.

- The model is designed to predict annual contaminant loadings based on long-term rainfall records, not for individual events. In addition, precipitation was measured at only one location in the watershed where local variations in total precipitation and precipitation intensity could affect flow quantity in the different monitoring locations chosen for this study.

- In the Towns of Midland and Penetanguishene, the presence of combined sewers could decrease the quantity of flow discharging at the monitoring location. Although the effects of the combined sewers were not examined in detail for this study, their locations coincide with catchments comprised mainly of commercial and industrial land, catchments that exhibited the greatest variability between modelled and measured flows.

Considering these factors, the study team believed that the model was predicting flows accurately and that modifications to the model were unnecessary.

The evaluation of loading estimation and overall effectiveness of RSWMPs in reaching loading reduction targets is subject to uncertainties in both model selection and input parameter estimation. The uncertainty of model selection was not analyzed in this study as the analytical probabalistic models applied were extensively compared to STORM in previous studies. The uncertainty of parameter estimation can be addressed by a sensitivity analysis which assesses the change in loading estimation and the overall effectiveness of RSWMPs with respect to variations in treatment efficiencies, contaminant concentrations and flow quantities assumed as inputs to the RSWMP model. The following outlines how each of these inputs can affect the overall model output:

- One of the most important inputs to the model relates to the monitoring program undertaken for this study. The average contaminant concentrations determined for rain events, dry weather and snowmelt runoff were applied to the long term average runoff calculations to determine annual loadings. Associated with the average contaminant concentrations was an upper and lower confidence interval that reflects a potential for error when using an average concentration. In order to determine the sensitivity of the RSWMP model to changes in the contaminant concentration applied, the upper and lower confidence levels have been applied.

- The treatment efficiencies associated with each of the retrofit stormwater management practices examined in this study were assumed to be similar to those used in the Centennial Watershed Study (Li, 1997) or derived from the MOE Stormwater Management Practices Manual (MOEE, 1994a). Because it is generally agreed that the efficiencies of stormwater management practices are debatable, the study team has assumed conservative treatment efficiencies for the modelling exercise. In order to determine the sensitivity of the RSMWP model to changes in the treatment efficiencies of the various stormwater management practices, variations in efficiencies of exfiltration systems, infiltration trenches and new quality ponds (most widely applied RSWMPs in this study) were examined.

- Although the study team agrees that the model is predicting annual runoff relatively accurately, estimation errors are inevitable. In order to test the sensitivity of the RSWMP model, a ±20% change in annual flow was examined.

With each of the above mentioned variations, only the one parameter was altered at a time to determine the lone effect of that variation. Tables 4.7 - Table 4.9 summarize the effects on total annual loading, the total treatment efficiency represented by the stormwater management strategy and the resultant annual load after implementation (note: model results for existing TP loading are 1083 kg/yr with a potential 19.8% removal efficiency resulting in an annual load of 868 kg/yr after implementation).

Table 4.7 Results of Varying Total Phosphorus Concentrations in the RSWMP Model

RSWMP Parameter	TP Concentration (mg/L)	Annual Load (kg/yr)	Potential Treatment Efficiency	Resulting Annual Load (kg/yr)	Error From Modelled TP Loading
Rain Event Runoff Contaminant Concentration					
Upper confidence interval	.563	1,681	20.9%	1,330	+55%
Modelled concentration	**.260**	1,083	**19.8%**	868	
Lower confidence interval	.187	939	19.4%	757	-13%
Snow Melt Runoff Contaminant Concentration					
Upper confidence interval	.221	1,401	20.0%	1,132	+29%
Modelled concentration	**.125**	1,083	**19.8%**	868	
Lower confidence interval	.102	1,008	19.2%	806	-7%
Dry Weather Runoff Contaminant Concentration					
Upper confidence interval	.055	1,128	19.8%	905	+4%
Modelled concentration	**.025**	1,083	**19.8%**	868	
Lower confidence interval	.012	1,063	19.8%	852	-2%

Table 4.8 Results of Varying Annual Runoff by ±20% in the RSWMP Model

Variation*	Annual Load (kg/yr)	Potential Treatment Efficiency	Resulting Annual Load (kg/yr)	Error From Modelled TP Loading
Increase Runoff by 20%	1,292	19.8%	1,035	+20%
Modelled Runoff	1,083	**19.8%**	868	
Decrease Runoff by 20%	874	19.8%	701	-20%

Table 4.9 Results of Varying Treatment Efficiencies of Stormwater Management Practices in the RSWMP Model

Stormwater Management Practice	Modelled Efficiency	Potential Treatment Efficiency	Resulting Annual Load (kg/yr)	Error From Modelled TP Reduction
Upper Efficiency	95%	20.0%	866	+0.2%
Exfiltration System	90%	**19.8%**	868	
Lower Efficiency	80%	19.6%	871	-0.2%
Upper Efficiency	85%	20.3%	863	+0.5%
Infiltration Trenches	70%	**19.8%**	868	
Lower Efficiency	55%	19.3%	873	-0.5%
Upper Efficiency	80%	22.1%	844	+2.3%
New Quality Ponds	60%	**19.8%**	868	
Lower Efficiency	50%	18.7%	880	-1.1%

It is apparent that the greatest impact on the annual loading estimation results from changes in the total phosphorus concentrations for the rain event, dry weather and snowmelt components of the RSWMP model. If the upper and lower confidence limits of each component were applied, the resulting difference would be in the order of -24% to +86% change. Although this represents a significant increase in total loading, the effects on the potential overall treatment efficiency are much less significant. This reflects that regardless of phosphorus concentration, the efficiency of stormwater management practices remains fairly constant.

Due to the fact that annual runoff is the driving parameter for estimating annual loading, the effect of increasing or decreasing annual flow by 20% is to alter annual loading by the same amount. However, potential overall treatment efficiencies remain the same, reflecting that regardless of runoff quantity, the efficiency of stormwater management practices remains fairly constant.

The effectiveness of stormwater management practices governs the annual loading reductions estimated in the RSWMP model. By varying the treatment efficiency of each of the three dominant management practices in this study, it was determined that the effects on overall treatment efficiency were insignificant. The greatest increase in overall treatment efficiency would be realized through new quality ponds, mainly because the efficiency applied in the model is more conservative than in other recently published findings (Liang and Thompson, 1996).

4.5 Bathing Area Monitoring Results

Monitoring of the bathing area at Pete Peterson Park was undertaken over the 1996 and 1997 summer seasons. A total of 4 sampling runs were conducted. Table 4.10 summarizes the precipitation and flow characteristics from the Vinden Street outfall for each of the monitored events. Appendix E provides graphical summaries of these precipitation events.

Table 4.10 Summary of Bathing Area Sampling Runs

Date	Time of Rain	Precipitation (mm)	Max 1 hr intensity (mm)	Flow (m3)
August 15/16 1996	13:00	3.2	3.2	47
August 26/27, 1996	09:30	25.8	14.4	905
August 12/13, 1997	20:00	17.4	6.8	1245
September 10/11, 1997	09:00	3.2	1.8	51*

* estimated from precipitation

In each of the events, the outfall responded very quickly to the onset of precipitation (within approximately 3 - 4 minutes). However, depending on the characteristics of the precipitation (duration, intensity) the response downstream varied. Time of travel between the storm outfall and the marina basin was relatively rapid during a rain event (1.5-3 hours). Estimated time of travel from the marina basin inlet (site 3) to the outlet of the marina basin (site 4) was considerably slower (6 hours).

The sampling regime for each of the monitored sampling runs was structured according to the rates and intensity of precipitation observed at the time. In some cases, it was evident that the time of travel from the outfall to the marina basin was more rapid (based on visual observation of cloudy water) so more frequent sampling was employed. In the cases of little precipitation or time of onset later in the evening, fewer samples were obtained. Tables 4.11a - 4.11d outline the location, time and E. coli count of each of the sampling runs. In addition to E. coli, suspended solids and total phosphorus samples were taken at each site (Appendix E).

Table 4.11a Bathing Area Monitoring Results (Aug 15/16, 1996 13:00 - 8:00 Flow = 47 m³)

STN ID	HOUR								
	0	0.25	0.5	0.75	1	2	3	6	20
1	>600	360	>600	>600	>600	>600	—	>600	—
2	150	190	---	—	—	—	—	140	170
3	>600	---	---	—	>600	—	>600	420	190
4	20	—	---	—	---	---	10	30	10
5	10	---	---	—	—	---	10	10	30
6	10	---	---	---	---	—	50	10	10
7	30	---	---	---	---	—	10	10	10
8	10	---	---	---	---	—	20	20	10
9	20	---	---	---	---	—	50	10	10
GM	14	---	---	---	---	---	22	11	12

All values in E. coli organisms/100 ml

GM - Geometric Mean of Bathing Area Sites

Table 4.11b Bathing Area Monitoring Results (Aug 26/27, 1996 9:30 - 9:30 Flow = 905 m^3)

STN ID	HOUR									
	0	0.25	0.5	0.75	1	2	3	6	12	24
1	>600	>600	>600	>600	>600	>600	—	—	—	—
2	380	—	—	—	—	—	>600	—	—	—
3	440	—	—	—	—	>600	>600	>600	>600	>600
4	10	—	—	—	—	—	10	50	220	50
5	10	—	—	—	—	—	70	310	50	20
6	10	—	—	—	—	—	10	310	>600	10
7	10	—	—	—	—	—	30	140	40	10
8	10	—	—	—	—	—	20	10	30	30
9	10	—	—	—	—	—	20	10	40	10
GM	**10**	—	—	—	—	—	**24**	**67**	**68**	**14**

All values in E. coli organisms/100 ml
GM - Geometric Mean of Bathing Area Sites

Table 4.11c Bathing Area Monitoring Results (Aug 12/13, 1997 20:00 - 8:00 Flow = 1245 m^3)

STN ID	HOUR	
	0.5	12
1	1,900	100
2	600	500
3	800	58
4	6	22
5	32	<2
6	14	<2
7	6	<2
8	2	<2
9	14	<2
GM	9	<2

All values in E. coli organisms/100 ml
GM - Geometric Mean of Bathing Area Sites

Table 4.11d Bathing Area Monitoring Results (Sept 10/11, 1997 9:00 - 9:00 Flow = 51 m³)

STN ID	HOUR								
	0	0.5	1.5	3	4	5	6	12	24
1	12,000	28,000	10,000	4,000	---	---	---	---	---
2	480	---	---	---	690	---	---		---
3	120	---	300	540	1,800	8,200	2,500	---	---
4	10	---	---	10	---	---	20	40	10
5	20	---	---	---	---	---	20	30	10
6	10	---	---	---	---	---	10	10	10
7	10	---	---	---	---	---	10	10	10
8	10	---	---	---	---	---	10	20	30
9	10	---	---	---	---	---	20	30	40
GM	11	---	---	---	---	---	13	18	16

All values in E. coli organisms/100 ml
GM - Geometric Mean of Bathing Area Sites

In the first event, E coli counts were immediately elevated at the outfall (site 1) and at the discharge to the marina (site 3). However, no response at the outlet of the marina basin (site 4) or at the bathing area (sites 5 through 9) was apparent.

The second rain event produced more substantial flow than the first event. The E. coli counts for the second event indicated that the bathing area responds relatively quickly to the onset of a rain storm (within 6 hours). During the event, the results indicated an impingement of water with elevated E. coli counts was occurring in the bathing area. Following the cessation of rain, E. coli counts fell to pre-event levels within 24 hours.

The third event also had more substantial flow but the rain started in the evening making frequent sampling during the first 8 hours impossible. Any impact on downstream stations had subsided by the time sampling could be resumed (12 hours from onset).

The fourth event yielded a small flow, similar to the first event. Elevated E. coli counts were again evident at sites 1 to 3. However, the marina basin outlet and the bathing area sites showed no response.

E. coli counts in the discharge from the reservoir area (site 2) exceeded 100 organisms/100 ml on all occasions sampled. The discharge into the marina basin (site 3) exceeded E. coli counts of 100 organisms/100 ml on all but one sampling occasion. However, the results for site 3 during the fourth rain event showed elevated counts at the same order of magnitude as the Vinden Street outfall, suggesting that downstream quality was being influenced more by urban stormwater than the reservoir.

Although exceedences were noted at different times during each of the sampling runs, it is important to note that the geometric mean of all bathing area samples indicated responses only to rain events of approximately 20 mm or more and did not produce exceedences of the PWQO.

4.5.1 Bathing Area Sampling Implications

Based on the limited sampling available, it appears that rain events of approximately 20 mm or more will result in impingement of water with elevated E. coli counts on the Pete Peterson Park bathing area within six hours of the onset of a rain event. The response of the flow path to the bathing area to rain events appears to be driven by the Vinden Street outfall.

In order to mitigate the problem of water quality impingement in the PetePeterson Park bathing area, it is recommended that further channelization of the flow route to the marina basin be minimized and that the wetland area receiving the drainage from Vinden Street and the reservoir area east of Fourth Street be maintained or enhanced for flow retention.

It is also recommended that further sampling be carried out in order to measure quality of the flow path to the bathing area under more rain events. Further modelling of the system could then be possible to predict periods of impingement.

5.0 MODEL APPLICATION AND RESULTS

5.1 Model Results

As outlined in Section 2, the Retrofit Stormwater Management Practices model has been applied to calculate runoff from the urban areas of Severn Sound and formulate alternative strategies for reducing phosphorus loading. The original 'broadbrush' estimate of 3,133 kg/yr of annual phosphorus loading to Severn Sound from urban stormwater sources has been revised to 1,083 kg/yr. This reduction represents the incorporation of existing stormwater treatment through lakes, ponds and in place stormwater management practices which were not considered for the initial estimate (i.e. Little Lake in Midland, beaver ponds on natural drainage courses, and man-made impoundments of water acting as recharge areas for groundwater supplies). Table 5.1 illustrates a summary of the information generated through the RSWMP model based on the baseline and contaminant concentration information gathered through the monitoring phase of this study:

Table 5.1 Model Results

Urban Area	Area (ha)	Annual Runoff (m^3)	Annual Suspended Solids Loading (kg)	Annual Phosphorus Loading (kg)	Potential Phosphorus Removal Efficiency	Predicted Total Cost
Town of Midland	2,477	9,217,303	168,800	420.4	19.1%	$842,387
Town of Penetanguishene	610	2,032,580	118,600	273.9	16.2%	$1,008,417
Community of Victoria Harbour	390	1,166,538	61,570	141.2	20.0%	$1,072,346
Community of Port McNicoll	270	853,927	44,420	100.6	43.2%	$1,221,316
Community of Waubaushene	145	486,892	32,630	75.3	19.5%	$416,843
Community of Coldwater	241	654,855	31,820	71.3	4.9%	$42,951
Total	**4,133**	**14,412,095**	**457,840**	**1,082.7**	**19.8%**	**$4,604,260**

The potential phosphorus removal efficiency and the predicted total cost values indicated above represent the model output based on all potential stormwater management projects identified in this study. Stormwater management options for each individual municipality were evaluated based on their potential to reduce phosphorus loading. Based on the identified projects, an overall potential reduction of 19.8% was obtained. The cumulative cost of this reduction is $4,604,260. Effectively, the original goal of 20% reduction in phosphorus can be achieved at considerably less expense than originally anticipated.

5.2 Stormwater Management Financing Mechanisms

It is widely accepted that municipalities have a significant role to play in dealing with urban non-point sources (NPS) of pollution when considering improvement of water quality. Although many municipalities may not have a direct interest in NPS, they are expected to be responsible for the design, implementation, and maintenance of stormwater management practices and have to assume the financial and other liabilities of these measures (Price and Tran, 1992). This study has identified a number of stormwater management projects required to reduce the impacts of stormwater runoff in the Severn Sound Area of Concern (AOC).

The required stormwater management projects identified for the Severn Sound AOC have significant capital outlays associated with them, as well as additional annual operations and maintenance costs. However, a wide variety of potential stormwater financing options exist to assist in achieving the 20% phosphorus reduction target. As a result, the purpose of this section is to provide information concerning alternative financing mechanisms in Severn Sound, and to provide some financing scenarios under more traditional financing schemes.

5.2.1 Alternative Financing Mechanisms

A study commissioned by the Regional Municipality of Ottawa-Carleton, Environment Canada and the Ontario Ministry of Environment and Energy, entitled "Financing Options for Stormwater Quantity and Quality Management in the RMOC" (1996), identified a number of potential financing options for stormwater management. These mechanisms were considered either revenue generating or debt mechanisms. The following outlines some of the mechanisms which have been considered as potentially applicable to local municipalities for capital and operations and maintenance stormwater funding.

i. Revenue Generating Mechanisms

Revenue generating mechanisms produce a flow of funds in direct proportion to certain economic activities or values. Examples of each of the following revenue generating mechanisms are outlined in Table 5.2.

a. Tax Revenues

Federal, provincial and municipal responsibility for the environment is reflected in the proportion of tax revenues collected to those that are dedicated to environmental issues/agencies. The collection and distribution of different taxes for environmental, and more specifically stormwater issues, has the potential to contribute to the solution of many environmental problems only if stronger support systems and frameworks for distribution of funds can be coordinated between all levels of government.

b. User Fees

A fee is generally a charge for a service rendered and can be based on the service provided or on the pollution being controlled. Fees establish direct links between demand for environmental services and the cost of providing them. User charges are typically paid by property owners and managed in a separate fund, which is a restricted account where revenues deposited into it are dedicated to financing specified government services (i.e. stormwater management). These fees may be flat rates that vary by group (e.g. industrial vs. residential), or volume-based rates which reflect a property's contribution to stormwater runoff (e.g. percent of impervious surface).

c. Special Charges

Special charges are those that are not placed upon the general population nor upon the sale of a particular good or service, but apply to specific types of transactions that impose environmental or development costs.

d. Grants

A grant is a sum of money awarded to a government or non-profit organization. Typically, grants are awarded by the federal or provincial government to municipal governments for the purpose of financing a particular activity or facility.

Table 5.2 Revenue Generating Mechanisms

Type	Description
Tax Revenues	
General Taxes	A general tax is a tax whose burden falls upon a broad section of the general public, such as wage earners or property owners.
Real (Ad Valorem) Property Taxes	Charges on general property owners are usually based on a percentage of the assessed value of the property. A share of the tax revenues could be used to improve infrastructure services, such as stormwater drainage.
User Fees	
Connection Fee	Connection fees charged to property owners for connection to a municipal utility. Hook-up fees and new connection fees are frequently charged in residential developments for water supply services and wastewater collection systems. Hook-up fees are typically intended to recover the fixed portion of total service costs.
Impact Fees	Charges to new users of government services to pay for expansion of the services that they require. These fees can be applied to new development or to new users who have located in existing development.
Inspection/Monitoring Fees	Charges for inspecting or monitoring construction plans, operation, or outputs of facilities that have an impact on the environment. Inspection/monitoring confirms that equipment or discharges meet applicable standards. Examples include: emissions inspection fees; septic tank inspection fees; laboratory inspection fees; and drinking water monitoring fees.
Licensing/Recreational Fees	Fees charged to an individual for the privilege of engaging in an activity.
Permitting Fees	Permitting fees are charged to recover governments' cost to process a permit. Examples include fees charged to obtain general business permits, permits to discharge wastewater to public sewers or waterways, or permits to operate pollution control equipment.
Special Charges	
Development Charges	Municipalities may levy development charges if residential or commercial development would increase the need for municipal services. These charges may be levied on residential, commercial, and industrial property and used to finance the capital costs of providing required services.
Special Assessments	A charge levied on a sub-group that accrues particular benefits from an environmental service or improvement not enjoyed by the remainder of the population in that area. Some communities finance river cleanup, for example, by charging residents with riverfront property a special assessment to reflect higher property values or increased levels of business activity associated with a cleaner waterway.
In-Lieu of Construction Charge	Developers may be given the option of paying a charge instead of building a stormwater facility on-site. These fees may then be used to finance various stormwater infrastructure.

Source: Financing Options for Stormwater Quantity and Quality Management in the RMOC (1996)

ii. Debt Mechanisms

Debt mechanisms simply form capital in advance of an anticipated flow of funds which are used to repay the capital plus interest accrued.

a. Bonds

A bond is a written promise to repay borrowed money on a predictable schedule and usually at a fixed rate of interest for the life of the bond. Bonds can stretch out payments for new projects over a period of fifteen to thirty years. Government repay this debt with taxes, fees, or other sources of government revenue. There are basically three types of bonds:

- *General Obligation (GO) Bonds* - bonds backed with the guarantee that the issuing government will use its taxing power to repay the bond. There are two types of GO bonds:
  - Unlimited recovery: bonds backed by the full taxing authority of the municipality.
  - Limited Recovery: bonds backed by the limited taxing authority of the municipality.

- *Revenue Bonds* - bonds generally backed by user fees or service charges paid by users of the facility. A utility enterprise revenue bond is backed by the user charges from a utility, while a lease rental revenue bond is backed by lease payments from the rental of a facility.

- *Double-Barrel Bonds (Self-Supporting Bonds)* - a revenue bond that is also backed by full or partial taxing power of the issuing government.

b. Revolving Loan Funds

A loan is the provision of funds upfront for a capital expenditure that must be repaid in a set amount of time at a negotiated interest rate. Loans are typically offered to municipal governments through federal programs or by commecial banks. A Revolving Loan Fund is a system whereby a initial infusion of capital is deposited in an institution that, in turn, makes loans to qualified facilities. As these loans are repaid, the initial capitalization "revolves," or is lent out to other municipalities.

c. Commercial Loans

Banks or financial institutions will offer government entities loans to finance a variety of capital projects. These loans are typically sought by small communities that are unknown in the generally lower-cost bond market, or where low-cost capital is otherwise unavailable, such as when a community's bonding capacity is exhausted.

5.2.2 Common Financing Mechanisms

The most commonly used financing mechanisms which have been applied to recover stormwater management costs are described below. Please note that although each of the mechanisms listed can be considered revenue generating, they can also be applied to service debt borne payments relating to stormwater management implementation.

- *Municipal Property Taxes* - General revenue funds have been a significant source of funding for stormwater management in many municipalities and townships. Municipal general revenue funds contain all undedicated revenues raised by the municipality or township. Property taxes comprise a large component of general funds.

- *Water/Sewer Bill Surcharges* - Some municipalities in Ontario have applied surcharges to household, commercial, and/or industrial water bills. Flat or ad valorem surcharges are deposited into a storm sewer capital reserve fund that is used strictly to finance municipal stormwater management initiatives.

- *Special Charges* - Municipalities may pass by-laws to impose charges, with certain exceptions, on all forms of development. These development charges aim the burden of payment on the developer. It should be noted that development charges finance only capital costs of stormwater infrastructure and not annual operating and maintenance costs. In other municipalities, when development charges have been applied towards stormwater infrastructure capital costs, operating and maintenance costs have been recouped through general revenues and/or sewer surcharges.

- *Grants from Other Levels of Government* - Revenues have been made available to municipalities, as transfers from the Canadian or Ontario Governments, for the purpose of financing a particular activity or facility.

- *User Fees* - In the past, public services were often provided with little consideration to disparities between those who caused the need for or used the services and those who paid for the services; however, recent economic realities have forced a shift in thinking. Financing mechanisms based on user pay principles have grown in popularity over the past decade, primarily because:
    - Canadians currently oppose additional tax burdens (i.e. are tax fatigued), and user-pay approaches are seen by many as an equitable alternative;

- user-pay schemes can be dedicated to specific uses, such as stormwater financing, and provide an element of fiscal accountability; and,
- user-pay approaches can increase the efficiency of resource use, by providing price signals for encouraging acceptable or discouraging unacceptable behaviour.

The user pay approach to stormwater management might satisfy ratepayers, and reduce the threat of opposition or challenges. The means of allocating revenue requirements may include the distribution of planned expenditures between new growth areas and existing areas. There has only been limited experience with user charges for stormwater management in Canada. Regina has had a user charge system in place for approximately four years. Originally the user charges were assessed on a fixed rate schedule of $3.00 per month. The City has altered the system so that the approximately 50,000 residential properties pay $3.50 per month while the 8,000 non-residential properties are charged on an area basis. This user pay system, assessed through the water bill, raises approximately $4,000,000 annually for stormwater management.

5.3 Retrofit Stormwater Management Financing Scenarios

5.3.1 *Town of Midland Retrofit Stormwater Management Financing Scenarios*

In the past, the Town of Midland relied on a variety of sources to meet their stormwater revenue requirements. In 1997 the Town funded stormwater projects through general revenue funds, grants and contributions from other municipalities. That same year, the Town spent approximately $98,800 on storm sewer related projects. These projects were partially funded ($59,000) through grants from the federal and provincial governments and contributions from other municipalities. The remainder, approximately $39,900, was funded through the Town general revenue fund, at a cost of approximately $6.76 per household or $2.65 per capita. Expenditures in 1997 related to the Severn Sound RAP Urban Stormwater Management Strategy amounted to approximately $11,286, which translates into $1.91 per household or $0.75 per capita (based on 1996 census data).

Based on the results of this study, the recommended stormwater management program in the Town of Midland is expected to cost $842,387 or approximately $112,400 annually over a 10 year period. These costs can be broken down further as $110,590 in annual capital costs and $1,805 in annual operating and maintenance costs (capital costs have been debentured over a 10 year period, at an interest rate of 7 percent and operation and maintenance costs are distributed over a 25 year period, the lifetime of the projects). Of course, the Town of Midland could simply adjust the existing mechanisms (raise taxes) to meet these new financial requirements. Under this scenario the annual cost per property, over a 10 year period, would be approximately $18. This annual cost is based on the total annual cost divided by 6,207 properties, which includes all residential, commercial, industrial and institutional properties (based on 1996 census data).

The cost estimates are based on potential retrofit remedial measures to existing storm drainage systems only. Consequently, development charges have not been included in these financing estimates (it should be noted that in the City of Gloucester, 15 percent of the revenue raised by development charges are raised from non-growth (existing) development).

Another option to meet revenue requirements could involve the introduction of user charges. Assuming a user charge assessed on a per serviced unit fix rate, the annual payment would be approximately $22 and the monthly payment would be less than $2. This is based on 4,792 residential, 278 commercial and 28 institutional/industrial serviced users. This user pay system, similar to the City of Regina, could be assessed through the water and sewage billing. Alternatively, user fees may be flat rates that vary by user group (e.g., industrial vs. residential), or volume-based rates reflecting a property ' s contribution to stormwater runoff (e.g. percent of impervious surface).

5.3.2 *Town Of Penetanguishene Retrofit Stormwater Management Financing Scenarios*

In 1997 the Town of Penetanguishene spent approximately $32,000 on storm sewer related projects. This translates into a cost per household of approximately $12 or $5 per capita (based on 1996 census data). As a share of total municipal spending, storm sewer expenditures funded through general revenues in 1997 accounted for approximately one half of one percent of the 1997 budget. In 1998 the Town council has approved $35,000 for storm sewer related projects.

Based on the findings of this study, the recommended retrofit stormwater management program in the Town of Penetanguishene is expected to cost approximately $1,000,000 or about $112,000 annually over a 10 year period. These costs can be broken down further as $100,212 in annual capital costs and $11,439 in annual operating and maintenance costs (capital costs have been debentured over a 10 year period, at an interest rate of 7 percent and operation and maintenance costs are distributed over a 25 year period, the life-time of the projects).

As in the past, the Town of Penetanguishene could fund future stormwater management projects through general revenues. Assuming this were the case, the annual cost per property would be approximately $39 over a 10 year period. This annual cost is based on the total annual cost divided by 2,840 properties, which includes all residential, commercial, industrial and institutional properties (based on 1996 census data).

Under a user pay approach, the means of allocating revenue requirements may include the consideration of the distribution of planned expenditures between new growth areas and existing areas. The cost estimates provided for the Town of Penetanguishene are based on potential retrofit remedial measures to existing drainage systems only. Consequently, development costs have not been included in these financing estimates. Under a user pay approach the annual cost per serviced user would be approximately $60 or approximately $5 per month. This is based on 1,758 residential and 88 commercial/industrial serviced users.

5.3.3 *Township Of Tay Retrofit Stormwater Management Financing Scenarios*

The 1998 budget for the Township of Tay does not include any stormwater projects, nor does it indicate that any projects were undertaken in 1997.

Based on this study, the recommended retrofit stormwater management program in the Township of Tay (Communities of Victoria Harbour, Port McNicoll and Waubaushene) is expected to cost approximately $2.7 million or about $291,000 annually, over a 10 year period. These costs can be broken down further as $257,237 in annual capital costs and $34,241 in annual operating and maintenance costs (capital costs have been debentured over a 10 year period, at an interest rate of 7 percent and operation and maintenance costs are distributed over a 25 year period, the life-time of the projects).

If the Township of Tay chose to fund future stormwater management projects through general revenues, the annual cost per property would be approximately $71 over a 10 year period. Alternatively, if the Town chose to impose a user fee linked to water and wastewater users, the annual cost per property would be approximately $120 per property over a 10 year period. This annual cost per property is based on the total annual cost divided by 2,440 properties, which includes all residential, commercial, industrial and institutional properties (based on 1996 census data).

5.3.4 *Township Of Severn Retrofit Stormwater Management Financing Scenarios*

Based on the results of this study, the recommended retrofit stormwater management program in the Township of Severn (Community of Coldwater) is expected to cost approximately $43,000 or about $5,500 annually over a 10 year period. This cost can be broken down further as $5,361 in annual capital costs and $161 in annual operating and maintenance costs (capital costs have been debentured over a 10 year period, at an interest rate of 7 percent and operation and maintenance costs are distributed over a 25 year period, the life-time of the projects). Based on 1996 census data the annual cost per household would amount to approximately $1.50.

In 1997, actual revenue through development charges in the Township of Severn was approximately $159,000. That same year, actual development related expenditures by the Township amounted to approximately $126,000. This surplus in revenue of approximately $33,000 would account for approximately 80 per cent of the Township's total retrofit stormwater program capital costs. If the project in the Township of Severn was to be completed and paid for within a year, the total capital cost would amount to approximately $39,000 or about $10.00 per household. The total capital costs account for less than 1 per cent of the Township's 1998 budget.

5.4 Retrofit Stormwater Management Financing Summary

Historically, financing mechanisms in most smaller urban municipalities in Ontario (including those in the Severn Sound AOC) have relied upon general revenues from property taxes, water/sewer bill surcharges, development charges or road grants for retrofit infrastructure improvements to recover the funds required to finance stormwater related infrastructure. Recognizing that the retrofit stormwater management projects outlined in this report have significant capital outlays and annual operations and maintenance costs associated with them, a number of alternative financing options have been provided as potential sources for funding these projects.

Alternative financing mechanisms incorporate measures of quantity and quality of stormwater runoff in user pay approaches. In these cases, the municipalities would have to collect significant amounts of data on land use, which could be expensive and time-consuming. As a result, in order to keep expenditures in perspective, the more traditional financing mechanism have been presented in greater detail and financing scenarios under these schemes has been provided (although usually a significant motivator and contributor to capital programs, grants were not considered in these scenarios due to their unpredictability and fierce competition for limited available funds).

The most basic scenario demonstrates that large amounts of revenue can be generated through general revenues from the taxation base. By recouping costs through general revenues, the annual household stormwater management charge would range from $18 to $71, over a ten year period, for three of the four participating municipalities/townships. In the Township of Severn, the required retrofit stormwater management program could feasibly be financed in a much shorter time-period. In fact, if the required project was financed within a one year period, the financial impact would amount to approximately $10 per household.

Under a user fee scenario based on water and sewer surcharges, unserviced properties may be exempted from paying charges, thus increasing the impact on the average serviced property. By recouping costs through user fees, the annual household stormwater management charge would range from $20 to $120, over a ten year period, for three of the four participating municipalities/townships.

6.0 URBAN STORMWATER MANAGEMENT STRATEGY IMPLEMENTATION

6.1 Guide to Understanding the Retrofit Stormwater Management Strategies

During the 1970's and 1980's, municipalities and government regulators alike endeavoured to develop effective criteria and methodologies for controlling stormwater. From these exercises, planning practices such as the watershed plan, subwatershed plan and stormwater management plan evolved and have become widely accepted. These types of plans provide environmental input to municipal Official Plans, Secondary Plans and Plans of Subdivision.

One of the main objectives of this study was to perform a planning level analysis of potential retrofit stormwater management practices with the goal of producing a long-term guidance document outlining potential implementation projects for each municipality involved. This guidance document is intended to assist municipalities in identifying potential retrofit stormwater management projects in conjunction with planned capital works and operating programs.

The structure of the guidelines follows the preferred hierarchy of stormwater management practices outlined in Section 3.1.3. The RSWMP options (if applicable to the municipality in question) is presented based on the catchment/drainage area it is located in and is structured to provide specific locations, area served, the resultant reduction in phosphorus associated with that option, and the capital and operations and maintenance costs per year of that option (see Figure 5.1 for an example). In addition, maps illustrating the locations of these RSWMP options are included.

Of particular importance to the success of retrofit stormwater management practices is the need for flexibility on the part of the participating municipalities. The potential projects outlined in this section should be considered as conceptual and should be examined in more detail as the opportunity for implementation arises. The draft drainage policy outlined in Appendix F includes a protocol by which to examine potential for RSWMP options based on opportunities arising from infrastructure improvements undertaken by the municipality. This protocol was developed for the Belleville Pollution Control Plan and is applicable to the Severn Sound AOC.

Figure 6.1 Guide to Using the RSWMP Plan

This indicates the land uses and size of the area to be served by the RSWMP

This column indicates the percentage reduction of phosphorus this RSWMP will provide for the catchment in question.

This column indicates the total capital cost of the RSWMP

This column indicates th total Operational and maintenance cost of the RSWMP

This indicates the time period in which the RSWMP is to be implemented.

This indicates the catchment area in which the RSWMP option is to be implemented in.

This is a verbal description of the location at which the RSWMP is to be implemented.

Table 2 Oil/Grit Separator Locations

Area	Location Description	Area Served	P Reduction	Capital Cost	O&M Cost/yr
0-10 yrs					
Catchment 10	Easy St. at First St. Serving area to the East but not all the way to King St.	0.13 ha Com, 0.05 ha Rds.	0.2%	$2,260	$36
Catchment 10	Hugel Ave. at South Entrance to Laneway between King St. and First St.	0.61 ha Com, 0.11 ha Rds.	0.8%	$9,820	$148
Catchment 11	Hugel Ave. at South Entrance to Laneway between King St. and Midland Ave.	1.4 ha Com, 0.2 ha Rds.	0.7%	$19,825	$324
Catchment 11	Bay St. at West Side of King St.	0.22 ha Com, 0.08 ha Rds.	0.2%	$3,930	$64
10-25 yrs					
Catchment 10	First St. at Elizabeth St. Serving South of this Point	0.94 Com, 0.38 Rds.	1.6%	$17,440	$285
Catchment 11	West Side of King St. at Elizabeth St.	0.2 ha Com, 0.1 ha Rds.	0.2%	$4,030	$66
Catchment 14	North East corner of WALTEC PLASTICS property on George St.	1.5 ha Ind, 0.15 ha Rds.	0.3%	$19,650	$322
Total			0.23%	$76,155	$1245

It is important to note that this reduction in phosphorus represents the percentage applicable to the entire municipal area and not an average of the above catchments.

RETROFIT STORMWATER MANAGEMENT PLAN
FIGURE M-1 TOWN OF MIDLAND

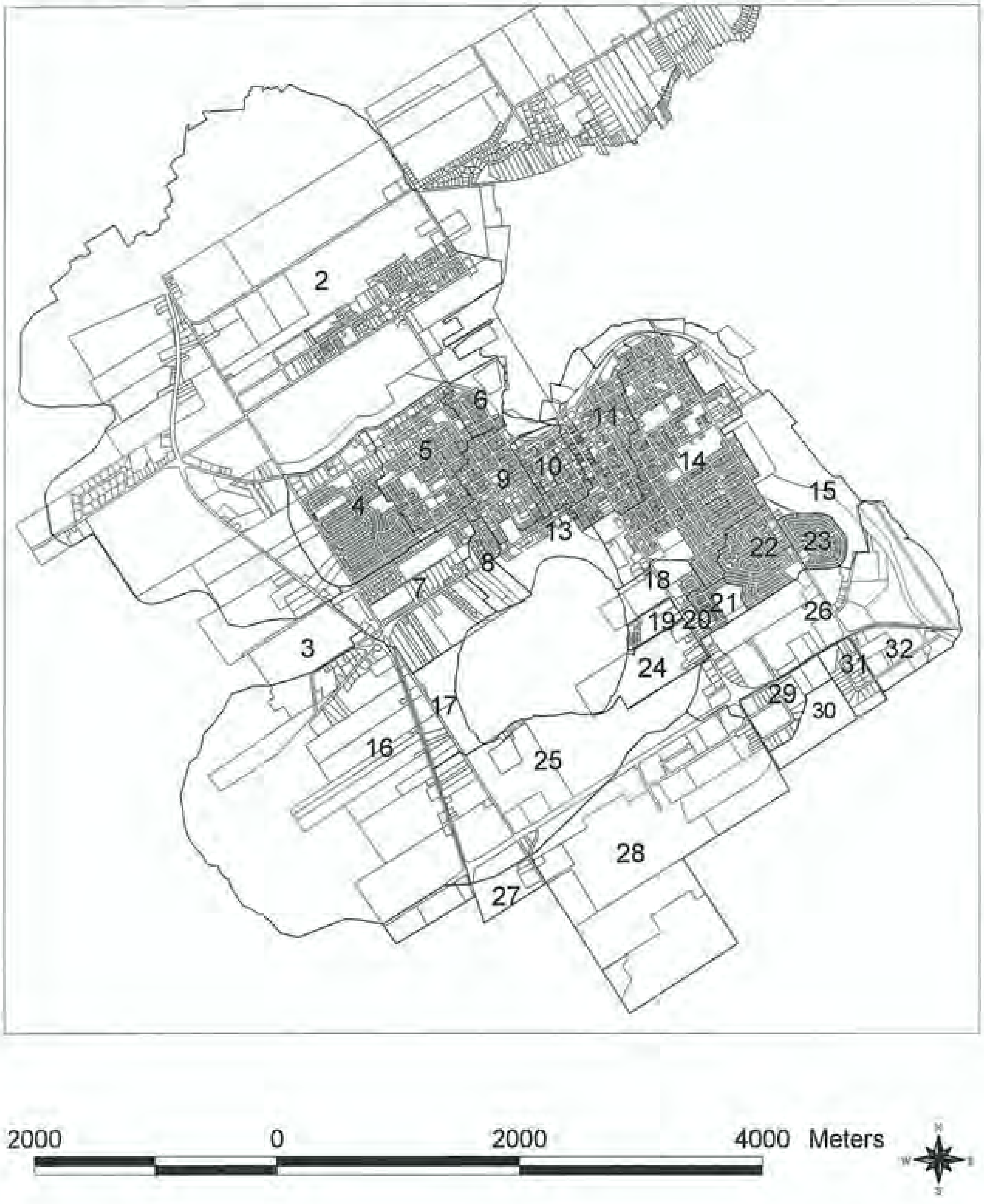


Table M-1 Midland Waterfront Outfalls and Other Catchments

Catchment Number and Name		Area (ha)	Current P Loading to Severn Sound (kg/yr)	P Loading Without Existing Treatment (kg/yr)	Land Use
Waterfront Outfalls					
2	Peterson Park Outfall	1024.0	44.71	295.60	Rural/Res/Com
3	Mountainview Mall	70.9	1.94	38.77	Com/Rural
4	Woodland Drive Outfall	84.4	8.95	44.74	Res/Com
5	Vinden Street Outfall*	67.6	11.82	39.41	Res/Com
6	Ottawa Street Outfall	21.4	10.87	10.87	Res
9	Quebec Street Outfall	43.0	23.22	23.22	Res
10	First Street Outfall*	27.6	19.09	19.09	Res/Com
11	King Street Outfall	69.0	50.20	50.20	Res/Com
12	Coal Docks	9.9	1.92	19.17	Vacant
14	William Street Outfall*	132.5	107.60	107.60	Res/Com
15	East Side (Tiffin Park)	86.9	18.34	19.32	Vacant/Ind
23	Birchwood Drive Outfall*	19.4	4.85	12.18	Res
Little Lake Outfalls					
7	Yonge Street Outfall	82.4	1.46	29.25	Res/Com
8	Shewfelt Outfall	19.2	0.40	8.00	Res
13	Midland Park Lake Outfall	41.5	0.66	13.23	Res/Vacant
16	Highway 93 (1) Outfall	197.1	2.49	49.89	Rural/Ind/Com
17	Highway 93 (2) Outfall	35.0	0.37	7.30	Vacant/Rural/Ind
18	King Street (1) Outfall	21.4	0.43	8.58	Vacant/Res
19	Retirement Villa Outfall	9.4	0.23	4.57	Res
24	King Street (2) Outfall	26.0	0.80	15.80	Vacant/Res
25	Hanson Development	149.9	1.46	29.28	Vacant/Rural/Ind
Other Drains					
20	King Street Outfall	3.9	1.66	19.13	Res
21	Fraser Street Outfall	12.7	5.64	6.41	Res
22	Christine Drive Outfall	36.5	18.48	21.02	Res
26	Highway 12 - Mitsubishi	155.8	64.65	70.25	Vacant/Ind/Res
27	Rural Outfall 1**	33.7	---	---	Rural/Com
28	Rural Outfall 2**	275.2	---	---	Vacant/Ind/Rural
29	Cranston Crescent	28.5	---	---	Com/Vacant
	Outfall**	21.5	---	---	Vacant
30	Rural Outfall 3**	18.4	---	---	Vacant/Ind
31	Rural Outfall 4**	29.5	---	---	Vacant/Ind
32	Rural Outfall 5**				
Total		**2854.2**	**402.24**	**962.88**	

* Monitored catchments

** Catchments draining away from the shoreline into other bodies of water, therefore not considered in the modelling component of this study.

RETROFIT STORMWATER MANAGEMENT PLAN RATIONALE

The Town of Midland is comprised of a number of varied physiographic landscapes common to glaciated areas. A majority of the soils are moderate to poorly drained glacial tills especially along the existing shoreline. These poorly drained soils continue away from the water and become interspersed with sandy areas, especially in the higher elevated portions of town above the ancient shoreline. These sandy areas are good to moderately well drained and lend themselves to infiltration/exfiltration type stormwater management practices.

Midland's stormwater conveyance system is dominated by curb and gutter/storm sewer drainage with a few ditches in the outskirts or undeveloped parts of town. As a result, infiltration trenches have not been considered as feasible ***retrofit*** options within this plan.

Downspout Disconnections:

Areas considered suitable for downspout disconnections have been indicated on Figure M-2. An estimated 336 lots were identified as being qualified for this retrofit option with costs and phosphorus reductions outlined below. Please note that these are only estimates of potential areas suitable for downspout disconnections. A more detailed survey of individual lots would be required in order to implement this option effectively. In addition, the highlighted areas are only a guideline and efforts should not be limited or constrained by them.

Table M-2 Midland Downspout Disconnection Potential

Area	Number of Qualified Lots	P Reduction*	Capital Cost	Amortized Capital Cost/yr
Catchment 4	71	1.2%	$7,100	$766
Catchment 5	25	0.8%	$2,800	$302
Catchment 6	8	0.7%	$800	$86
Catchment 7	29	1.9%	$2,900	$313
Catchment 8	10	1.4%	$1,000	$108
Catchment 9	21	1.0%	$2,100	$227
Catchment 10	5	0.2%	$500	$54
Catchment 11	22	0.4%	$2,200	$237
Catchment 13	4	0.4%	$400	$43
Catchment 14	109	0.9%	$10,900	$1,176
Catchment 18	4	0.7%	$400	$43
Catchment 21	18	1.4%	$1,800	$194
Catchment 23	7	0.5%	$700	$76
Total	**336**	**0.5%**	**$33,600**	**$3,625**

*note: P Reduction is shown based on the effect on each individual catchment while the total represents the reduction of the overall load from Midland.

Recommendation 1:

Establish a downspout disconnection program to assist households in disconnecting drains from storm and/or sanitary sewers**. This would require the development of a survey program targetted on areas suitable for downspout disconnection to identify households willing to participate in the disconnection process. It would also require the purchase of splash pads and pipe elbows for each participating household.

** Although connections to sanitary sewers results in treated stormwater, it would be beneficial to the Water Pollution Control Plant to reduce these extraneous flows. As a result, targetting the two sewer systems in the survey would be appropriate.

Figure M-2 Areas Considered Suitable for Downspout Disconnection in Midland

Oil/Grit Separators:

Suitable oil/grit separator locations were determined based on the potential for road reconstruction over the next 25 years and the industrial/commercial uses and are illustrated on Figure M-3. For the purposes of this study, the projects have been broken down into two time frames, 0-10 year and 10-25 year projects.

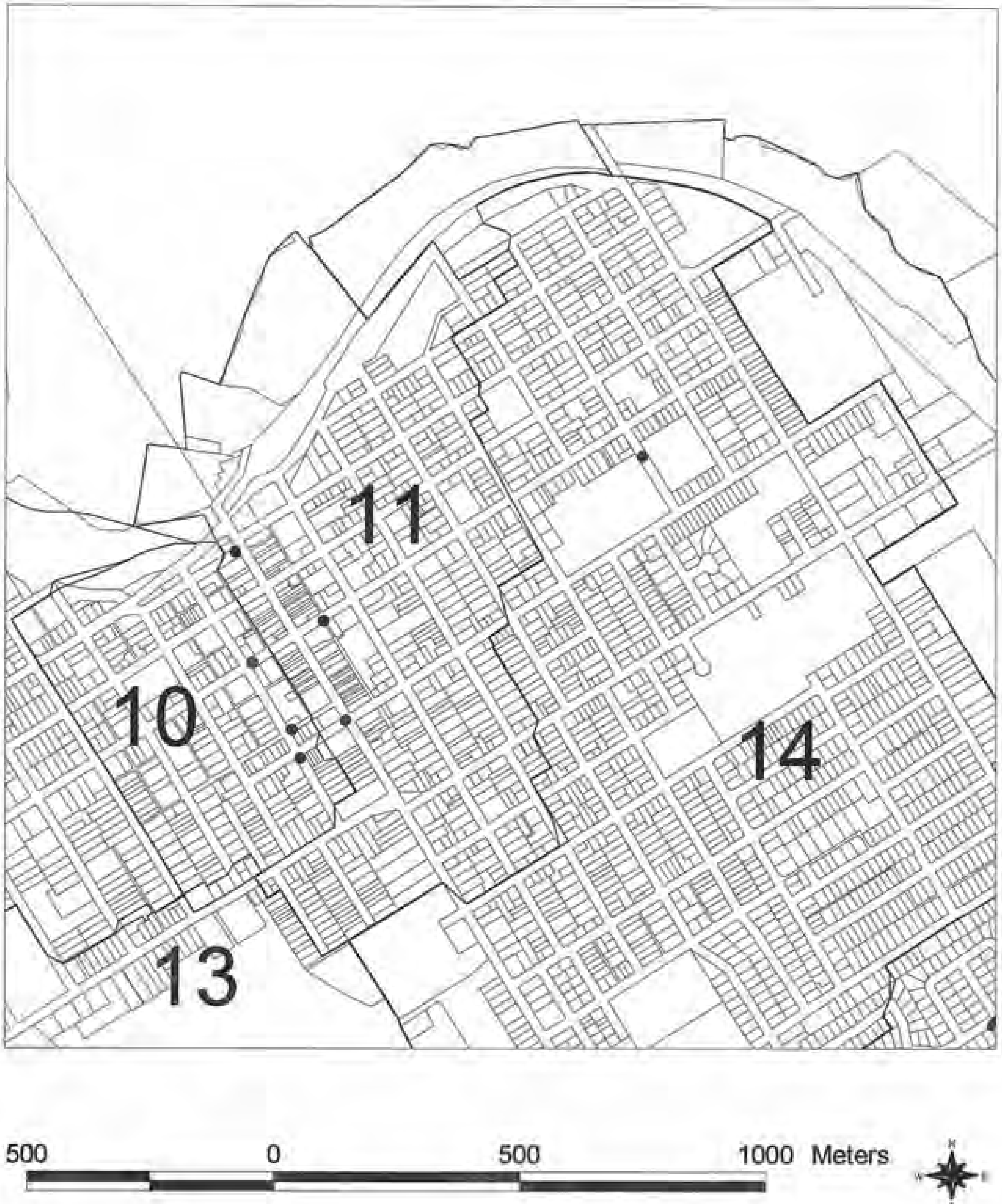
Table M-3 Midland Oil/Grit Separator Locations

Area	Location Description	Area Served	P Reduction	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
0-10 yrs						
Catchment 10	Easy St. at First St. Serving area to the East to King St.	0.12 ha Com, 0.05 ha Rds.	0.3%	$2,280	$318	$16
Catchment 10	Hugel Ave. at South Entrance to Laneway between King St and First St	0.61 ha Com, 0.11 ha Rds.	1.2%	$8,565	$1,193	$60
Catchment 11	Hugel Ave. at South Entrance to Laneway between King St. and Midland Ave.	1.4 ha Com, 0.2 ha Rds.	0.9%	$20,060	$2,795	$142
Catchment 11	Bay St. at West Side of King St.	0.22 ha Com, 0.08 ha Rds.	0.2%	$3,980	$555	$28
10-25 yrs						
Catchment 10	First St. at Elizabeth St. Serving South of this Point	0.94 Com, 0.38 Rds.	2.3%	$17,645	$2,458	$125
Catchment 11	West Side of King St. at Elizabeth St.	0.2 ha Com, 0.1 ha Rds.	0.2%	$4,080	$568	$29
Catchment 14	North East corner of WALTEC PLASTICS property on George St.	1.5 ha Ind, 0.15 ha Rds.	0.5%	$19,890	$2,771	$140
Total			**0.5%**	**$76,500**	**$10,658**	**$540**

Recommendation 2:

In all cases of road reconstruction or drainage improvement activities, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of commercial or industrial properties, oil/grit separators should be given consideration.

Figure M-3 Locations Considered Suitable for Oil/Grit Separators in Midland



Stormwater Exfiltration Systems:

Similar to Oil/Grit Separators, suitable sites for stormwater exfiltration were chosen based on potential for road reconstruction projects and other site characteristics. Because of the wide range of locations, no map has been produced illustrating the locations of these projects.

Table M-4 Midland Potential Stormwater Exfiltration Projects

Area	Road Name	From	To	Length	P Reduction	Capital Cost	Amortized Capital Cost/yr
0-10 yrs							
Catchment 6	Sixth St.	Quebec St.	Victoria St.	220 m	7.0%	$11,660	$1,625
Catchment 11	Manly St.	Elizabeth St.	Bay St.	315 m	2.0%	$16,700	$2,327
Catchment 11	Queen St.	Dominion Av.	Bay St.	90 m	0.6%	$4,770	$665
Catchment 11	Manly St.	Dominion Av	Bay St.	90 m	0.6%	$4,770	$665
Catchment 11	Frederick St.	All	All	175 m	1.5%	$9,275	$1,292
Catchment 14	Donalda St.	Johnson St.	William St.	400 m	2.1%	$21,200	$2,954
Catchment 14	Johnson St.	Colborne St.	Hanley St.	350 m	2.4%	$18,550	$2,585
Catchment 14	Hannah St.	All	All	460 m	2.5%	$19,080	$2,658
10-25 yrs							
Catchment 5	Ninth St.	Dominion Av.	Bay St.	90 m	1.4%	$4,770	$665
Catchment 6	Victoria St.	Sixth St.	Fourth St.	200 m	7.0%	$10,600	$1,477
Catchment 9	Fifth St.	Quebec St.	Yonge St.	780 m	20.0%	$41,340	$5,760
Catchment 9	Sixth St.	Quebec St.	Yonge St.	760 m	19.5%	$40,280	$5,612
Catchment 9	Seventh St.	Hugel Av.	Yonge St.	310 m	7.9%	$16,430	$2,289
Catchment 9	Dominion Av.	Eighth St.	Fifth St.	350 m	9.0%	$18,550	$2,585
Catchment 10	Third St.	Yonge St.	Easy St.	215 m	6.0%	$11,400	$1,588
Catchment 10	Second St.	Yonge St.	Easy St.	210 m	5.8%	$11,130	$1,551
Catchment 10	Elizabeth St.	Second St.	First St.	50 m	1.4%	$2,650	$369
Catchment 11	Queen St.	Yonge St.	Hugel Ave.	400 m	3.5%	$21,200	$2,954
Catchment 11	Midland Av.	Yonge St.	Ellen St.	220 m	1.9%	$11,660	$1,625
Catchment 11	Hugel Av.	Queen St.	Russel St.	250 m	2.2%	$13,250	$1,846
Catchment 14	Johnson St.	Hanley St.	Ellen St.	520 m	2.4%	$27,560	$3,840
Catchment 14	Scott St.	Johnson St.	William St.	400 m	1.9%	$21,200	$2,954
Catchment 14	Ruby St.	Irwin St.	William St.	140 m	0.7%	$7,420	$1,034
Catchment 14	Wellington St.	Colbourne St.	End	205 m	1.0%	$10,870	$1,515
Catchment 14	Manly St.	Ellen St.	Yonge St.	200 m	0.9%	$10,600	$1,477
Total				6,435 m	10.71%	$386,915	$53,939

Recommendation 3:

In all cases of road reconstruction or drainage improvement activities, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of curb and gutter stormwater conveyance, exfiltration systems should be given consideration.

Infiltration Trenches:

Due to the predominance of curb and gutter conveyance systems in the Town of Midland, infiltration trenches were not considered feasible as options for retrofit projects. However, in the case of new development in areas without existing curb and gutter systems, infiltration trenches should be considered favourable stormwater conveyance systems.

Recommendation 4:

In all cases of road reconstruction or drainage improvement activities, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of ditched stormwater conveyance, infiltration trenches should be given consideration.

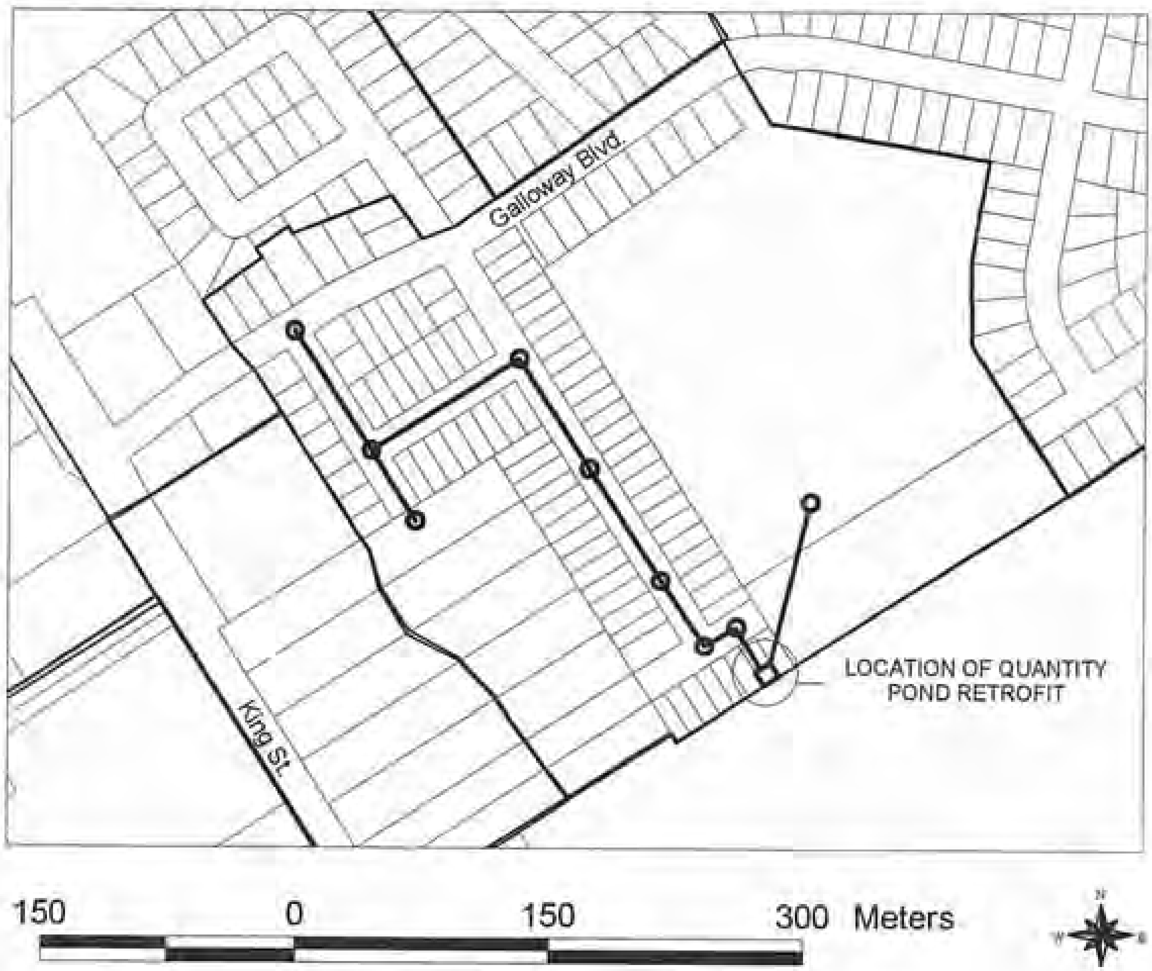
Quantity Pond Retrofits:

For the Town of Midland, only one potential quantity pond retrofit exists in catchment 21. The existing pond is located at the south west corner of the Saint Theresa high school property (Figure M-4) and collects runoff from a 12.72 ha area of which 10.12 ha is residential/institutional and 2.6 ha is vacant. The total additional storage which will be required is 763 m^3 and will result in a 59.4% removal of phosphorus for this catchment. This RSWMP represents an overall phosphorus reduction for the Town of Midland of 0.96% with an estimated total cost of $18,240 ($2,541 amortized capital cost/yr)

Recommendation 5:

In order to maximize the economic and treatment efficiency of retrofit quality ponds, attempts should be made to integrate future development or planning activities with the construction of new quality ponds for stormwater treatment.

Figure M-4 Location of Quantity Pond Considered Suitable for Retrofit in Midland



New Quality Ponds:

Locations considered suitable for new quality ponds have been indicated on Figure M-5. When considering new quality ponds, integrating implementation with existing plans can result in economic benefits and increased functionality. For example, if housing development is to take place within the catchment identified for a new quality pond, a joint cost sharing effort between the municipality and the developer may take place so existing and proposed housing will be serviced.

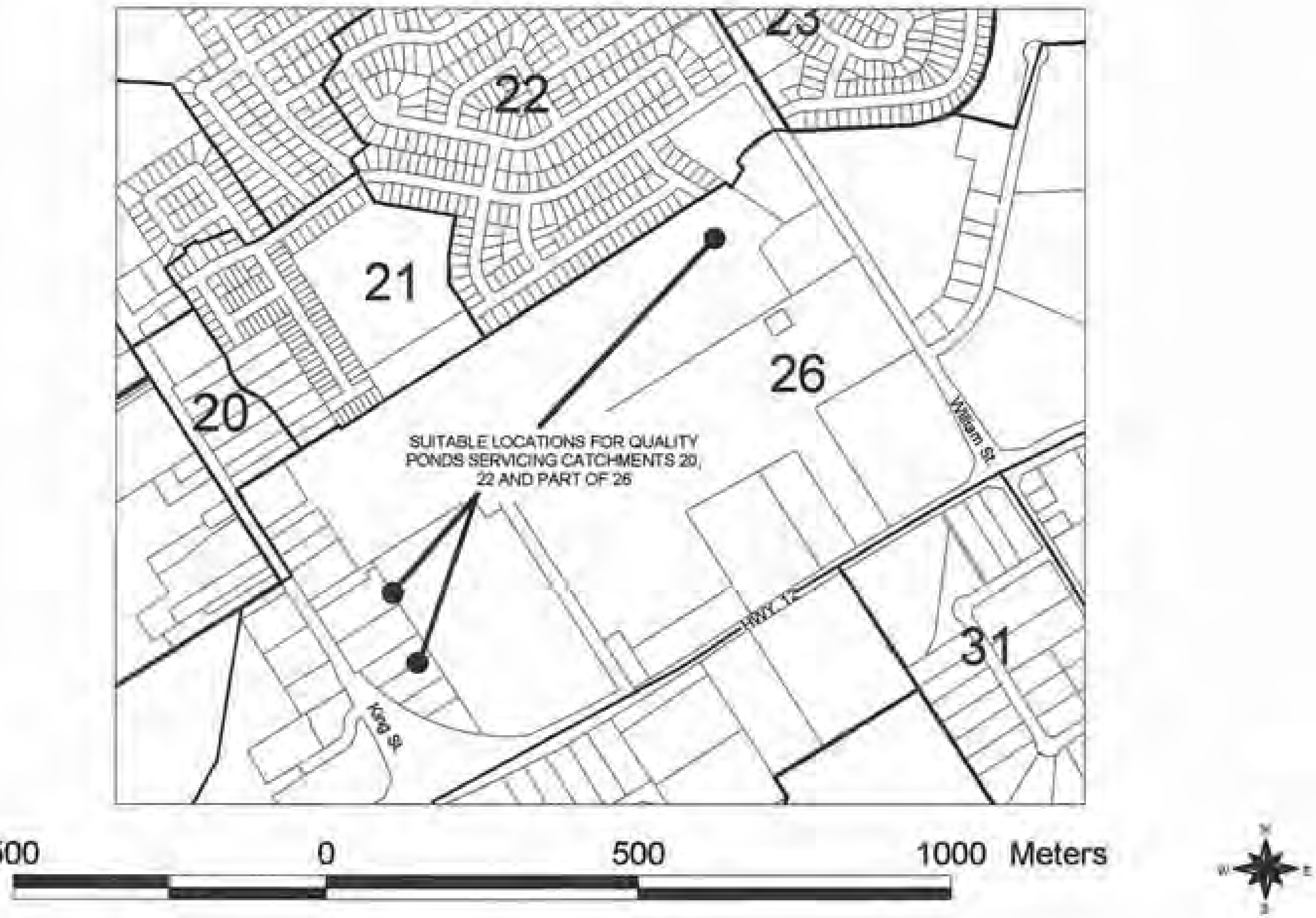
Table M-5 Midland New Quality Pond Potential

Area	P Removal Efficiency	Water Storage Created (m^3)	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 6	57.9%	2,183	$67,355	$9,382	$300
Catchment 20	60.8%	395	$12,440	$1,733	$55
Catchment 22	60.0%	3,651	$115,000	$16,023	$510
Catchment 26	16.1%	2,877	$90,500	$12,609	$400
Total	**7.9%**	**9,061**	**$285,295**	**$39,747**	**$1,265**

Recommendation 6:

In order to maximize the economic and treatment efficiency of new quality ponds, attempts should be made to integrate future development or planning activities with the construction of new quality ponds for stormwater treatment.

Figure M-5 Locations Considered Suitable for New Quality Ponds Midland



RETROFIT STORMWATER MANAGEMENT PLAN
FIGURE P-1 TOWN OF PENETANGUISHENE

Table P-1 Penetanguishene Waterfront Outfalls and Other Catchments

Catchment Number and Name		Area (ha)	Current Phosphorus Loading (kg/yr)	Land Use
Waterfront Outfalls				
1	Mental Health Center*	74.2	42.7	Res
2	Broad Street Outfall	46.7	31.6	Vacant/Res
3	Fox Street (1) Outfall	48.0	25.3	Res/Vacant
4	Fox Street (2) Outfall	105.2	54.1	Vacant/Res/Com
5	Burke Street Outfall	46.1	27.2	Res/Vacant
5b	Chatham Street Outfall	12.9	8.7	Res/Vacant
5c	Yeo Street Outfall	19.0	11.1	Res/Vacant
5d	Baycourt Outfall	13.2	9.0	Res/Vacant
10	Wolfe Street Outfall	47.5	33.9	Res
11	Penetanguishene Road Outfall	24.4	21.1	Com/Res
11b	Waterfront Outfall*	7.3	6.4	Com
11c	Owen Street Outfall	9.1	7.4	Res/Com
13	Scott Street Outfall	14.5	9.5	Res/Vacant
13b	John Street (1) Outfall	10.3	7.3	Res/Vacant
13c	John Street (2) Outfall	2.1	1.7	Vacant/Res
14	Park Street Outfall	63.8	32.5	Vacant/Res
14b	Center Street Outfall	10.3	6.0	Res/Vac/Com
15	Champlain Road (1)	31.6	13.8	Vacant/Rural
16	Champlain Road (2)	23.5	10.0	Rural/Vacant
Other Drains				
6	Lake St. George**	93.6	---	Rural/Vacant/Ind
7	Peterson Park (1) Outfall**	56.3	---	Vacant/Ind
8	Peterson Park (2) Outfall**	39.5	---	Vacant/Res
9	Peterson Park (3) Outfall**	90.6	---	Res/Vacant/Com
12	Peterson Park (4) Outfall**	63.2	---	Vacant/Res/Com
Total		**952.9**	**359.3**	

* Monitored catchments

** Catchments draining away from the shoreline into other bodies of water, therefore not considered in the modelling component of this study.

RETROFIT STORMWATER MANAGEMENT PLAN RATIONALE

Penetanguishene is comprised of two distinctly unique physiographic areas. The low lying areas situated along the shoreline are comprised of relatively poorly drained glacial till and silty sandy soils. These conditions persist eastward up the slope towards the ancient shoreline. Gradually, a very well drained sandy soil begins to dominate and is prevalent throughout the higher elevated portions of the town.

Corresponding to these physiographic regions are two distinctly different stormwater drainage/conveyance systems. From the edge of the slope going down towards the lakeshore a curb and gutter stormwater drainage/collection system drains straight into Penetanguishene Bay. In the higher ground a ditch drainage/collection system dominates with the exception of a small area of curb and gutter at the crest of Main Street and Highway 93. These ditches either drain down the slope, parallelling the storm sewers, or drain into the storm sewers themselves.

Downspout disconnections and infiltration/exfiltration type stormwater management practices are appropriate in the sandy soils found in the higher ground, because they are dependent upon the rate at which water infiltrates into the ground. In the lower area of town, new quality ponds would be more appropriate.

Downspout Disconnections:

Areas considered suitable for downspout disconnections have been indicated on Figure P-2. An estimated 53 lots were identified as being qualified for this retrofit option with costs and phosphorus reductions outlined below. Please note that these are only estimates of potential areas suitable for downspout disconnections. A more detailed survey of individual lots would be required in order to implement this option effectively. In addition, the highlighted areas are only a guideline and efforts should not be limited or constrained by them.

Table P-2 Penetanguishene Downspout Disconnection Potential

Area	Number of Qualified Lots	P Reduction*	Capital Cost	Amortized Capital Cost/yr
Catchment 4	19	0.40%	$1,900	$265
Catchment 5	26	1.00%	$2,600	$362
Catchment 5c	8	1.10%	$800	$111
Total	**53**	**0.10%**	**$5,300**	**$738**

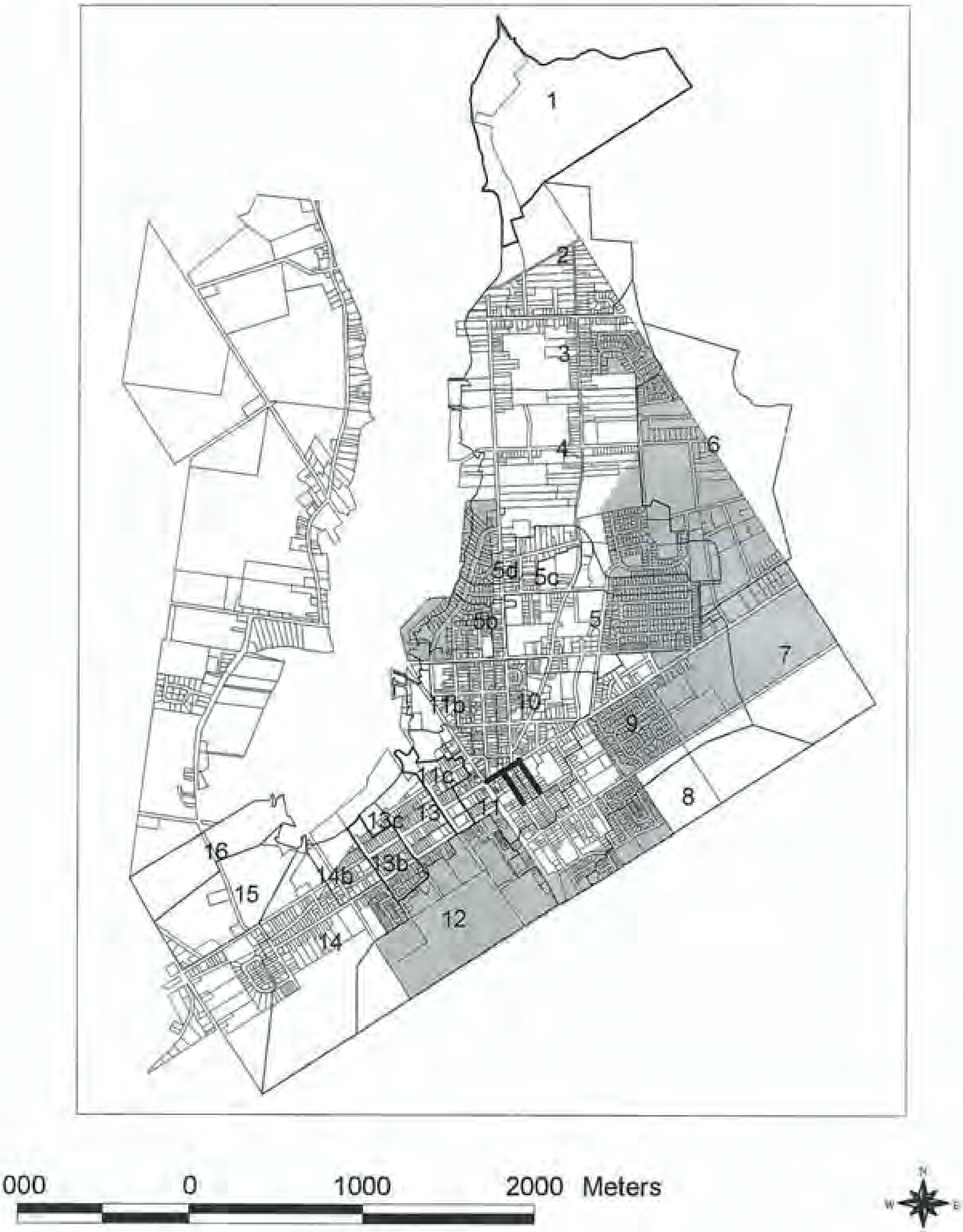
*note: P Reduction is shown based on the effect on each individual catchment while the total represents the reduction of the overall load from Penetanguishene.

Recommendation 1:

Establish a downspout disconnection program to assist households in disconnecting drains from storm and/or sanitary sewers**. This would require the development of a survey program targetted on areas suitable for downspout disconnection to identify households willing to participate in the disconnection process. It would also require the purchase of splash pads and pipe elbows for each participating household.

** Although connections to sanitary sewers results in treated stormwater, it would be beneficial to the Water Pollution Control Plant to reduce these extraneous flows. As a result, targetting the two sewer systems in the survey would be appropriate.

Figure P-2 Areas Considered Suitable for Downspout Disconnection in Penetanguishene



Stormwater Exfiltration Systems:

The roads considered most likely to undergo complete reconstruction within the next 25 years are indicated on Figure P-3. This list is only a guideline and consideration of exfiltration systems should not be constrained to these projects alone.

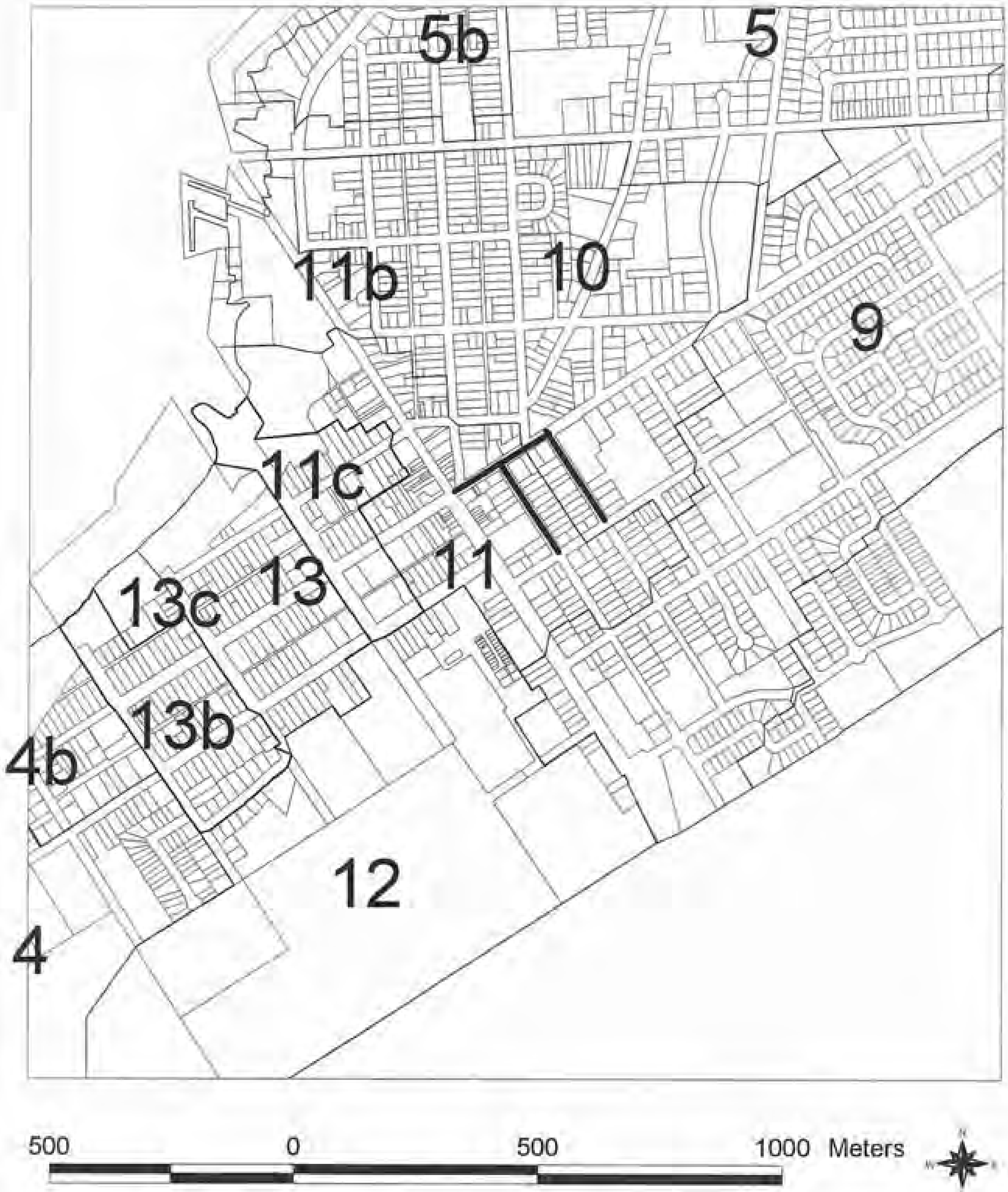
Table P-3 Penetanguishene Potential Stormwater Exfiltration Projects

Area	Road Name	From	To	Length	P Reduction	Capital Cost	Amortized Capital Cost/yr
0-25 yrs							
Catchment 11	Robert St.	Main St.	Harriet St.	220 m	2.7%	$10,640	$1,482
Catchment 11	Maria St.	Robert St.	Edward St.	350 m	7.6%	$16,927	$2,385
Catchment 11	Harriet St.	Robert St.	Edward St.	350 m	9.9%	$16,927	$2,385
Total				**920 m**	**1.88%**	**$44,494**	**$6,252**

Recommendation 2:

In all cases of road reconstruction or drainage improvement activities, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of curb and gutter stormwater conveyance, exfiltration systems should be given consideration.

Figure P-3 Locations Considered Suitable for Exfiltration Systems in Penetanguishene



Infiltration Trenches:

Areas considered most suitable for infiltration trench implementation have been identified on Figure P-4. Please note that these areas have been identified as areas most likely to require some kind of drainage improvements over the next 25 years. Consideration for infiltration trenches should not be constrained to these areas.

Table P-4 Penetanguishene Infiltration Trench Breakdown

Area	Vacant and Residential Area Served (ha)	P Reduction	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 3	10.16	17.4%	$52,050	$7,029	$1,981
Catchment 4	8.63	7.1%	$44,200	$5,968	$1,683
Catchment 5	16.82	25.7%	$86,200	$11,640	$3,280
Catchment 5c	10.32	44.0%	$52,900	$7,143	$2,012
Catchment 14	4.03	9.3%	$21,200	$2,863	$786
Total	**49.96**	**3.73%**	**$256,550**	**$34,643**	**$9,742**

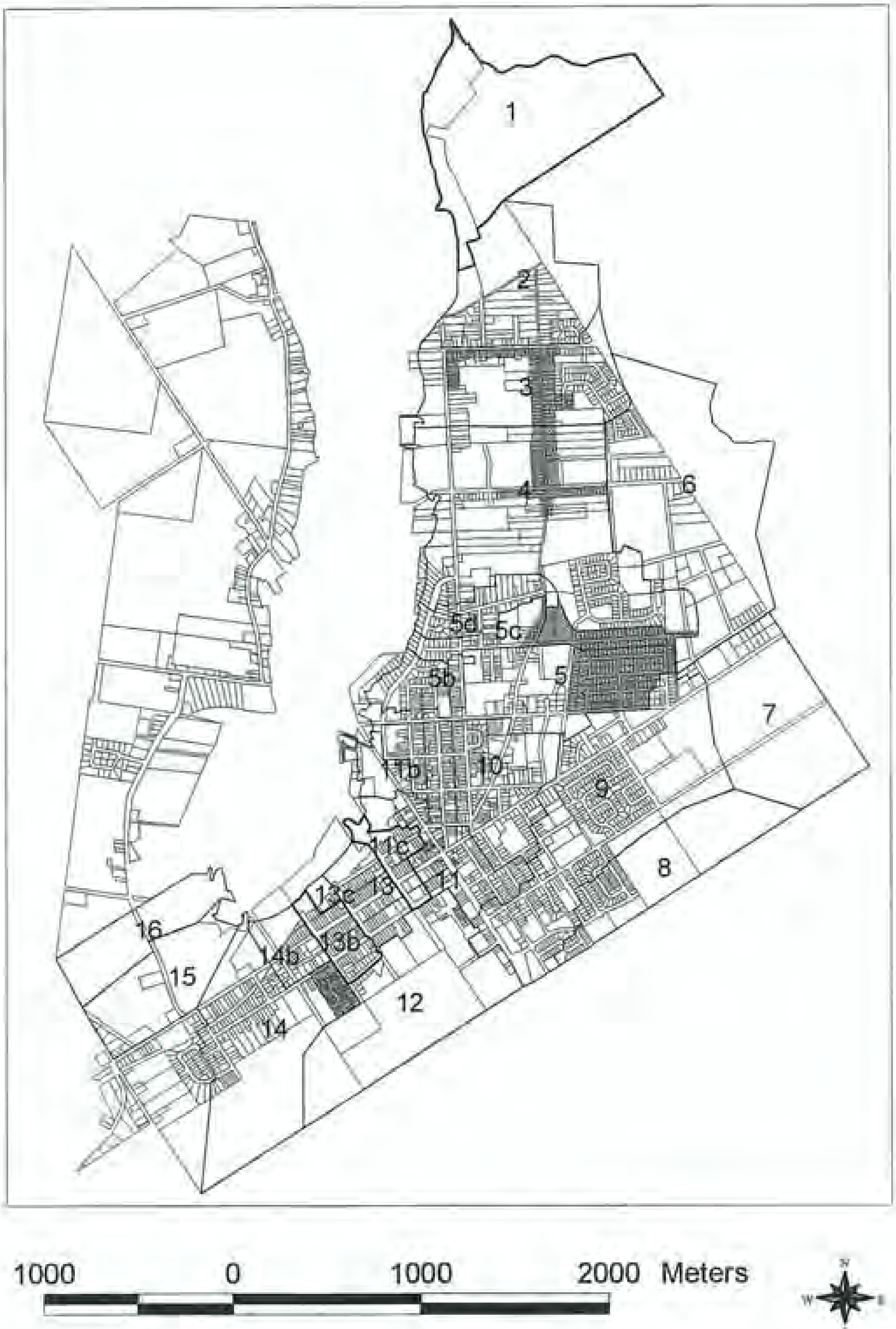
Table P-5 Penetanguishene Potential Infiltration Trench Locations

Area	Road Name	From	To	Length
Catchments 3/4	Cambridge St.	-----	-----	600 m
	Church St.	Cambridge St.	Broad St.	900 m
	Broad St.	Church St.	Fox St.	600 m
	Fox St.	Broad St.	200m South	200 m
Catchments 5/5c	Rue Brule	Burke St.	Dufferin St.	450 m
	Burke St.	Dufferin St.	Lorne Ave.	450 m
	Viel St.	Richelieu St.	Dufferin St.	480 m
	Richelieu St.	Dufferin St.	Lorne Ave.	480 m
	Hill Top Dr.	Centennial Dr.	Church St.	800 m
	Church St.	Don St.	Hill Top Dr.	200 m
Catchment 14	Beaumour Dr.	End	End	250 m

Recommendation 3:

In all cases of road reconstruction or drainage improvement activities, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of ditched stormwater conveyance, infiltration trenches should be given consideration.

Figure P-4 Areas Considered Suitable for Infiltration Trenches in Penetanguishene



New Quality Ponds:

Locations considered suitable for new quality ponds have been indicated on Figure P-5. When considering new quality ponds, integrating implementation with existing plans can result in economic benefits and increased functionality. For example, if housing development is to take place within the catchment identified for a new quality pond, a joint cost sharing effort between the municipality and the developer may take place so existing and proposed housing will be serviced.

Specific to the potential projects listed below (Catchment 11), integration with the proposed waterfront park development would be ideal.

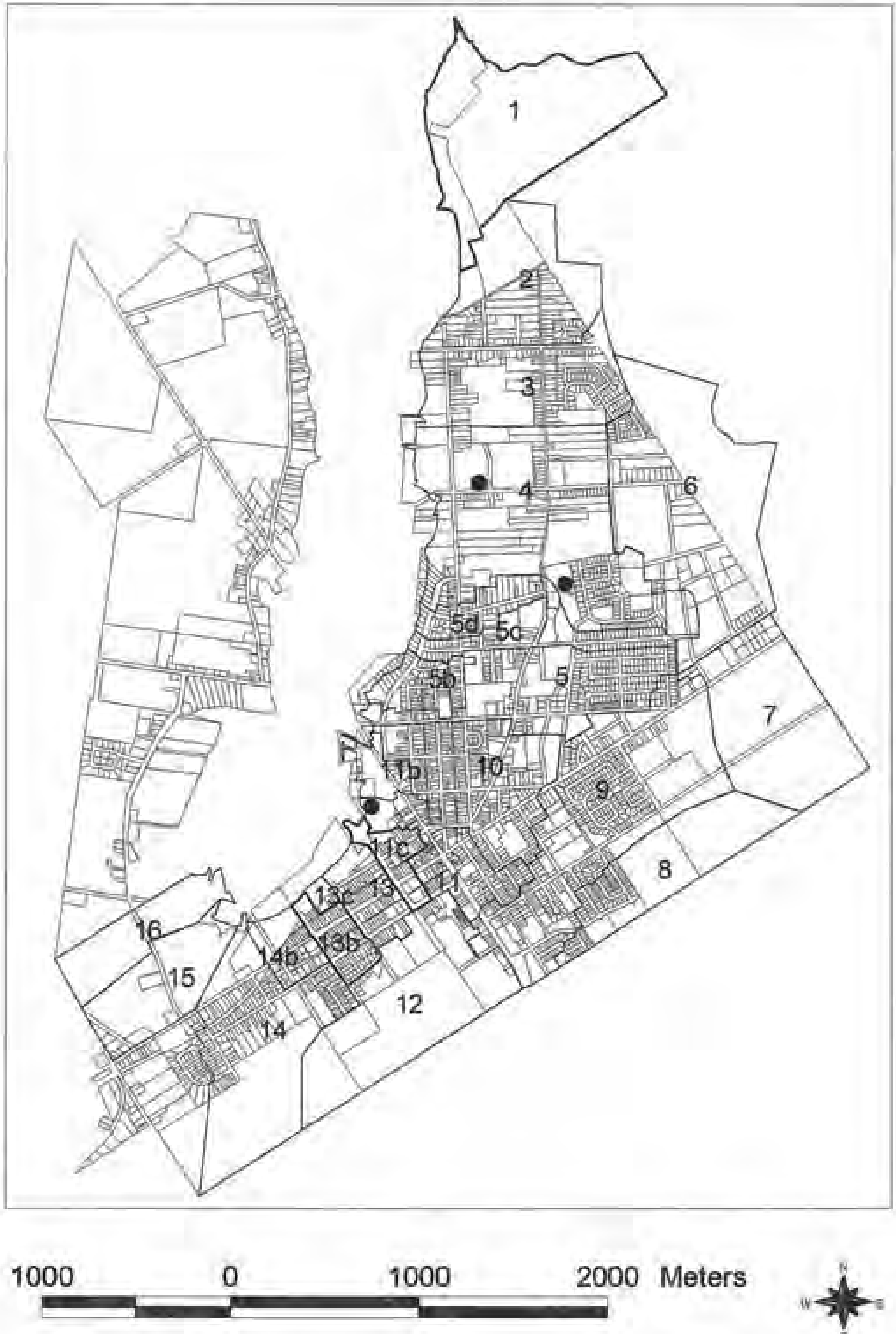
Table P-6 Penetanguishene New Quality Pond Potential

Area	P Reduction	Water Storage Created (m^3)	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 4					
Payette Dr. Outfall	37%	7,090	$61,650	$8,590	$247
Cambridge/Fox St	18%	3,440	$127,075	$17,705	$508
Catchment 11					
Main St. Outfall	55%	2,440	$43,800	$6,103	$175
Total	**11.06%**	**12,970**	**$232,525**	**$32,398**	**$930**

Recommendation 4:

In order to maximize the economic and treatment efficiency of new quality ponds, attempts should be made to integrate future development or planning activities with the construction of new quality ponds for stormwater treatment.

Figure P-5 Locations Considered Suitable for New Quality Ponds in Penetanguishene



RETROFIT STORMWATER MANAGEMENT PLAN
TOWNSHIP OF TAY

RETROFIT STORMWATER MANAGEMENT PLAN RATIONALE

The soils of the Township of Tay are generally moderate to poorly drained glacial tills or hardpan, especially along the existing shoreline. However, in some areas along the ancient shoreline, sandier, well drained soils can be found.

It is important to note at this time that the majority of the Township of Tay's drainage is handled by open ditches, with small portions of curb and gutter draining the core areas. Due to this predominance of surface drainage, stormwater management practices such as exfiltration systems or oil/grit separators are not practical. As a result, the focus for this retrofit stormwater management practices plan has remained on infiltration trenches and stormwater quality ponds.

FIGURE VH-1 COMMUNITY OF VICTORIA HARBOUR

Table VII-1 Victoria Harbour Waterfront Outfalls and Other Catchments

Catchment Number and Name		Area (ha)	Current Phosphorus Loading (kg/yr)	Land Use
Waterfront Outfalls				
1	Winfield Drive Outfall	30.3	14.5	Res
2	Albert Street Outfall*	19.5	12.3	Res/Com
3	Ellen Street Outfall	58.0	20.6	Res/Com
4	Hoyt Avenue Outfall	3.7	2.2	Res/Com
5	Marina	0.6	0.6	Com/Res
6	Jeuno Street Outfall	9.3	5.9	Res/Com
7	Bergie Drive Outfall	2.9	1.8	Res
8	Lighthouse Crescent Outfall	5.1	2.8	Res/Vacant
9	Osborne Street	9.2	5.0	Res/Vacant
10	Lovejoy Street - McDermot Road	24.0	3.3	Vacant/Res
11	Highway 12 (1)	45.2	9.3	Vacant/Res
12	Industrial Road Outfall	61.6	21.6	Vacant/Res/Com/Ind
13	Industrial Road Outfall	14.5	5.1	Rural/Ind
14	Bay Street- Highway 12	76.5	24.2	Vacant/Res
15	Highway 12 (2)	9.9	2.2	Vacant
16	Crescent Drive Outfall	9.4	3.7	Vacant/Res
Total		**379.7**	**135.1**	

* Monitored Catchment

Infiltration Trenches:

Areas considered most suitable for infiltration trench implementation in the Community of Victoria Harbour have been identified on Figure VH-2. Please note that these areas have been identified as being most likely to require some kind of drainage improvements over the next 25 years. Consideration for infiltration trenches should not be constrained to these areas.

Table VH-2 Victoria Harbour Infiltration Trench Breakdown

Area	Vacant and Residential Area Served (ha)	P Reduction*	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 2	0.61	1.9 %	$3,125	$435	$119
Catchment 3	7.60	13.3 %	$39,175	$5,458	$1,490
Catchment 11	10.00	34.3 %	$51,250	$7,141	$1,950
Catchment 12	15.47	9.1 %	$79,275	$11,045	$3,017
Catchment 14	27.30	17.8 %	$139,925	$19,496	$5,324
Catchment 15	1.81	0.7 %	$9,300	$1,296	$354
Total	**62.79**	**8.6 %**	**$322,050**	**$44,871**	**$12,254**

*note: P Reduction is shown based on the effect on each individual catchment while the total represents the reduction of the overall load from the Township of Tay.

Table VH-3 Victoria Harbour Potential Infiltration Trench Locations

Area	Road Name	From	To	Length
Catchment 2	Jephson St.	Martha St	St. Mary's Cres.	225 m
Catchment 3	Jephson St.	Park St.	Ellen St.	450 m
Catchment 11	Albert St.	Jephson St.	George St.	350 m
	West St.	George St.	Bay St.	250 m
	George St.	West St.	Albert St.	200 m
Catchment 12	Albert St.	George St.	Bay St.	120 m
	George St.	Albert St.	Park St.	500 m
	Maple St.	Albert St.	Park St.	500 m
	Elizabeth St.	Jephson St.	End	270 m
	Bay St.	Albert St.	Park St.	500 m
	Industrial Rd.	Park St.	CN Line	270 m
Catchment 14	John Dillinger	West St.	Park St.	700 m
	Albert St.	Bay St.	Hwy 93	500 m
	Trillium St.	John Dillinger	End	175 m
	Ivy Lane	John Dillinger	End	175 m
	Davis Dr.	Park St.	CN Line	300 m

Recommendation 1:

In all cases of road reconstruction or drainage improvement activities in the Community of Victoria Harbour, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of ditched stormwater conveyance, infiltration trenches should be considered.

Figure VH-2 Areas Considered Suitable for Infiltration Trenches in Victoria Harbour

New Quality Ponds:

Locations considered suitable for new quality ponds in the Community of Victoria Harbour have been indicated on Figure VH-3. When considering new quality ponds, integrating implementation with existing plans can result in economic benefits and increased functionality. For example, if a housing development is to take place within the catchment identified for a new quality pond, a joint cost sharing effort between the municipality and the developer may take place so existing and proposed housing will be serviced.

Table VH-4 Victoria Harbour New Quality Pond Potential

Area	P Removal Efficiency	Water Storage Created (m^3)	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 12	56.0%	5,219	$164,400	$22,906	$731
Catchment 14	46.6%	7,465	$235,150	$32,763	$1,046
Total	15.03%	12,684	$399,550	$55,669	$1,776

Recommendation 2:

In order to maximize the economic and treatment efficiency of new quality ponds, attempts should be made to integrate future development or planning activities with the construction of new quality ponds for stormwater treatment in the Community of Victoria Harbour.

Figure VH-3 Locations Considered Suitable for New Quality Ponds in Victoria Harbour

FIGURE PM-1 COMMUNITY OF PORT MCNICOLL

Table PM-1 Port McNicoll Waterfront Outfalls and Other Catchments

Catchment Number and Name		Area (ha)	Current Phosphorus Loading (kg/yr)	Land Use
Waterfront Outfalls				
1	North Rural Outskirts	53.9	16.8	Rural/Vacant/Res
2	Seventh Street Outfall	50.8	15.7	Vacant/Res
3	Albert Street Outfall	17.8	7.0	Res/Vacant
4	Bell Street Outfall	7.8	3.4	Res/Vacant
5	McNicoll Street Outfall	7.9	3.6	Res/Vacant
6	Armstrong Street Outfall	6.3	3.6	Res/Vacant/Com
7	Davidson Street Outfall	75.9	24.9	Rural/Res/Vacant
8	Talbot Street Outfall	12.7	6.4	Vacant/Res/Com
9	Broderick Street Outfall	36.8	14.5	Res/Vacant
Total		**269.9**	**95.9**	

Infiltration Trenches:
Areas considered most suitable for infiltration trench implementation in the Community of Port McNicoll have been identified on Figure PM-2. Please note that these areas have been identified as areas most likely to require some kind of drainage improvements over the next 25 years. Consideration for infiltration trenches should not be constrained to these areas.

Table PM-2 Port McNicoll Infiltration Trench Breakdown

Area	Vacant and Residential Area Served (ha)	P Reduction	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 1	11.55	10.0 %	$59,250	$8,255	$2,254
Catchment 2	14.73	24.4 %	$75,500	$10,519	$2,872
Catchment 3	9.04	42.8 %	$46,350	$6,458	$1,764
Catchment 4	3.96	40.6 %	$20,250	$2,821	$772
Catchment 7	20.25	19.5 %	$103,825	$14,466	$3,950
Total	**59.53**	**8.21%**	**$305,175**	**$42,519**	**$11,612**

Table PM-3 Port McNicoll Potential Infiltration Trench Locations

Area	Road Name	From	To	Length
Catchment 1	Seventh Ave.	EastonDr.	McPhee Blvd	250 m
	Sixth Ave.	Easton Dr.	Keewatin Dr.	350 m
	Fifth Ave.	Easton Dr.	Keewatin Dr.	350 m
Catchment 2	Simcoe Ave.	Keewatin Dr.	Alberta Dr.	200 m
	Midland Ave.	Keewatin Dr.	Alberta Dr.	200 m
	Seventh Ave.	McPhee Blvd	Alberta Dr.	250 m
	Sixth Ave.	Keewatin Dr.	Alberta Dr.	200 m
	Fifth Ave.	Keewatin Dr.	Alberta Dr.	200 m
	Keewatin Dr.	Simcoe Ave.	Fourth Ave.	650 m
	Alberta Dr.	Simcoe Ave.	Fourth Ave.	650 m
Catchment 3	Wardell St.	Seventh Ave.	Fourth Ave.	400 m
	Hayes St.	Seventh Ave.	Fourth Ave.	400 m
	Seventh Ave.	Hayes St.	Wardell St.	180 m
	Fifth Ave.	Alberta Dr.	Wardell St.	180 m
	Fourth Ave.	Alberta Dr.	Wardell St.	180 m
Catchment 4	McNicoll St.	Seventh Ave.	Third Ave.	400 m
Catchment 7	Simcoe Ave.	Alberta Dr.	Talbot St.	750 m

Recommendation 3:
In all cases of road reconstruction or drainage improvement activities in the Community of Port McNicoll, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of ditched stormwater conveyance, infiltration trenches should be given consideration.

Figure PM-2 Areas Considered Suitable for Infiltration Trenches in Port McNicoll

New Quality Ponds:

Locations considered suitable for new quality ponds in the Community of Port McNicoll have been indicated on Figure PM-3. When considering new quality ponds, integrating implementation with existing plans can result in economic benefits and increased functionality. For example, if a housing development is to take place within the catchment identified for a new quality pond, a joint cost sharing effort between the municipality and the developer may take place so existing and proposed housing will be serviced.

Table PM-4 Port McNicoll New Quality Pond Potential

Area	P Removal Efficiency	Water Storage Created (m^3)	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 1	55%	5,385	$169,650	$23,637	$754
Catchment 2	55%	5,083	$160,100	$22,307	$712
Catchment 3	55%	1,779	$56,050	$7,809	$249
Catchment 4	55%	781	$24,625	$3,431	$109
Catchment 5	55%	789	$24,850	$3,462	$110
Catchment 6	55%	625	$19,700	$2,745	$88
Catchment 9	48.5%	3,438	$108,275	$15,086	$481
Total	**39.9%**	**17,880**	**$563,250**	**$77,477**	**$2,503**

Recommendation 4:

In order to maximize the economic and treatment efficiency of new quality ponds, attempts should be made to integrate future development or planning activities with the construction of new quality ponds for stormwater treatment in the Community of Port McNicoll.

Figure PM-3 Locations Considered Suitable for New Quality Ponds in Port McNicoll

FIGURE W-1 COMMUNITY OF WAUBAUSHENE

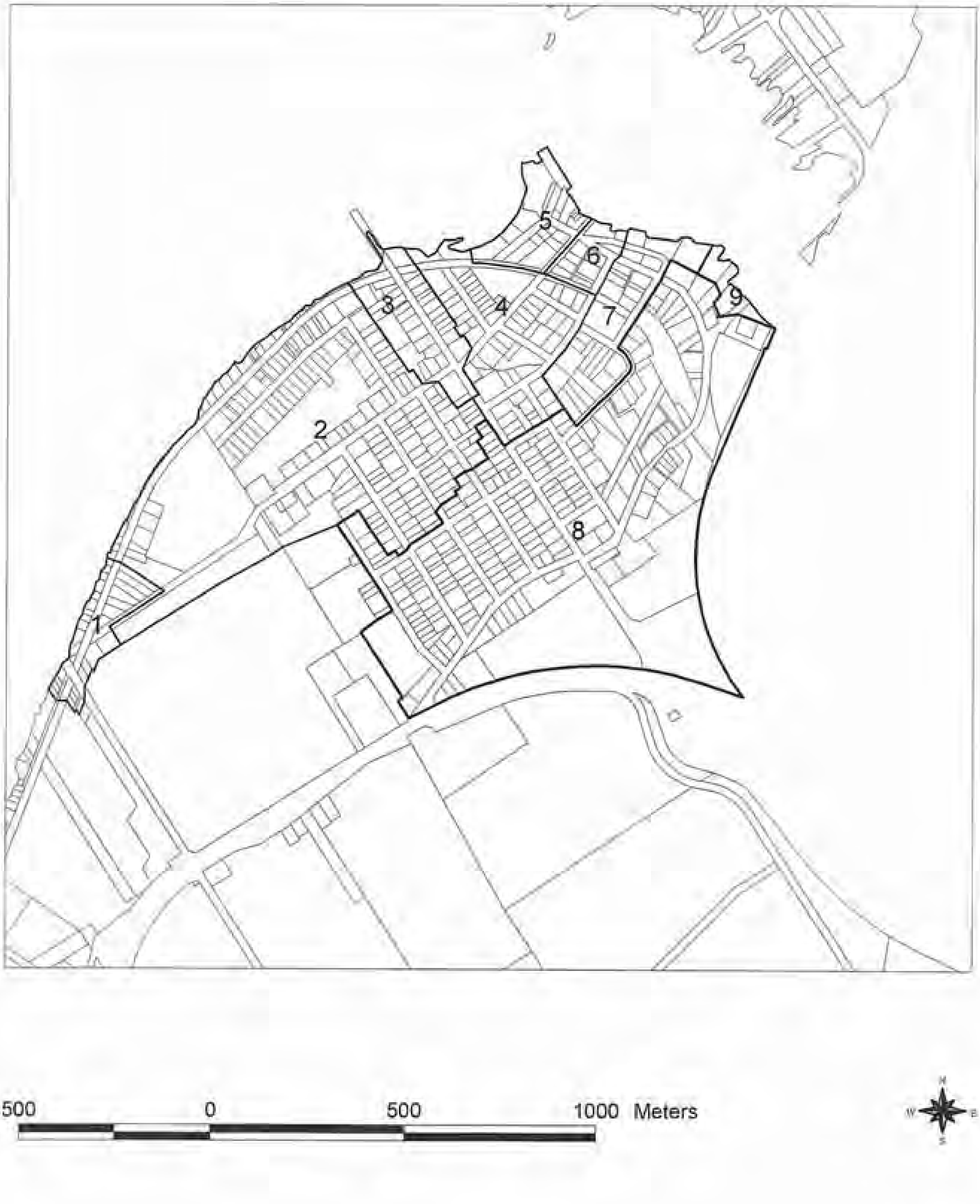


Table W-1 Waubaushene Waterfront Outfalls and Other Catchments

Catchment Number and Name		Area (ha)	Current Phosphorus Loading (kg/yr)	Land Use
Waterfront Outfalls				
1	Community Entrance 1	4.0	2.41	Res/Vacant
2	King Road Outfall	43.6	20.84	Res/Vacant
3	Pine Street Outfall	6.4	3.72	Res/Vacant
4	Ash Street - CN Line Outfall	12.5	6.62	Res/Vacant
5	Balsam Street Outfall	4.6	1.91	Res/Vacant
6	Elm Street Outfall	2.2	1.33	Res/Vacant/Com
7	Willow Street Outfall	7.5	3.85	Res/Vacant/Ind
8	Matchedash Bay (1) Outfall	63.1	30.62	Res/Vacant/Com
9	Matchedash Bay (2) Outfall	1.3	0.69	Vacant/Com
Total		**145.2**	**71.99**	

Infiltration Trenches:

Areas considered most suitable for infiltration trench implementation in the Community of Waubaushene have been identified on Figure W-2. Please note that these areas have been identified as areas most likely to require some kind of drainage improvements over the next 25 years. Consideration for infiltration trenches should not be constrained to these areas.

Table W-2 Waubaushene Infiltration Trench Breakdown

Area	Vacant and Residential Area Served (ha)	P Reduction	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 2	6.52	12.5 %	$33,400	$4,654	$1,271
Catchment 4	4.89	26.2 %	$25,050	$3,490	$954
Catchment 8	8.58	11.9 %	$87,950	$12,254	$3,346
Total	**19.99**	**11.4 %**	**$146,400**	**$20,398**	**$5,571**

Table W-3 Waubaushene Potential Infiltration Trench Locations

Area	Road Name	From	To	Length
Catchment 2	Percy St.	Cedar St.	John St.	300 m
	Ouida St.	Cedar St.	John St.	300 m
	George St.	Ouida St.	End	125 m
Catchment 4	Elm St.	Pine St.	Spruce St.	225 m
	Spruce St.	Elm St.	Hazel St.	170 m
Catchment 8	Percy St.	John St.	Sturgeon Bay Rd.	300 m
	Ouida St.	John St.	Sturgeon Bay Rd.	250 m
	Brown's Line	John St.	Sturgeon Bay Rd.	300 m
	Sturgeon Bay Rd.	Highway 12	Mary St.	350 m
	Mary St.	John St.	Sturgeon Bay Rd.	250 m
	Cherry St.	End	End	275 m

Recommendation 5:

In all cases of road reconstruction or drainage improvement activities in the Community of Waubaushene, the *Protocol for Implementation of Infrastructure Improvement Projects* should be followed. In areas of ditched stormwater conveyance, infiltration trenches should be given consideration.

Figure W-2 Areas Considered Suitable for Infiltration Trenches in Waubaushene

New Quality Ponds:

Locations considered suitable for new quality ponds in the Community of Waubaushene have been indicated on Figure W-3. When considering new quality ponds, integrating implementation with existing plans can result in economic benefits and increased functionality. For example, if a housing development is to take place within the catchment identified for a new quality pond, a joint cost sharing effort between the municipality and the developer may take place so existing and proposed housing will be serviced.

Table W-4 Waubaushene New Quality Pond Potential

Area	P Removal Efficiency	Water Storage Created (m^3)	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 8	33.4%	3,748	$ 118,050	$16,448	$525
Total	**14.4%**	**3,748**	**$118,050**	**$16,448**	**$525**

Recommendation 6:

In order to maximize the economic and treatment efficiency of new quality ponds, attempts should be made to integrate future development or planning activities with the construction of new quality ponds for stormwater treatment in the Community of Waubaushene.

Figure W-3 Locations Considered Suitable for New Quality Ponds in Waubaushene

RETROFIT STORMWATER MANAGEMENT PLAN
FIGURE C-1 COMMUNITY OF COLDWATER

Table C-1 Coldwater Waterfront Outfalls and Other Catchments				
Catchment Number and Name		Area (ha)	Current Phosphorus Loading (kg)	Land Use
Waterfront Outfalls				
1	Rural Drainage (1)	150.0	91.4	Rural
2	Coldwater Road (1)	2.5	1.7	Res/Vacant/Rural
3	Coldwater Road (2)	5.1	4.0	Res/Com/Vacant
4	Mill Street Outfall	5.3	3.8	Res/Com/Vacant
4b	Coldwater Road (3)	1.2	1.2	Com/Res
5	Rural Drainage (2)	1.0	0.7	Rural
6	Sturgeon Road (1)	2.3	1.7	Res/Com/Vacant
7	Sturgeon Road (2)	18.0	12.9	Res/Vacant//Com
7b	Harriet Street Outfall	5.5	3.9	Res
8	River Street Outfall	7.9	4.9	Res/Vacant/Com
9	Brick Pond Road Outfall	11.9	7.7	Res/Vacant
Total		**952.9**	**133.9**	

RETROFIT STORMWATER MANAGEMENT PLAN RATIONALE

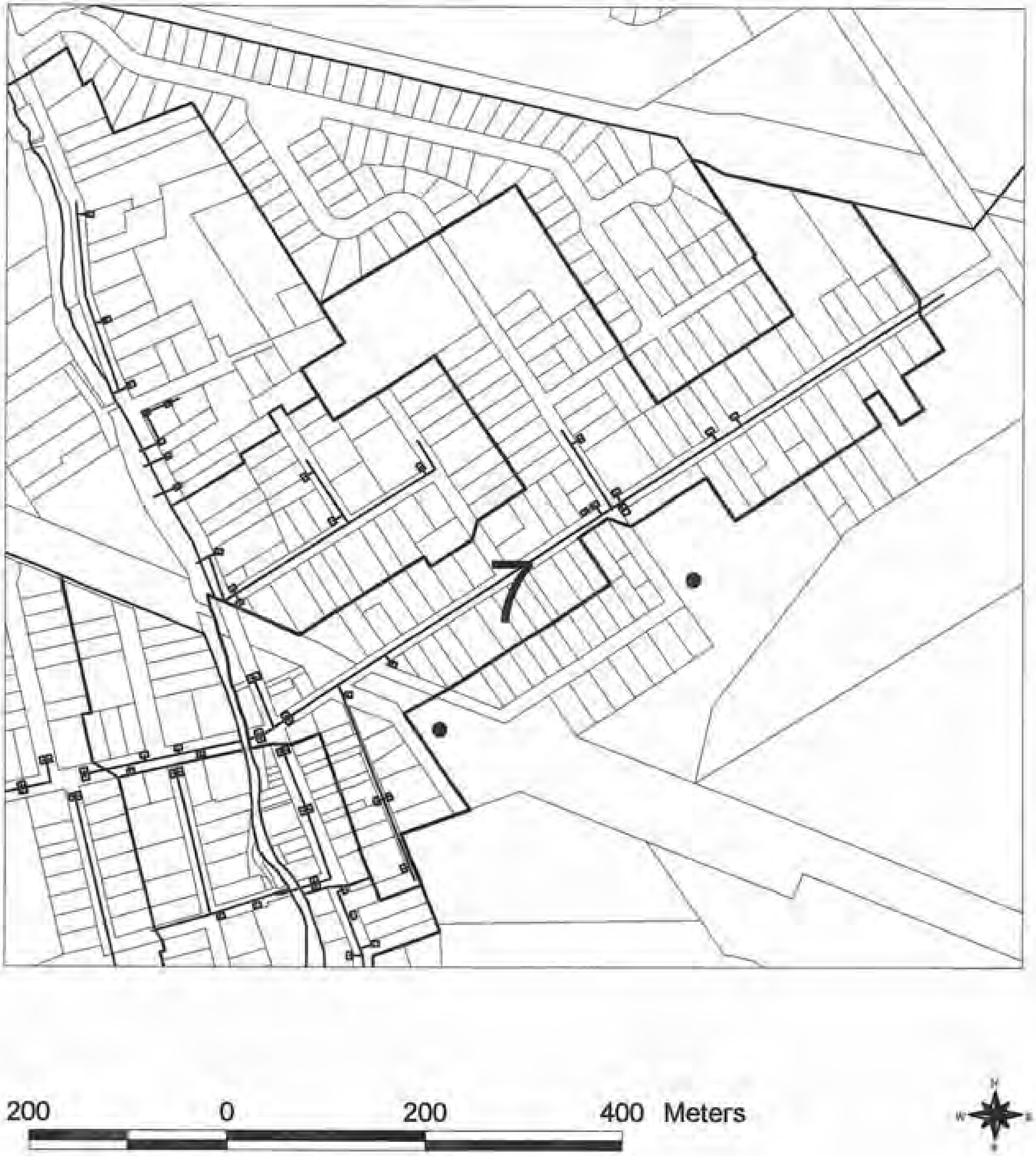
Due to the fact that a large part of the Community of Coldwater is located on a flood plain, few options for retrofit stormwater management are available. In addition, the agricultural drain outletting within the community overshadows the effect of urban stormwater quality and loadings.

New Quality Ponds:

Table C-2 Coldwater New Quality Pond Potential					
Area	P Removal Efficiency	Water Storage Created (m³)	Capital Cost	Amortized Capital Cost/yr	O&M Cost/yr
Catchment 7	33.9%	1,227	$ 92,125	$12,836	$515
Total	**4.9%**	**1,227**	**$96,125**	**$12,836**	**$515**

See Figure C-2 for potential pond locations.

Figure C-2 Locations Considered Suitable for New Quality Ponds in Coldwater



7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 General Conclusions

The results of this study provide important insight into the characteristics of wet and dry weather discharges originating from small urban centers, and more specifically, the characteristics of annual loadings into Severn Sound. The emphasis on examining potential retrofit remediation of stormwater contaminant loading has also led to the development of detailed guidelines for local municipalities based on cost functions developed based for local experiences.

The following summarizes the conclusions drawn from this study:

- The total annual volume of flows from urban outfalls discharging into Severn Sound was estimated to be approximately 14.4 million cubic meters/year.

- Based on seasonal water quality sampling performed for this study, urban stormwater contributes to contaminant loadings into Severn Sound. These findings support initial assumptions outlined in the Stage I RAP report indicating that reductions of phosphorus loadings originating from urban stormwater must be remediated to achieve open water levels in accord with the Provincial Water Quality Objectives.

- Of the 28 water quality parameters tested in this study, all were detected in each of the monitoring phases. In general, all parameters were detected in higher concentrations in the rain event samples than in the other monitoring phases with significant exceedences of the Provincial Water Quality Objectives for 7 of the 16 measured metals.

- Although mean contaminant concentrations are generally lower than those found in other studies, the order of magnitude by which they surpass the Provincial Water Quality Objectives (PWQO) is the same. Some metals concentrations ranged in the order of 3 to 7 times greater than the PWQO compared to the Toronto study where the same metals ranged from 2 to 11 times greater than the PWQO.

- The original baseline loading estimate for phosphorus of 3,300 kg/year from urban sources has been revised to 1,037 kg/year. This reflects the consideration of existing treatment in the form of in place stormwater management practices, lakes and ponds, and natural ponding areas such as beaver ponds and man-made structures associated with reservoir recharge areas.

- The study has shown that a 19.8% reduction of phosphorus loading is achievable with the stormwater management practices considered for this study. This effectively meets the original 20% reduction target.

- The original cost estimate of $35,000,000 to achieve the target of 20% reduction in phosphorus has been revised to $4,604,260.

- Total phosphorus concentrations were not significantly different for urban areas of differing land use (residential, commercial, industrial). An average total phosphorus concentration of 0.26 mg/L was measured. This concentration was slightly lower than that found in the Toronto study but in the same order of magnitude. The phosphorus loadings estimated for areas of residential, commercial or industrial land uses were different due to differing runoff volume estimates.

- Although the focus of this report has been the reduction of total phosphorus entering Severn Sound, elevated bacteria levels is also a major concern. Many of the stormwater management practices designed to control total phosphorus also control bacteria. In addition, specific site controls such as 'poop and scoop' bylaws and ongoing research and disconnection of illegal connections to storm sewers by municipalities will also help to reduce bacteria input.

- The study has determined that there is a connection between stormwater and water quality at the bathing area sampled during rain events. Water quality sampling suggested impingement of water with elevated E. coli counts at the bathing area within 6 hours of the onset of a rain event.

7.2 Recommendations

1. The draft Drainage Policy and Protocol for Implementation of Infrastructure Improvement Projects should be adopted as policy documents by the Towns of Midland, Penetanguishene, and the Townships of Tay and Severn. The documents should then be utilized by Engineering and Public Works staff for developing roads or drainage strategies.

2. Individual urban stormwater retrofit projects listed for each municipality should be implemented over the next 25 years as resources and timing allow. Wherever possible, the retrofit projects should be combined with new development stormwater treatment projects to optimize the treatment provided and maximize cost efficiencies.

3. As a condition for approval for all new developments, the design and construction of such new developments shall include stormwater management facilities designed to address both the control of the quantity of stormwater runoff and the control of the quality of stormwater runoff.

4. The Simcoe County District Health Unit should consider a protocol for posting the Pete Peterson Park bathing area following rain events of greater than 20 mm falling within six hours in order to avoid bather contact with bacteriologically contaminated water.

5. A follow-up study should be undertaken to further identify and trace illegal connections to storm sewers, and to track and correct these sources.

8.0 REFERENCES

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APPENDIX A

Q-LOGGER SETUPS

```
                         QBasePlus
                     Datalogger setup
    ID:  1                Instrument:  STR Q-Logger depth, velocity
Comment: STATION #1 Penetanguishene (Tessier Dr)

   Probe: Type 2 (5 psi)    Depth: cm     Depth offset:    1.0000 cm
Direction: Upstream       Velocity: m/s       Interval:  2 min
                                                Memory: Wraparound

         Equation:  STR Q = V x A (round pipe)
             Flow: l/s

     Pipe diameter:  120.0000 cm       Operate sampler: Yes
     Default depth:    0.0000 cm         Flow quantity:    5.000K l
  Flow coefficient:    1.0000             Sampler mode: High flow
  Default velocity:    0.0000 m/s      Threshold depth:    7.5000 cm


   Connection: Direct

          F1/F2-Change ID  F3-Duplicate  ENTER-View options
          ESC to exit, ↑↓ to move, ┘ to select, F10 for Help
Study name: moemtrca                       NUM Lock Fri Nov 27, 1998 13 15
```

```
                         QBasePlus
                     Datalogger setup
    ID:  2                Instrument:  STR Q-Logger depth, velocity
Comment: STATION #2 Birchwood Drive and Wilson Parkway

   Probe: Type 2 (5 psi)    Depth: cm     Depth offset:    0.5000 cm
Direction: Upstream       Velocity: m/s       Interval:  2 min
                                                Memory: Wraparound

         Equation:  STR Q = V x A (round pipe)
             Flow: l/s

     Pipe diameter:   75.0000 cm       Operate sampler: Yes
     Default depth:    0.0000 cm         Flow quantity:    1.500K l
  Flow coefficient:    1.0000             Sampler mode: High flow
  Default velocity:    0.0000 m/s      Threshold depth:    5.0000 cm


   Connection: Direct

          F1/F2-Change ID  F3-Duplicate  ENTER-View options
          ESC to exit, ↑↓ to move, ┘ to select, F10 for Help
Study name: moemtrca                       NUM Lock Fri Nov 27, 1998 13 21
```

```
                         QBasePlus
                     Datalogger setup
   ID:  3            Instrument:  STR Q-Logger depth, velocity
Comment: STATION #3 William Street and Bayshore Drive

    Probe: Type 2 (5 psi)    Depth: cm     Depth offset:    0.5000 cm
Direction: Upstream       Velocity: m/s        Interval:  2 min
                                                 Memory: Wraparound

          Equation:  STR Q = V x A (round pipe)
              Flow: 1/s

     Pipe diameter:  140.0000 cm       Operate sampler: Yes
     Default depth:    0.0000 cm         Flow quantity:   10.000K l
  Flow coefficient:    1.0000             Sampler mode: High flow
  Default velocity:    0.0000 m/s      Threshold depth:    9.0000 cm


    Connection: Direct

           F1/F2-Change ID  F3-Duplicate  ENTER-View options
           ESC to exit, ↑↓ to move, ┘ to select, F10 for Help
Study name: moemtrca                          NUM Lock Fri Nov 27, 1998 13 22
```

```
                         QBasePlus
                     Datalogger setup
   ID:  4            Instrument:  STR Q-Logger depth, velocity
Comment: STATION4FirstStreet

    Probe: Type 2 (5 psi)    Depth: cm     Depth offset:    0.7500 cm
Direction: Upstream       Velocity: m/s        Interval:  2 min
                                                 Memory: Wraparound

          Equation:  STR Q = V x A (custom cross section)
              Flow: 1/s

       Table name: FIRSTST             Operate sampler: Yes
     Default depth:    0.0000 cm         Flow quantity:    4.000K l
  Flow coefficient:    1.0000             Sampler mode: High flow
  Default velocity:    0.0000 m/s      Threshold depth:    4.0000 cm
    Channel Height:   70.5000 cm


    Connection: Direct

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Study name: moemtrca                          NUM Lock Fri Nov 27, 1998 13:26
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```
QBasePlus
Datalogger setup
     ID:  5                     Instrument:  STR Q-Logger depth, velocity
Comment: Station#5 Victoria Harbour

    Probe: Type 2 (5 psi)    Depth: cm     Depth offset:    0.5000 cm
Direction: Upstream        Velocity: m/s        Interval:  2 min
                                                  Memory: Wraparound

           Equation:  STR Q = V x A (round pipe)
               Flow: l/s

      Pipe diameter:   62.0000 cm       Operate sampler: Yes
      Default depth:    0.0000 cm         Flow quantity:    5.000K l
   Flow coefficient:    1.0000             Sampler mode: High flow
   Default velocity:    0.0000 m/s      Threshold depth:    4.0000 cm


    Connection: Direct

F1/F2-Change ID  F3-Duplicate  ENTER-View options
ESC to exit, ↑↓ to move, ┘ to select, F10 for Help
Study name: moemtrca                          NUM Lock Fri Nov 27, 1998 13:27
```

```
QBasePlus
Datalogger setup
     ID:  7                     Instrument:  STR Q-Logger depth, velocity
Comment: Station #7 Vinden Street

    Probe: Type 2 (5 psi)    Depth: cm     Depth offset:    0.7500 cm
Direction: Upstream        Velocity: m/s        Interval:  2 min
                                                  Memory: Wraparound

           Equation:  STR Q = V x A (round pipe)
               Flow: l/s

      Pipe diameter:   90.0000 cm       Operate sampler: Yes
      Default depth:    0.0000 cm         Flow quantity:    5.000K l
   Flow coefficient:    1.0000             Sampler mode: High flow
   Default velocity:    0.0000 m/s      Threshold depth:    4.0000 cm


    Connection: Direct

F1/F2-Change ID  F3-Duplicate  ENTER-View options
ESC to exit, ↑↓ to move, ┘ to select, F10 for Help
Study name: moemtrca                          NUM Lock Fri Nov 27, 1998 13:28
```

```
QBasePlus
Datalogger setup
    ID:  8                    Instrument:  STR Q-Logger depth, velocity
Comment: Station #8 Mental Health Centre

    Probe: Type 2 (5 psi)   Depth: cm     Depth offset:    0.7500 cm
Direction: Upstream       Velocity: m/s        Interval:  2 min
                                                 Memory: Wraparound

          Equation:  STR Q = V x A (round pipe)
              Flow: l/s

      Pipe diameter:   68.0000 cm        Operate sampler: Yes
      Default depth:    0.0000 cm          Flow quantity:    5.000K l
   Flow coefficient:    1.0000              Sampler mode: High flow
   Default velocity:    0.0000 m/s       Threshold depth:    4.0000 cm


    Connection: Direct

F1/F2-Change ID  F3-Duplicate  ENTER-View options
ESC to exit, ↑↓ to move, ┘ to select, F10 for Help
Study name: moemtrca                        NUM Lock Fri Nov 27, 1998 13 29
```

APPENDIX B

ANALYTICAL PROBABILISTIC AND MULTI-EFFICIENCY MODELS DESCRIPTION

Average annual runoff volume and solids loadings are estimated by the analytical probabilistic models given by Adams and Bontje (1983) and Li (1991) as follows:

$$R = 10 * A * \left(\frac{\theta\varphi}{\zeta}\right) e^{-\zeta S_d}$$

$$L = \frac{R * C}{1000}$$

Where:

R = average annual runoff volume (m^3/yr)
A = drainage area (ha)
θ = average number of rainfall events
φ = area-weighted average runoff coefficient
ζ = reciprocal of average rainfall event volume (1/mm)
L = average annual runoff solids loading (kg/yr)
C = average runoff solids concentration (mg/L)

The Weatherbe (1995) multi-efficiency model used to estimate cumulative volume and solids loading reduction efficiencies of a series of RSWMPs is as follows:

$$N_v = \left|1 - \prod_i^n (1 - \eta_v)\right| * 100\%$$

$$N_s = \left|1 - \prod_i^n (1 - \eta_v)(1 - \eta_s)\right| * 100\%$$

Where:

N_v = cumulative volume reduction efficiency
N_s = cumulative solids loading reduction efficiency
I = i^{th} RSWMP
n = total number of RSWMP
η_v = runoff volume reduction efficiency of a RSWMP
η_s = solids concentration reduction efficiency of a RSWMP

The runoff volume reduction efficiency of roof leader disconnection is determined by:

$$\eta_v = \left[1 - \left(\frac{R_s}{R_e}\right)\right] * 100\%$$

Where: η_v = runoff volume reduction efficiency
R_s = average annual runoff volume after the application of an RSWMP
R_e = existing average annual runoff volume

The solids concentration reduction efficiency of an oil/grit separator for a subcatchment is determined by:

$$\eta_s = \eta_{sa} * \frac{R_a}{R_c}$$

Where: η_s = solids concentration reduction efficiency
η_{sa} - solids concentration reduction efficiency of an RSWMP
R_a = average annual runoff volume from the area served by an RSWMP
R_c = average annual runoff volume from the subcatchment

The runoff volume reduction efficiency of a storm water exfiltration system for a subcatchment is determined by:

$$\eta_v = \eta_{va} * \frac{R_a}{R_c}$$

Where: η_v = runoff volume reduction efficiency
η_{va} = solids concentration reduction efficiency of an RSWMP
R_a = average annual runoff volume from the area served by an RSWMP
R_c = average annual runoff volume from the subcatchment

The average annual runoff volume and solids loading reduction efficiency for quantity pond retrofits and new quality ponds is determined in a manner similar to that of oil/grit separators.

The average annual runoff volume and solids loading after the application of a series of RSWMPs is determined by:

$$R_n = R * N_v$$

$$L_n = L * N_s$$

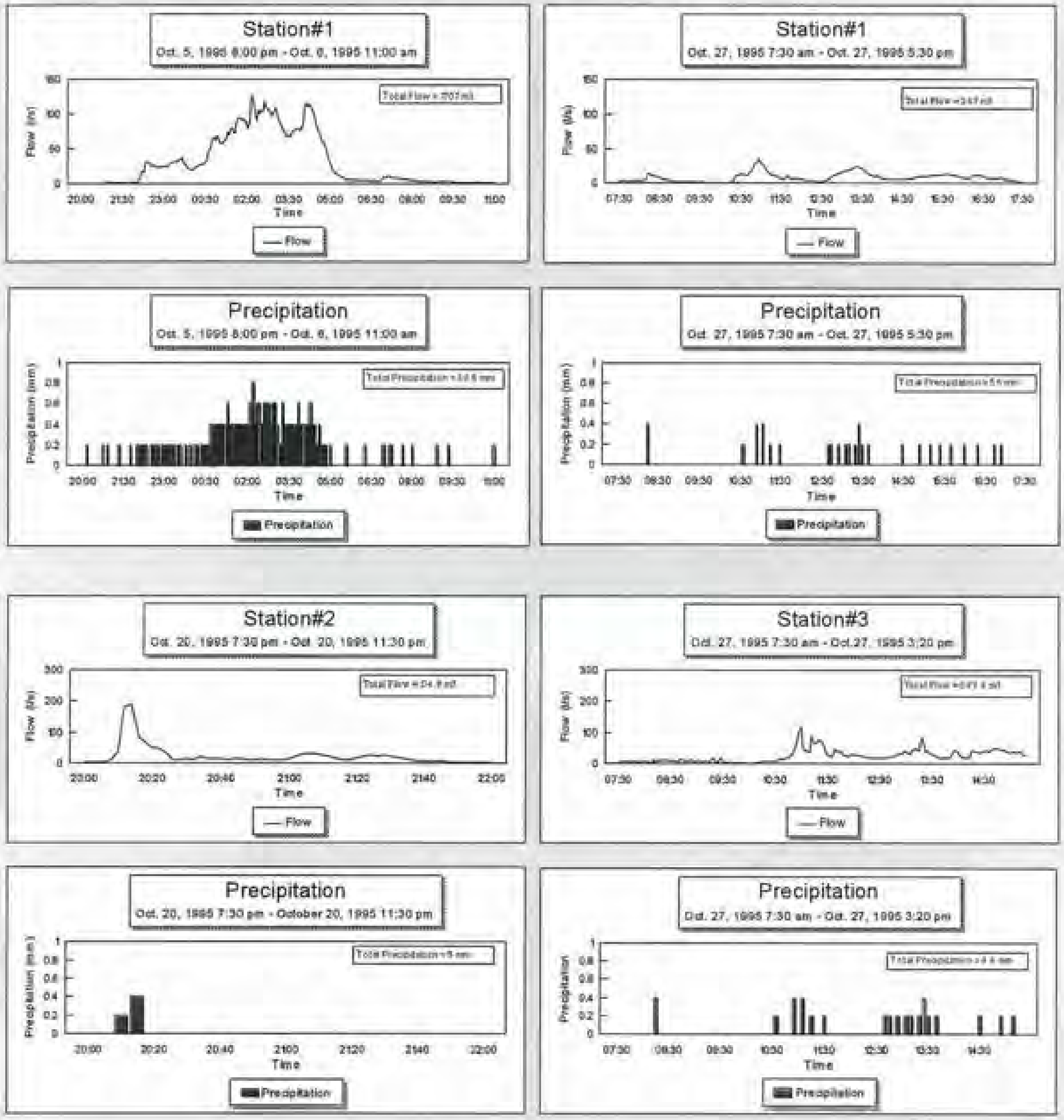
Where:

R_n = average annual runoff volume
L_n = average annual solids loading
R = average annual runoff volume (m3/yr)
L = average annual runoff solids loading (kg/yr)
N_v = cumulative volume reuction efficiency of a series of RSWMPs
N_s = cumulative solids loading reduction efficiency of a series of RSWMPs

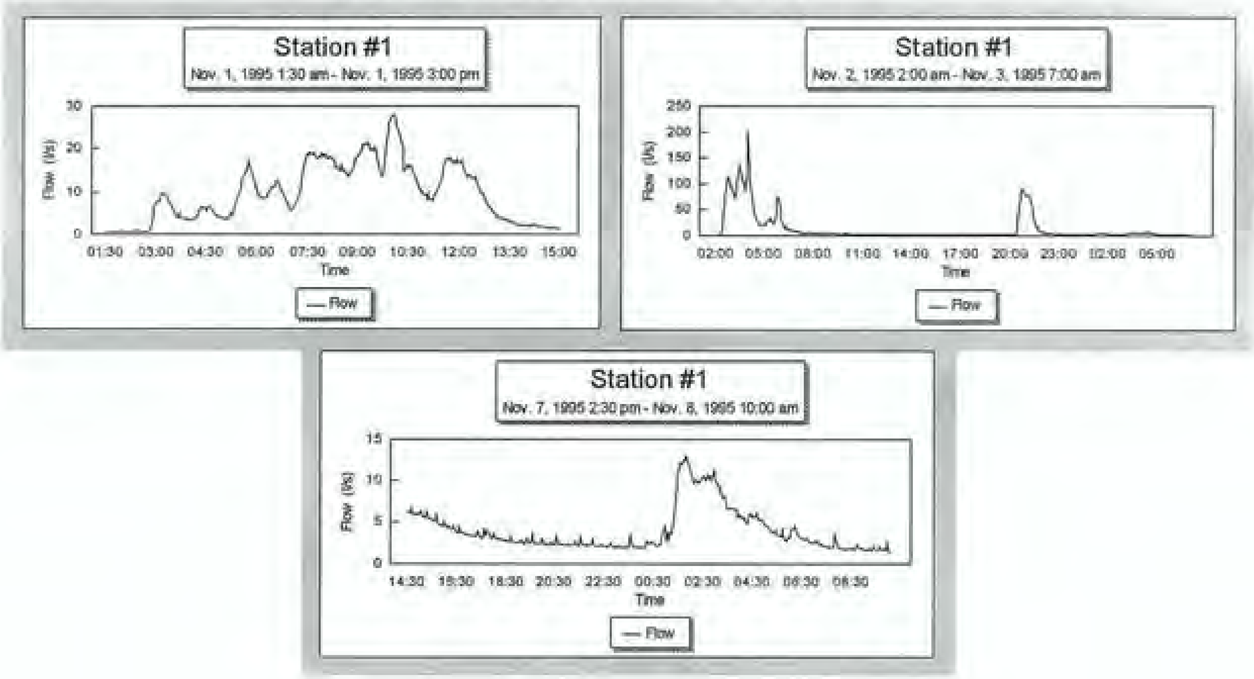
APPENDIX C

EVENT FLOW AND PRECIPITATION SUMMARIES

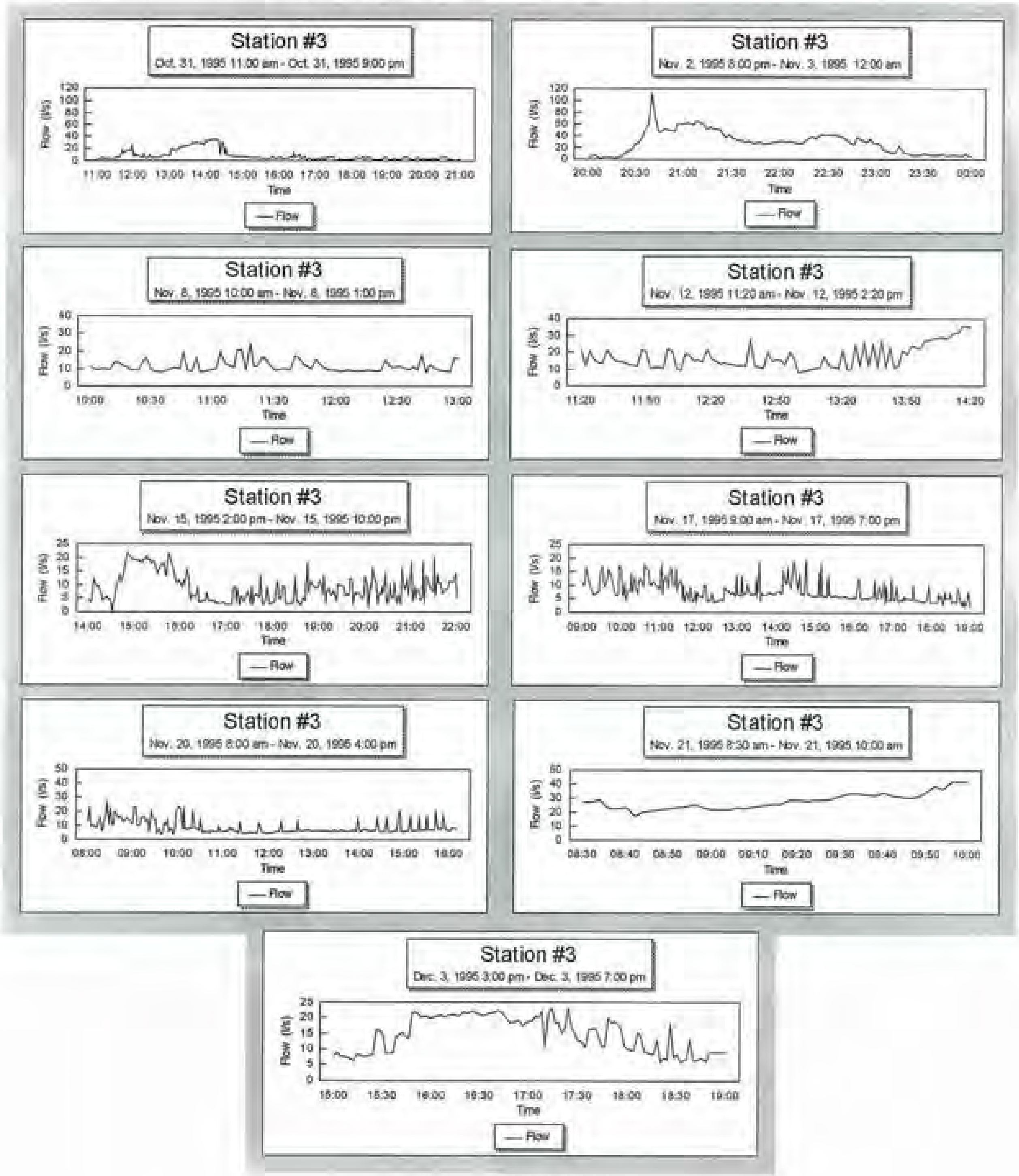
1995 EVENTS (FLOW AND PRECIPITATION)



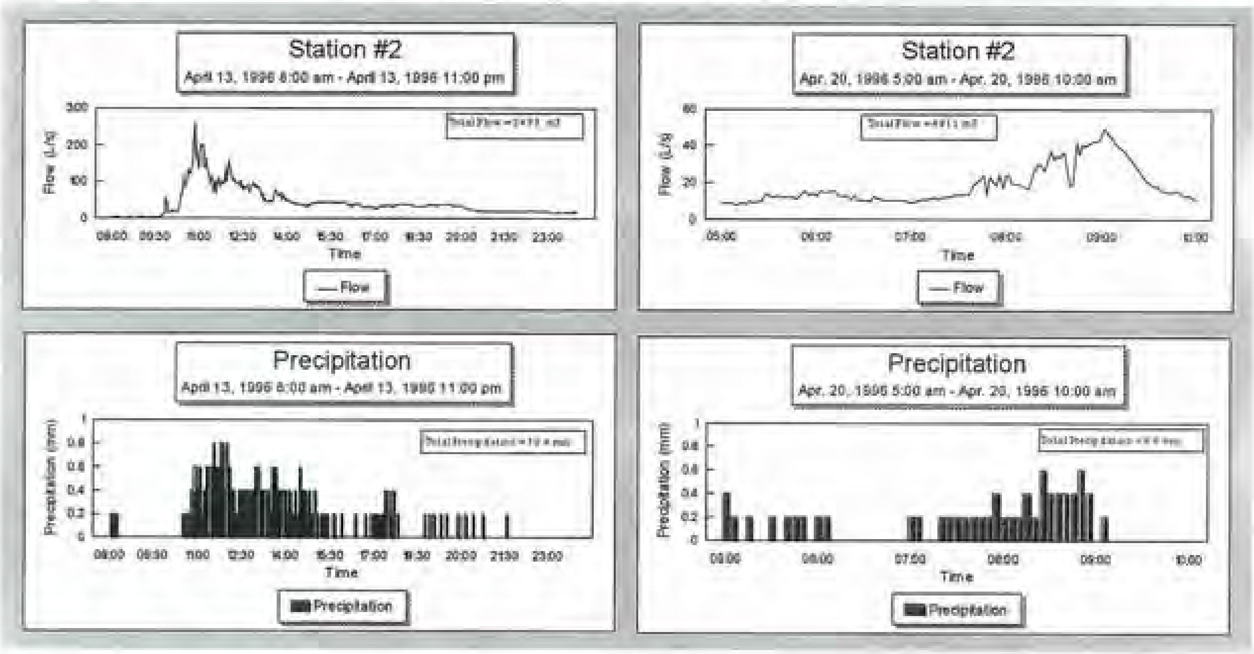
1995 SNOW EVENTS STATION #1 (FLOW ONLY)



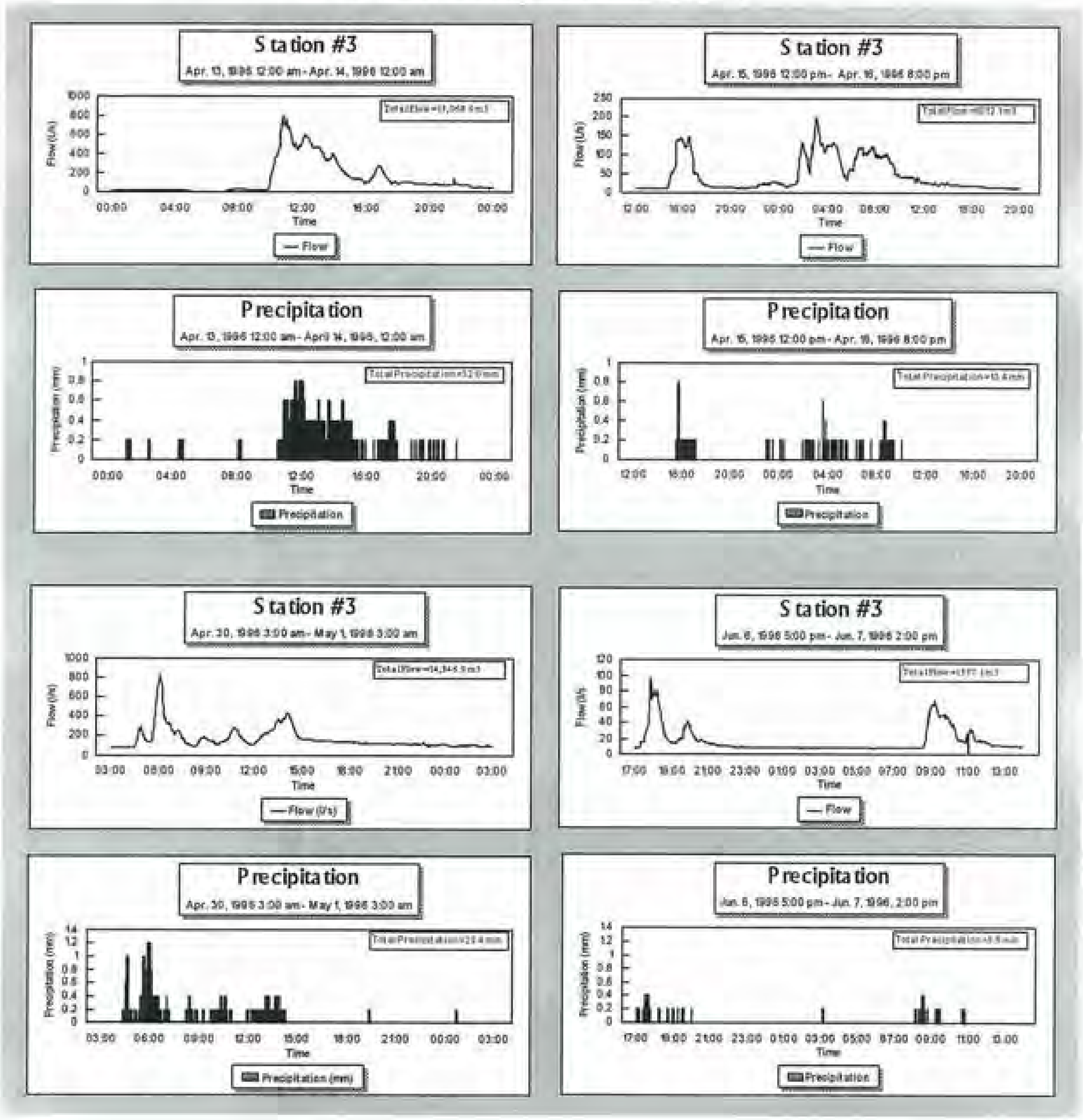
1995 SNOW EVENTS STATION #3 (FLOW ONLY)



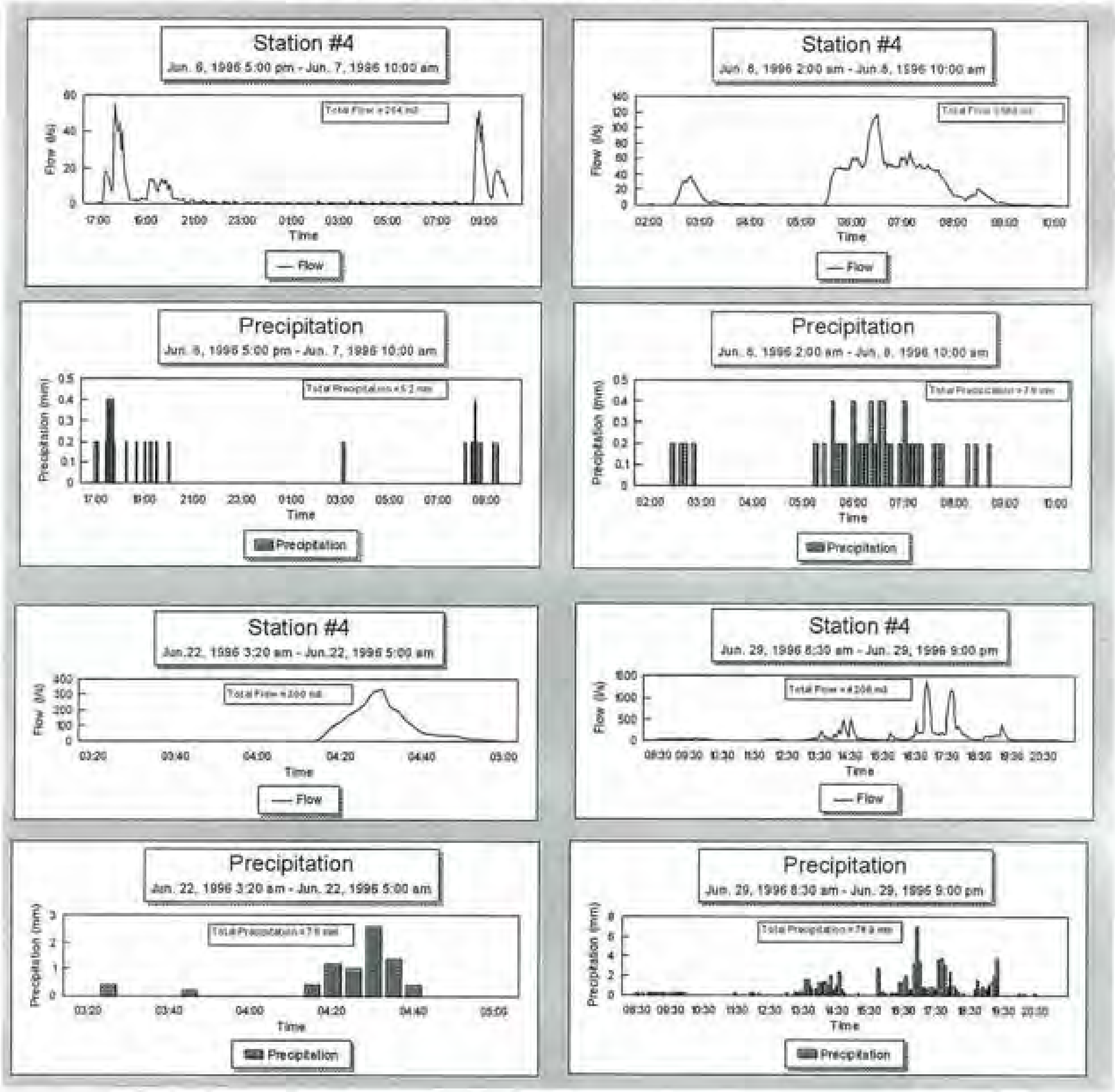
1996 EVENTS STATION #2 (FLOW AND PRECIPITATION)



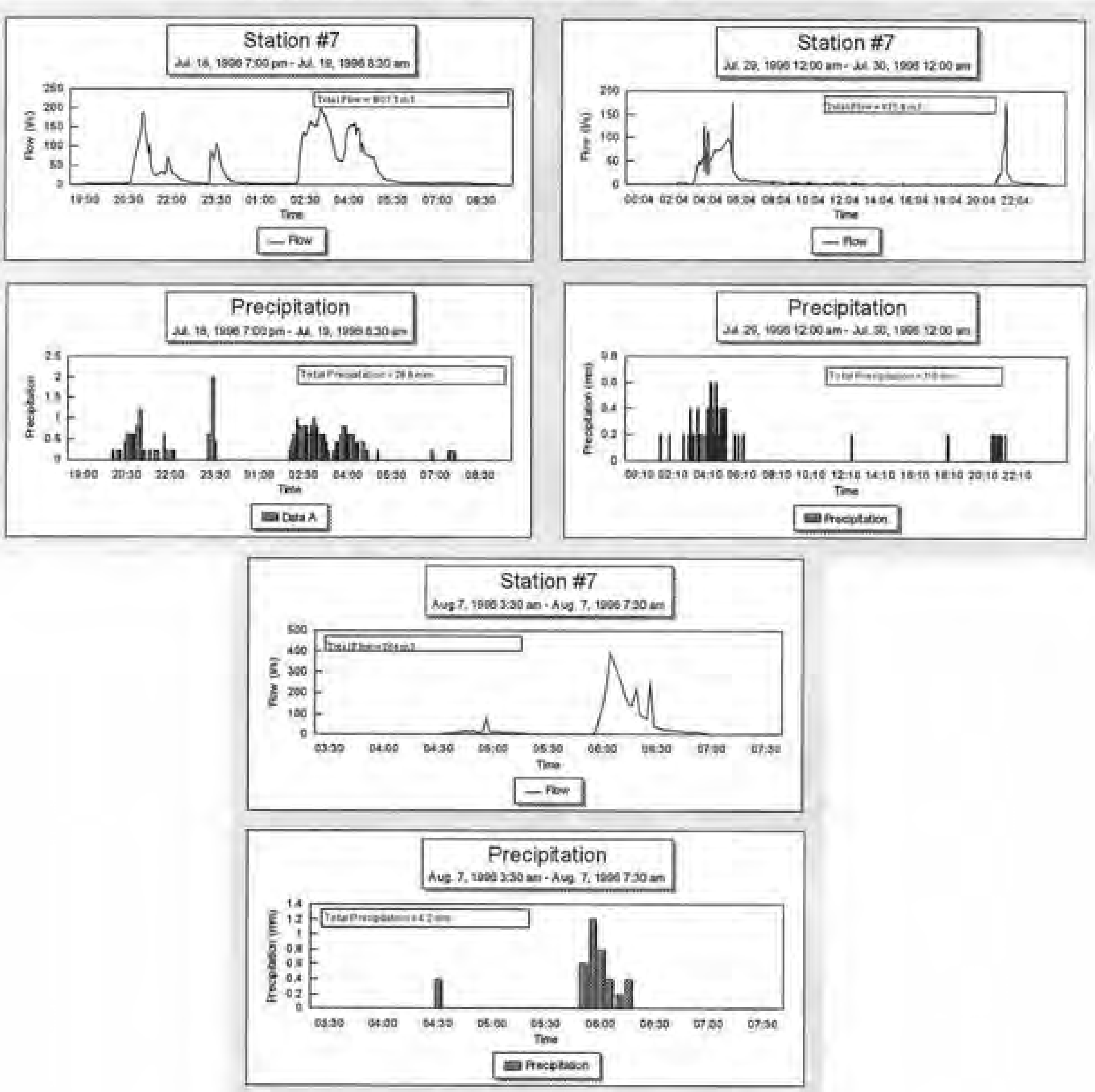
1996 EVENTS STATION#3 (FLOW AND PRECIPITATION)



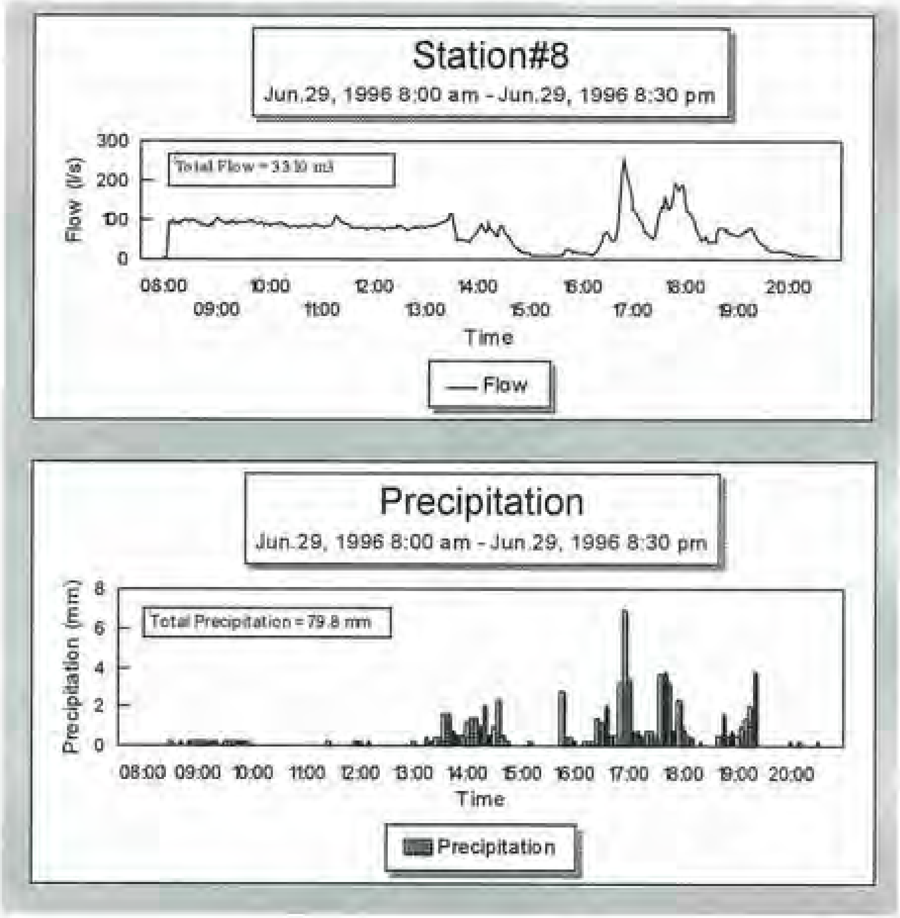
1996 EVENTS STATION #4 (FLOW AND PRECIPITATION)



1996 EVENTS STATION #7 (FLOW AND PRECIPITATION)



1996 EVENTS STATION #8 (FLOW AND PRECIPITATION)



APPENDIX D

STATISTICAL SUMMARIES OF CONTAMINANT DATA

Rain Event Stormwater Characteristics in the Severn Sound Area of Concern (Nutrients)
(all values in average mg/L unless otherwise stated)

Catch	N	Turb[1]	SS	Cl	Na	Cond[2]	pH	TP	DRP	TKN	FA	NO2	NO3	DOC	DIC
1	2	22.4	83.5	14.6	8.9	210.5	7.7	0.387	0.065	1.690	0.068	0.045	0.600	5.7	16.3
2	3	231.2	308.0	43.2	27.2	325.7	7.9	0.360	0.041	1.420	0.025	0.027	0.998	3.4	18.3
3	5	71.0	107.8	57.7	37.2	439.8	7.8	0.246	0.059	1.264	0.035	0.048	1.262	7.2	26.2
4	4	59.8	186.3	10.1	6.9	252.0	7.6	0.357	0.040	2.307	0.371	0.063	1.295	8.0	19.2
5	3	246.6	553.7	27.7	18.4	330.0	8.0	0.445	0.015	2.000	0.533	0.025	1.313	5.3	24.7
7	3	75.1	221.5	80.2	50.6	476.0	7.7	0.370	0.055	1.470	0.153	0.133	1.248	9.0	24.4
8	1	16.8	63	11.8	7.5	180	7.5	0.170	0.049	0.800	0.224	0.064	0.255	2.7	15.0
Totals		Turb	SS	Cl	Na	Cond	pH	TP	DRP	TKN	FA	NO2	NO3	DOC	DIC
Mean		114.7	229.3	38.6	24.7	340.8	7.8	0.337	0.046	1.612	0.191	0.053	1.109	6.2	21.8
Geomean		49.6	138.4	21.7	14.5	295.8	7.8	0.257	0.025	1.325	0.043	0.033	0.806	5.6	20.2
SStdDev		166.9	264.3	38.6	24.5	180.0	0.2	0.220	0.044	0.981	0.360	0.049	0.746	3.0	8.4
StdDev		162.4	257.2	37.6	23.8	175.1	0.2	0.214	0.043	0.955	0.351	0.047	0.726	3.0	8.2

Turb- turbidity
SS- suspended solids
Cl- chlorides

[1] Turbidity is expressed as FTU
[2] Conductivity is expressed as µS/cm

Na- sodium
Cond- conductivity
pH- pH
TP- total phosphorus

DRP- phosphorus; phosphate
TKN- total Kjeldahl nitrogen
FA- ammonia + ammonium
NO2- nitrite

NO3- nitrates
DOC- dissolved organic carbon
DIC- dissolved inorganic carbon

Snowmelt Stormwater Characteristics in the Severn Sound Area of Concern (Nutrients)
(all values in average mg/L unless otherwise stated)

Catch	N	Turb[1]	SS	Cl	Na	Cond[2]	pH	TP	DRP	TKN	FA	NO2	NO3	DOC	DIC
1	2	44.0	73.3	401.0	239.9	1365.7	7.8	0.159	0.015	0.900	0.033	0.027	0.520	2.9	18.9
3	5	78.7	78.3	939.5	572.2	6116.7	7.9	0.142	0.042	0.867	0.070	0.036	0.883	4.2	30.2
Totals		**Turb**	**SS**	**Cl**	**Na**	**Cond**	**pH**	**TP**	**DRP**	**TKN**	**FA**	**NO2**	**NO3**	**DOC**	**DIC**
Mean		70.0	77.1	804.9	489.1	4928.9	7.9	0.146	0.039	0.875	0.061	0.034	0.792	3.9	27.4
Geomean		36.5	44.2	178.7	111.6	1334.8	7.9	0.125	0.019	0.788	0.026	0.027	0.596	3.366	25.8
SStdDev		79.3	74.4	1009.6	611.2	8747.6	0.163	0.080	0.065	0.424	0.110	0.024	0.474	2.4	9.4
StdDev		75.9	71.2	966.6	585.2	8375.2	0.156	0.077	0.062	0.406	0.105	0.023	0.453	2.3	9.0

Turb- turbidity
SS- suspended solids
Cl- chlorides
Na- sodium
Cond- conductivity
pH- pH
TP- total phosphorus
DRP- phosphorus; phosphate
TKN- total Kjeldahl nitrogen
FA- ammonia + ammonium
NO2- nitrite
NO3- nitrates
DOC- dissolved organic carbon
DIC- dissolved inorganic carbon

[1] Turbidity is expressed as FTU
[2] Conductivity is expressed as μS/cm

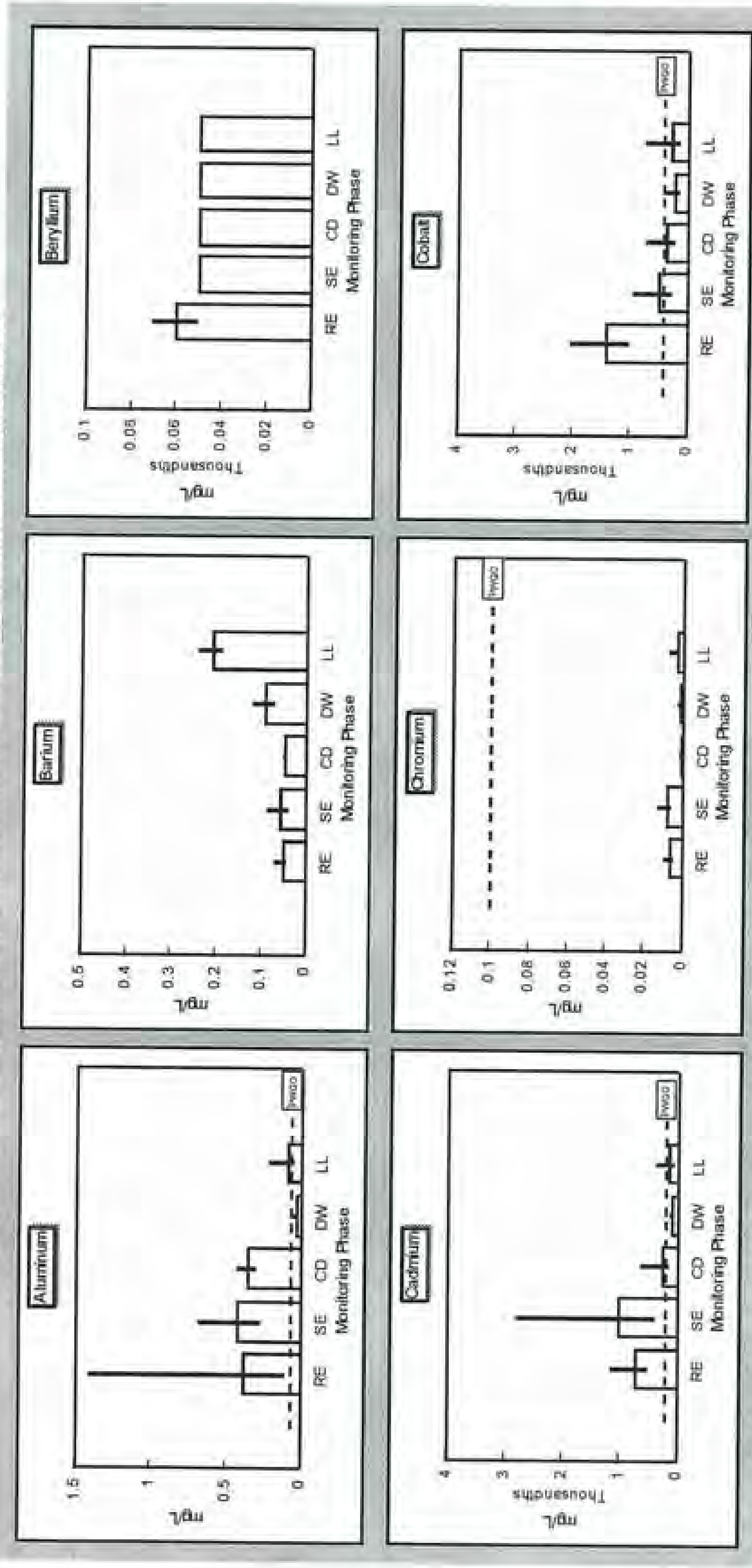
Little Lake Drain Characteristics in the Severn Sound Area of Concern (Nutrients)
(all values in average mg/L unless otherwise stated)

Catch	N	Turb[1]	SS	Cl	Na	Cond[2]	pH	TP	DRP	TKN	FA	NO2	NO3	DOC	DIC
LL	9	3.8	12.2	53.9	28.3	306.8	7.9	0.047	0.009	0.489	0.045	0.026	0.229	4.7	12.8
Totals		**Turb**	**SS**	**Cl**	**Na**	**Cond**	**pH**	**TP**	**DRP**	**TKN**	**FA**	**NO2**	**NO3**	**DOC**	**DIC**
Geomean		1.6	5.2	52.9	27.5	305.1	7.9	0.037	0.008	0.458	0.026	0.023	0.212	4.7	12.8
SStdDev		6.4	18.5	12.2	5.9	37.1	0.105	0.044	0.006	0.220	0.030	0.014	0.112	0.16	1.1
StdDev		6.0	17.4	11.5	5.6	35.0	0.099	0.042	0.005	0.208	0.028	0.013	0.106	0.16	1.0

Turb- turbidity
SS- suspended solids
Cl- chlorides
Na- sodium
Cond- conductivity
pH- pH
TP- total phosphorus
DRP- phosphorus; phosphate
TKN- total Kjeldahl nitrogen
FA- ammonia + ammonium
NO2- nitrite
NO3- nitrates
DOC- dissolved organic carbon
DIC- dissolved inorganic carbon

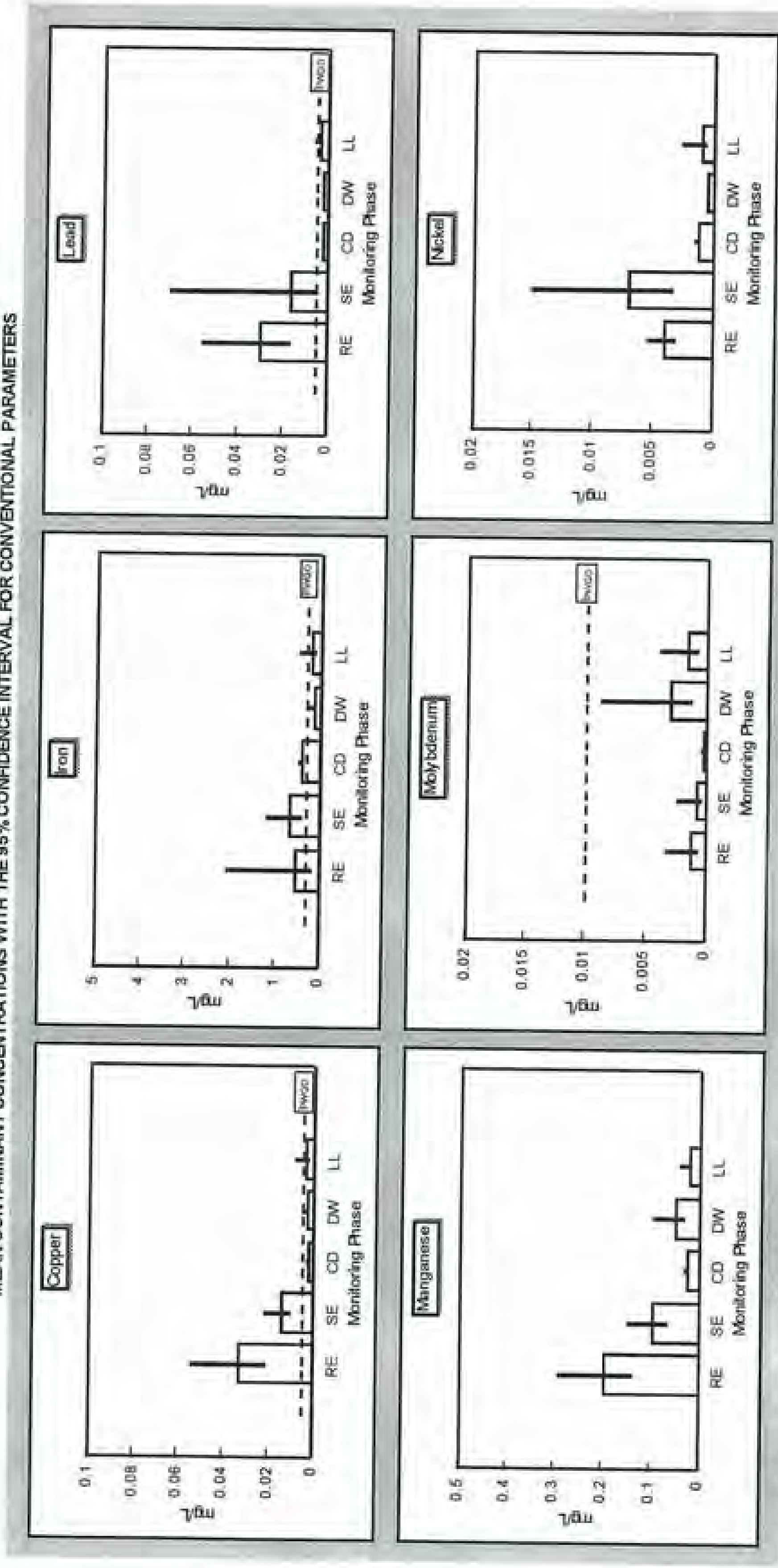
[1] Turbidity is expressed as FTU
[2] Conductivity is expressed as µS/cm

MEAN CONTAMINANT CONCENTRATIONS WITH THE 95% CONFIDENCE INTERVAL FOR CONVENTIONAL PARAMETERS



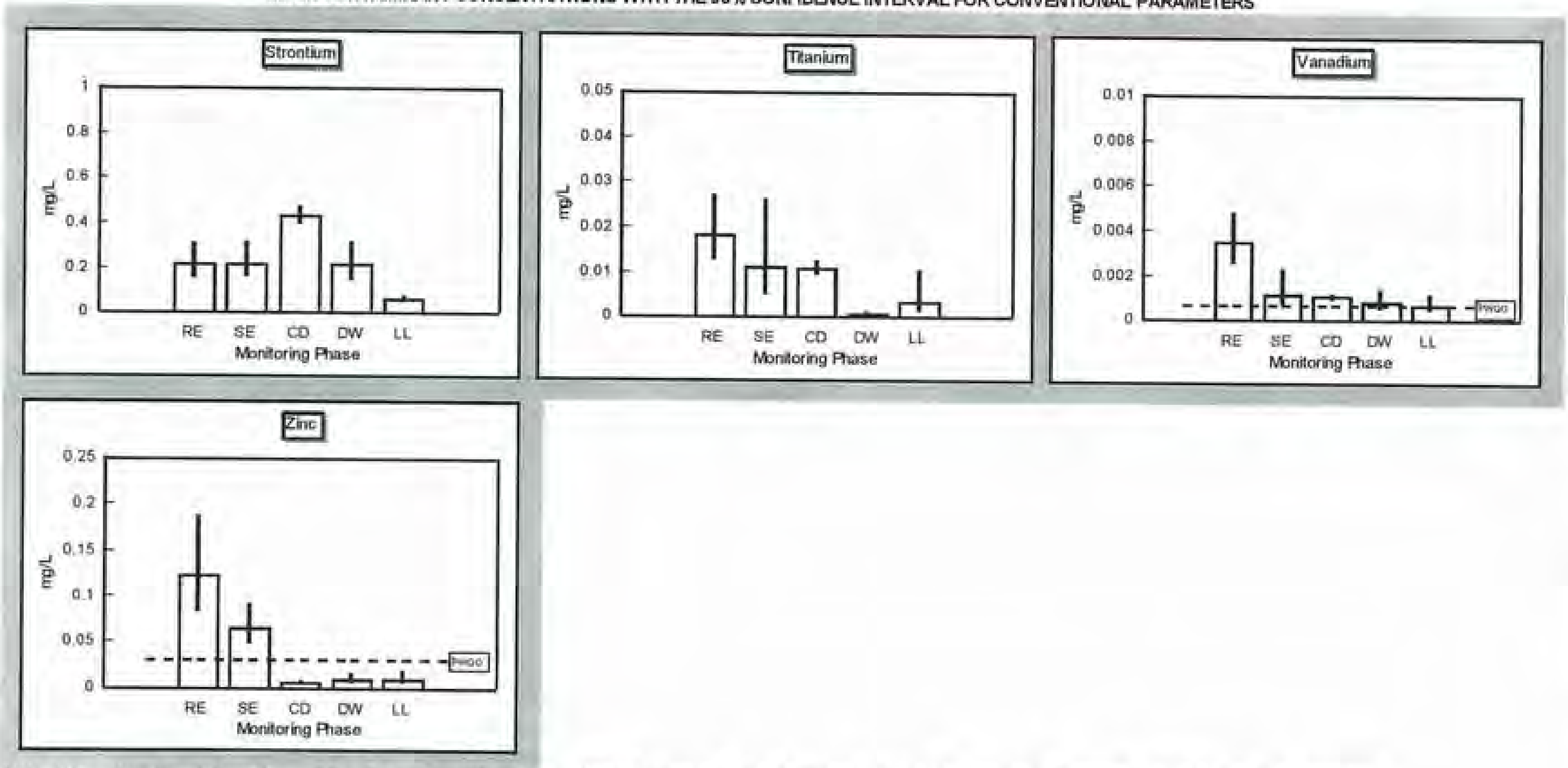
Note: RE = Rain Event Samples SE = Snow Event Samples CD = Coldwater Drain Samples DW = Dry Weather Samples LL = Little Lake Samples

MEAN CONTAMINANT CONCENTRATIONS WITH THE 95% CONFIDENCE INTERVAL FOR CONVENTIONAL PARAMETERS



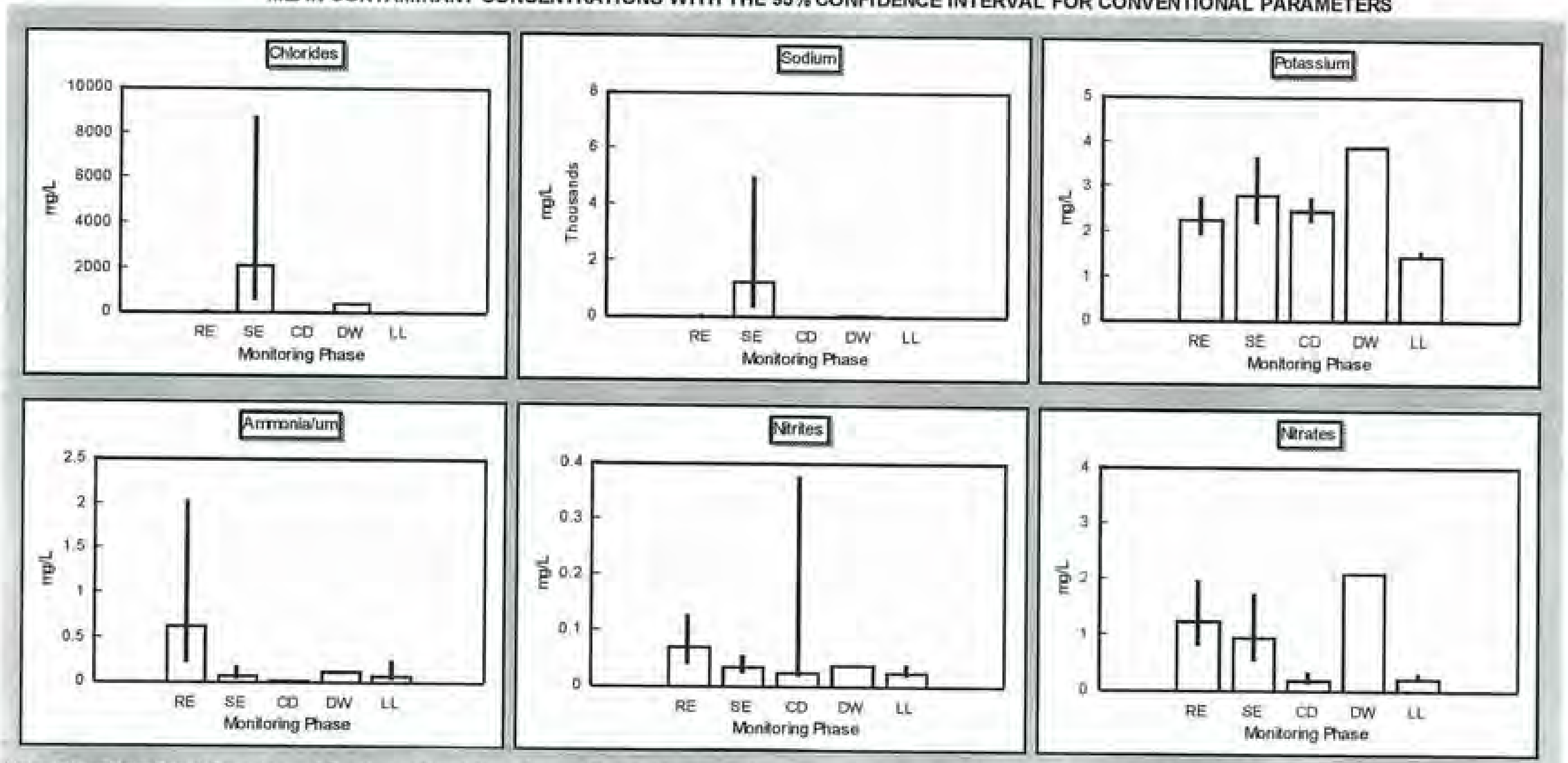
Note: RE = Rain Event Samples SE = Snow Event Samples CD = Coldwater Drain Samples DW = Dry Weather Samples LL = Little Lake Samples

MEAN CONTAMINANT CONCENTRATIONS WITH THE 95% CONFIDENCE INTERVAL FOR CONVENTIONAL PARAMETERS



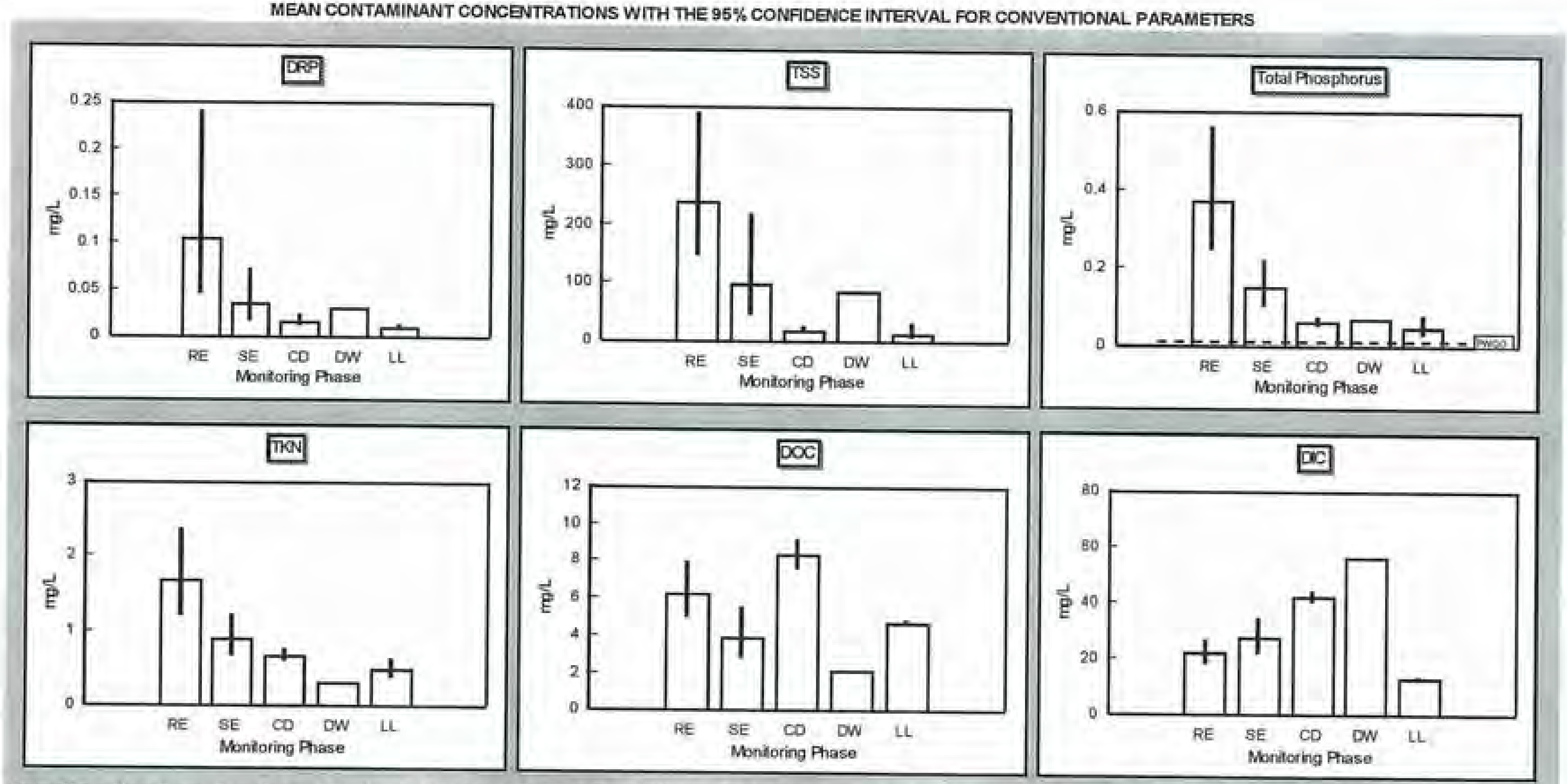
Note: RE = Rain Event Samples SE = Snow Event Samples CD = Coldwater Drain Samples DW = Dry Weather Samples LL = Little Lake Samples

MEAN CONTAMINANT CONCENTRATIONS WITH THE 95% CONFIDENCE INTERVAL FOR CONVENTIONAL PARAMETERS



Note: RE = Rain Event Samples SE = Snow Event Samples CD = Coldwater Drain Samples DW = Dry Weather Samples LL = Little Lake Samples

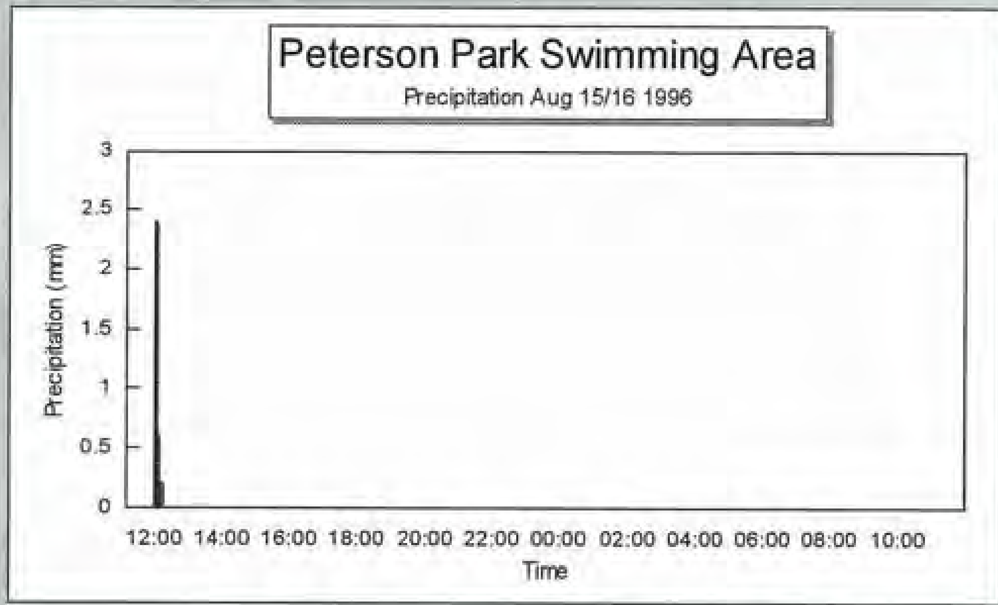
MEAN CONTAMINANT CONCENTRATIONS WITH THE 95% CONFIDENCE INTERVAL FOR CONVENTIONAL PARAMETERS

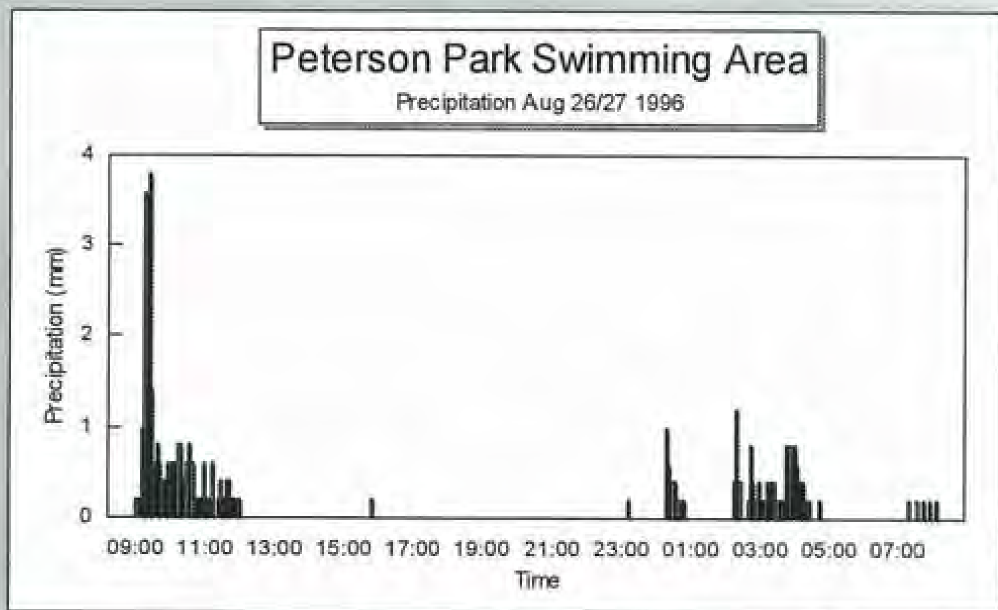


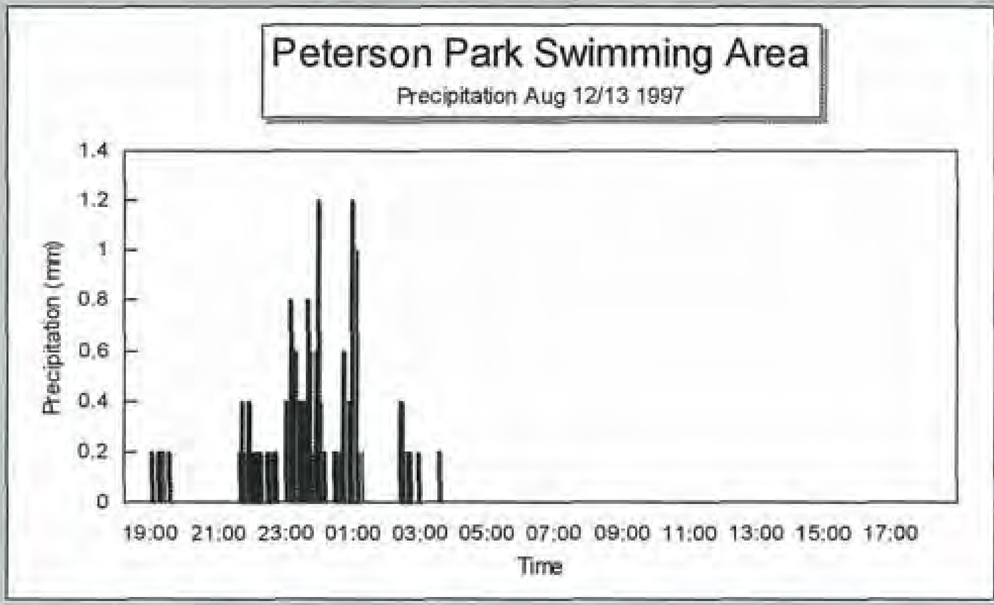
Note: RE = Rain Event Samples SE = Snow Event Samples CD = Coldwater Drain Samples DW = Dry Weather Samples LL = Little Lake Samples

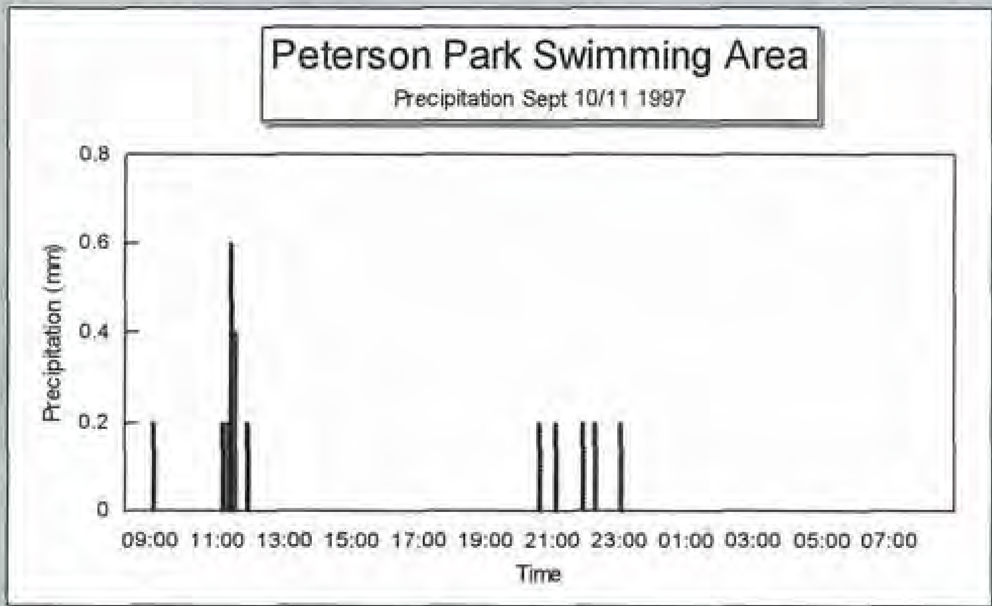
APPENDIX E

BATHING AREA PRECIPITATION AND CONTAMINANT CONCENTRATION RESULTS


Peterson Park Swimming Area
Precipitation Aug 15/16 1996
Precipitation (mm)
3
2.5
2
1.5
1
0.5
0
12:00 14:00 16:00 18:00 20:00 22:00 00:00 02:00 04:00 06:00 08:00 10:00
Time


Peterson Park Swimming Area
Precipitation Aug 26/27 1996
Precipitation (mm)
4
3
2
1
0
09:00 11:00 13:00 15:00 17:00 19:00 21:00 23:00 01:00 03:00 05:00 07:00
Time


Peterson Park Swimming Area
Precipitation Aug 12/13 1997
Precipitation (mm)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
19:00 21:00 23:00 01:00 03:00 05:00 07:00 09:00 11:00 13:00 15:00 17:00
Time


Peterson Park Swimming Area
Precipitation Sept 10/11 1997
Precipitation (mm)
0.8
0.6
0.4
0.2
0
09:00 11:00 13:00 15:00 17:00 19:00 21:00 23:00 01:00 03:00 05:00 07:00
Time

August 13 Baseline Results

MOE ID	HU ID	Time	Date	Coliforms	SS	TP	TKN
PCP4100	1.00	13:00	13-Aug-96	600	9	0.138	1.64
PCP4200	2.00	13:05	13-Aug-96	400	6	0.012	0.3
PCP4300	3.00	13:10	13-Aug-96	440	5	0.012	0.24
PCP4400	4.00	13:15	13-Aug-96	30	1	0.01	0.3
PCP4500	5.00	13:20	13-Aug-96	30	1	0.014	0.26
PCP4600	6.00	13:25	13-Aug-96	10	1	0.008	0.26
PCP4700	7.00	13:30	13-Aug-96	10	1	0.008	0.24
PCP4800	8.00	13:35	13-Aug-96	30	1	0.006	0.24
PCP4900	9.00	13:40	13-Aug-96	10	3	0.01	0.46

August 15/16 13:00

MOE ID	HU ID	Time	Date	Coliforms	Cl	Cond	pH	Nit a+a	N ite	N ate+ite	P ate	SS	TP	TKN
Station 1														
PCP4114	1.14	13:42	15-Aug-96	600	1260	3550	7.87	0.006	0.023	1.4	0.0125	25	0.054	0.52
PCP4101	1.01	13:56	15-Aug-96	360	1250	3540	7.92	0.008	0.005	0.545	0.0005	28	0.038	0.42
PCP4102	1.02	14:06	15-Aug-96	600	137	749	7.51	0.008	0.032	1.27	0.0055	102	0.16	1.5
PCP4103	1.03	14:16	15-Aug-96	600	93.2	517	7.11	0.106	0.031	1.31	0.0415	61	0.27	2.3
PCP4104	1.04	14:26	15-Aug-96	600	102	535	7.14	0.302	0.083	1.92	0.11	43	0.41	3.1
PCP4105	1.05	14:36	15-Aug-96	600	154	716	7.05	0.982	0.175	2.15	0.145	14	0.36	2.4
PCP4106	1.06	15:30	15-Aug-96	600	356	1480	7.21	0.486	0.15	1.61	0.053	18	0.084	0.62
PCP4107	1.07	20:20	15-Aug-96	600	1100	3140	7.86	0.002	0.039	1.5	0.0025	16	0.028	0.64
Station 2														
PCP4206	2.06	13:42	15-Aug-96	150	41.2	449	8.25	0.014	0.002	0.535	0.0005	8	0.012	0.34
PCP4201	2.01	13:56	15-Aug-96	190	40.8	3530	7.97	0.016	0.019	1.37	0.015	6	0.036	0.4
PCP4202	2.02	20:20	15-Aug-96	140	39.2	445	8.21	0.002	0.001	0.61	0.0005	5	0.01	0.38
PCP4203	2.03	8:00	16-Aug-96	170	38.4	440	8.13	0.012	0.001	0.73	0.0005	7	0.01	0.34
Station 3														
PCP4309	3.09	13:47	15-Aug-96	600	56.8	494	8.13	0.026	0.016	0.57	0.0005	3	0.01	0.36
PCP4301	3.01	14:43	15-Aug-96	600	58.4	499	8.08	0.026	0.018	0.54	0.001	3	0.01	0.38
PCP4302	3.02	16:45	15-Aug-96	600	69.6	536	8.02	0.022	0.015	0.525	0.001	3	0.01	0.34
PCP4303	3.03	20:00	15-Aug-96	420	60.4	511	8.04	0.026	0.009	0.525	0.0005	4	0.008	0.32
PCP4304	3.04	8:05	16-Aug-96	190	52.6	500	8.03	0.034	0.016	0.55	0.0015	4	0.006	0.3
Station 4														
PCP4406	4.06	13:50	15-Aug-96	20	18	249	8.16	0.018	0.001	0.065	0.001	1	0.014	0.3
PCP4401	4.01	16:48	15-Aug-96	10	21.6	283	8.17	0.016	0.003	0.095	0.0015	1	0.008	0.3
PCP4402	4.02	20:03	15-Aug-96	30	24	292	8.09	0.018	0.004	0.115	0.001	3	0.012	0.32
PCP4403	4.03	8:08	16-Aug-96	10	20.4	261	8.03	0.03	0.004	0.1	0.0015	4	0.008	0.3
Station 5														
PCP4505	5.05	13:55	15-Aug-96	10	14.6	224	8.13	0.032	0.001	0.04	0.001	1	0.01	0.34
PCP4501	5.01	16:51	15-Aug-96	10	10.8	198	8.15	0.028	0.003	0.07	0.001	1	0.014	0.4
PCP4502	5.02	20:05	15-Aug-96	10	12.4	210	8.15	0.026	0.005	0.065	0.0025	6	0.018	0.38
PCP4503	5.03	8:01	16-Aug-96	30	11.2	203	8.15	0.024	0.007	0.05	0.0005	1	0.006	0.3
Station 6														
PCP4605	6.05	13:56	15-Aug-96	10	13	214	8.11	0.028	0.001	0.075	0.0005	2	0.01	0.42
PCP4601	6.01	16:52	15-Aug-96	50	10.8	197	8.12	0.024	0.001	0.085	0.0005	1	0.01	0.3
PCP4602	6.02	20:06	15-Aug-96	10	12.8	210	8.18	0.012	0.001	0.08	0.0005	1	0.01	0.3
PCP4603	6.03	8:02	16-Aug-96	10	11.2	203	8.18	0.022	0.001	0.06	0.0005	1	0.006	0.3
Station 7														
PCP4705	7.05	13:57	15-Aug-96	30	12.4	211	8.17	0.02	0.001	0.08	0.0005	1	0.008	0.32
PCP4701	7.01	16:53	15-Aug-96	10	11	198	8.15	0.016	0.001	0.105	0.0005	1	0.009	0.28
PCP4702	7.02	20:07	15-Aug-96	10	12.6	209	8.17	0.02	0.001	0.105	0.0005	1	0.009	0.3
PCP4703	7.03	8:03	16-Aug-96	10	11.2	204	8.15	0.018	0.001	0.06	0.0005	1	0.01	0.32
Station 8														
PCP4805	8.05	13:58	15-Aug-96	10	12.4	210	8.14	0.022	0.001	0.07	0.001	1	0.006	0.34
PCP4801	8.01	16:54	15-Aug-96	20	10.8	200	8.14	0.026	0.008	0.09	0.0005	2	0.008	0.3
PCP4802	8.02	20:08	15-Aug-96	20	11.8	207	8.17	0.034	0.006	0.095	0.015	1	0.01	0.34
PCP4803	8.03	8:04	16-Aug-96	10	11.2	205	8.15	0.026	0.008	0.065	0.0005	1	0.008	0.34
Station 9														
PCP4905	9.05	13:59	15-Aug-96	20	12.8	213	8.13	0.028	0.001	0.075	0.0005	3	0.01	0.38
PCP4901	9.01	16:55	15-Aug-96	50	11.2	200	8.14	0.022	0.001	0.095	0.0005	2	0.008	0.32
PCP4902	9.02	20:09	15-Aug-96	10								2	0.01	0.32
PCP4903	9.03	8:05	16-Aug-96	10								1	0.01	0.32

August 26/27 9:30 -

MOE ID	HU ID	Time	Date	Coliforms	Cl	Cond	pH	NH a+a	N ite	N ate+ite	P ate	SS	TP	TKN
Station 1														
PCP4108	1.08	9:30	26-Aug-96	600	1320	3760	7.94	0.022	0.012	1.54	0.014	4	0.088	0.46
PCP4111	1.11	10:00	26-Aug-96	600	1350	3830	8.02	0.002	0.013	1.56	0.0085	38	0.05	0.42
PCP4112	1.12	10:15	26-Aug-96	600	22.8	256	7.79	0.002	0.137	1.38	0.0395	776	0.054	0.3
PCP4113	1.13	10:30	26-Aug-96	600	3.6	85	8.33	0.03	0.027	0.285	0.077	637	0.88	1.9
PCP4115	1.15	11:30	26-Aug-96	600	9.2	97	8.31	0.002	0.021	0.195	0.042	143	0.204	0.76
Station 2														
PCP4204	2.04	9:30	26-Aug-96	380	39.2	448	8.25	0.016	0.004	0.68	0.0005	22	0.026	0.32
PCP4207	2.07	12:30	26-Aug-96	600	38.4	416	8.07	0.022	0.021	0.425	0.0155	21	0.094	0.7
Station 3														
PCP4305	3.05	9:30	26-Aug-96	440	57.6	520	8	0.02	0.011	0.625	0.001	4	0.01	0.28
PCP4306	3.06	11:00	26-Aug-96	600	57.6	494	7.98	0.034	0.013	0.61	0.0115	2	0.056	0.62
PCP4307	3.07	12:30	26-Aug-96	600	38.4	376	7.95	0.012	0.008	0.42	0.003	20	0.034	0.66
PCP4308	3.08	14:30	26-Aug-96	600	40	366	8	0.002	0.014	0.355	0.009	11	0.03	0.42
PCP4310	3.10	21:30	26-Aug-96	600	47.2	454	8.08	0.02	0.008	0.295	0.002	6	0.016	0.36
PCP4311	3.11	9:30	27-Aug-96	600	48	460	7.98	0.028	0.009	0.305	0.0025	5	0.018	0.4
Station 4														
PCP4404	4.04	9:30	26-Aug-96	10	13.4	217	8.18	0.012	0.002	0.04	0.001	1	0.01	0.32
PCP4405	4.05	12:30	26-Aug-96	50	18	244	8.15	0.012	0.003	0.075	0.001	1	0.008	0.32
PCP4407	4.07	14:30	26-Aug-96	20	16.6	229	8.19	0.014	0.004	0.06	0.0005	1	0.008	0.3
PCP4408	4.08	21:30	26-Aug-96	220	17.4	245	8.17	0.02	0.004	0.07	0.0005	8	0.028	0.4
PCP4409	4.09	9:30	27-Aug-96	50	17.2	243	8.12	0.03	0.004	0.07	0.0015	10	0.022	0.38
Station 5														
PCP4504	5.04	9:15	26-Aug-96	10	12	207	8.17	0.012	0.002	0.03	0.0005	1	0.008	0.3
PCP4505	5.05	12:30	26-Aug-96	70	12	205	8.18	0.016	0.002	0.025	0.0005	2	0.008	0.32
PCP4507	5.07	14:30	26-Aug-96	310	12	206	8.2	0.012	0.001	0.025	0.001	3	0.01	0.38
PCP4508	5.08	21:30	26-Aug-96	50	12.8	212	8.15	0.026	0.003	0.03	0.001	29	0.06	0.58
PCP4509	5.09	9:30	27-Aug-96	20	12.8	215	8.17	0.026	0.003	0.03	0.002	14	0.034	0.46
Station 6														
PCP4604	6.04	9:18	26-Aug-96	10	12	208	8.22	0.01	0.001	0.03	0.0005	1	0.006	0.28
PCP4605	6.05	12:33	26-Aug-96	10	12	205	8.17	0.018	0.002	0.03	0.0005	2	0.008	0.3
PCP4607	6.07	14:33	26-Aug-96	310	12	206	8.18	0.012	0.001	0.03	0.0005	2	0.008	0.3
PCP4608	6.08	21:33	26-Aug-96	600	12.6	217	8.16	0.018	0.002	0.028	0.002	32	0.072	0.64
PCP4609	6.09	9:33	27-Aug-96	10	13	214	8.17	0.026	0.003	0.036	0.0035	19	0.032	0.44
Station 7														
PCP4704	7.04	9:21	26-Aug-96	10	12	206	8.22	0.012	0.002	0.03	0.0005	1	0.006	0.28
PCP4705	7.05	12:36	26-Aug-96	30	12	205	8.18	0.014	0.002	0.025	0.0005	2	0.008	0.3
PCP4707	7.07	14:36	26-Aug-96	140	12	206	8.15	0.016	0.002	0.025	0.001	2	0.008	0.3
PCP4708	7.08	21:36	26-Aug-96	40	13.2	210	8.12	0.018	0.002	0.025	0.002	48	0.068	0.62
PCP4709	7.09	9:36	27-Aug-96	10	12.9	212	8.14	0.028	0.002	0.03	0.0025	11	0.034	0.42
Station 8														
PCP4804	8.04	9:24	26-Aug-96	10	12.2	207	8.21	0.01	0.002	0.03	0.0005	2	0.01	0.3
PCP4805	8.05	12:39	26-Aug-96	20	12	205	8.17	0.016	0.002	0.03	0.0005	1	0.006	0.3
PCP4807	8.07	14:39	26-Aug-96	10	12	206	8.17	0.016	0.002	0.025	0.0005	2	0.008	0.3
PCP4808	8.08	21:39	26-Aug-96	30	12.8	211	8.12	0.012	0.002	0.025	0.003	50	0.114	0.82
PCP4809	8.09	9:39	27-Aug-96	30	12.6	212	8.15	0.024	0.003	0.025	0.003	14	0.064	0.54
Station 9														
PCP4904	9.04	9:27	26-Aug-96	10	12	207	8.2	0.02	0.002	0.025	0.001	1	0.012	0.34
PCP4905	9.05	12:41	26-Aug-96	20	12	204	8.18	0.018	0.001	0.025	0.0005	1	0.008	0.3
PCP4907	9.07	14:41	26-Aug-96	10	12.2	205	8.19	0.016	0.002	0.025	0.0005	28	0.01	0.32
PCP4908	9.08	21:41	26-Aug-96	40	12.6	210	8.15	0.012	0.002	0.025	0.0015	1	0.056	0.52
PCP4909	9.09	9:41	27-Aug-96	10	13.2	213	8.12	0.026	0.003	0.025	0.004	17	0.054	0.52

September 10/11, 1997

Location	Time	E.coli	Temp	TSS
Station 1				
1A	09:00	12000	18	5
1B	09:30	28000	18	14
1C	10:00	10000	18	355
1D	12:30	4000	18	583
1E	13:00	2000	18	118
Station 2				
2A	09:02	480	15	6
2B	13:00	690	15	5
Station 3				
3A	09:10	120	15	4
3B	10:40	300	15	10
3C	12:00	540	15	12
3D	13:00	1800	15	25
3E	14:00	8200	15	21
3F	15:00	2500	15	7
Station 4				
4A	09:20	10	18	1
4B	12:20	10	18	3
4C	15:20	20	18	2
4D	19:00	40	17	5
4E	08:20	10	18	1
Station 5				
5A	09:30	20	19	8
5B	14:58	10	18	17
5C	18:58	30	16	13
5D	08:00	10	18	1
Station 6				
6A	09:32	10	19	
6B	15:00	10	18	13
6C	19:00	10	16	19
6D	13:00	2000	18	118
Station 7				
7A	09:35	10	19	1
7B	15:01	10	18	8
7C	19:02	10	16	11
7D	08:03	10	18	1
Station 8				
8A	09:37	10	19	1
8B	15:02	10	18	
8C	19:03	20	16	
8D	08:04	30	18	1
Station 9				
9A	09:40	10	19	
9B	15:05	10	18	5
9C	19:05	30	16	
9D	08:05	40	18	1

APPENDIX F

DRAFT DRAINAGE POLICY AND PROTOCOL FOR INFRASTRUCTURE IMPROVEMENT PROJECTS

DRAFT DRAINAGE POLICY

Through this urban drainage policy, the Municipality intends to:

i. Maintain or improve the current level of service to our residents.
ii. Protect and enhance the surrounding environment in a cost effective and well planned fashion.

Drainage Principles

The Municipality is committed to heightened environmental awareness and endeavors to:

i. Preserve and improve the quality of our receiving waters and environmentally sensitive areas.
ii. Encourage sustainable development for present and future uses.
iii. Protect life and property from flood water and erosion damage by application of efficient and maintainable stormwater management practices.

This shall be achieved through the pursuit of the following principles as they relate to the care and control of our drainage system:

- Commit to comprehensive water resource planning.
- Prevent health hazards, loss of life and property damage from flooding, erosion and adverse environmental effects.
- Limit contamination of the local groundwater system and minimize adverse changes to the hydrologic cycle.
- Minimize water quality degradation resulting from nutrient and other pollutant discharges to receiving waters.
- Encourage infiltration of stormwater on sites where conditions permit and maintain or enhance baseflow in receiving waters.

Drainage Guidelines

The purpose of these guidelines is to clarify the municipality's objectives to the management of our urban drainage system. They will provide users with clear direction and practical water management guidelines.

The primary focus of these guidelines is to provide direction for plans of subdivision, condominium plans, site plans and redevelopment proposals (which may include severences of five or more lots), and for proponents making changes to the storm drainage systems or the maintenance of the same. The objectives are to provide proponents with direction and guidelines to make appropriate stormwater management proposals. This shall include consideration of land requirements and cost comparison analysis of the proposed stormwater management alternatives. Agency objectives as expressed in Provincial Policy statements shall be addressed to streamline this process. A clearly defined procedure should result from these initiatives.

Watershed and subwatershed planning documents will provide environmental and land use guidance while incorporating water management options within the study limits. This ecosystem based approach identifies changing land use scenarios and considers alternatives for integration of existing natural systems. The Ministry of the Environment document ***Stormwater Management Practice, Planning and Design Manual*** (1994) provides a better defined understanding of this process and presents various stormwater management alternatives for implementation in new development scenarios. In the case of retrofit stormwater management opportunities, the ***Severn Sound Remedial Action Plan Urban Stormwater Management Strategy*** (1998) recommendations will be supported based on opportunity and budgetary considerations. In endorsing these concepts and strategies, the Municipality remains consistent with Provincial and County Policies Statements.

Runoff Quantity and Quality Control

Since development invariably affects both quantity and quality of runoff from any storm due to increased impermeable surfaces, it will usually be necessary to compensate by exercising control on the rate, quantity and quality of runoff both during and after construction. In accord with the concept of ecosystem planning, there is a preferred hierarchy associated with stormwater management measures. These measures can take the form of non-structural management controls, source controls, drainage controls, inlet controls, system controls and finally outlet controls (see Figure 1). Control of runoff at the source (or as close as possible) is always a preferred strategy, minimizing the capital expenditures required for infrastructure and for maintaining the spatial and temporal characteristics of the natural hydrologic features of an area.

Within certain overall defined restrictions contained in these guidelines, the Municipality will take a flexible approach and encourage innovation in the development of new approaches to stormwater management. Stormwater storage and treatment is accepted as a basic philosophy but it is to be designed on a watershed/subwatershed basis. Of particular importance to this strategy is that **post-development hydrologic conditions will reproduce or improve on pre-development hydrologic conditions by minimizing increases in rates and quantity of runoff, and by improving runoff quality**. Suitability criteria for each stormwater management practice will be derived from the MOE stormwater management practices design manual.

1. Non-Structural Management Controls

Non-structural management control measures are pollution prevention techniques that focus on public education and by-law enforcement. The Municipality commits to preserving and improving the quality of the receiving waters into which storm discharges flow by:

- minimizing fertilizer and pesticide/herbicide use in parks;
- maintaining areas of natural vegetation where possible on public lands;
- ensuring proper disposal of materials from street sweeping and catch basin cleaning activities;
- establishing appropriate sewer use by-laws and enforcing them; and
- instituting and enforcing a 'poop-and-scoop' by-law for pet owners.

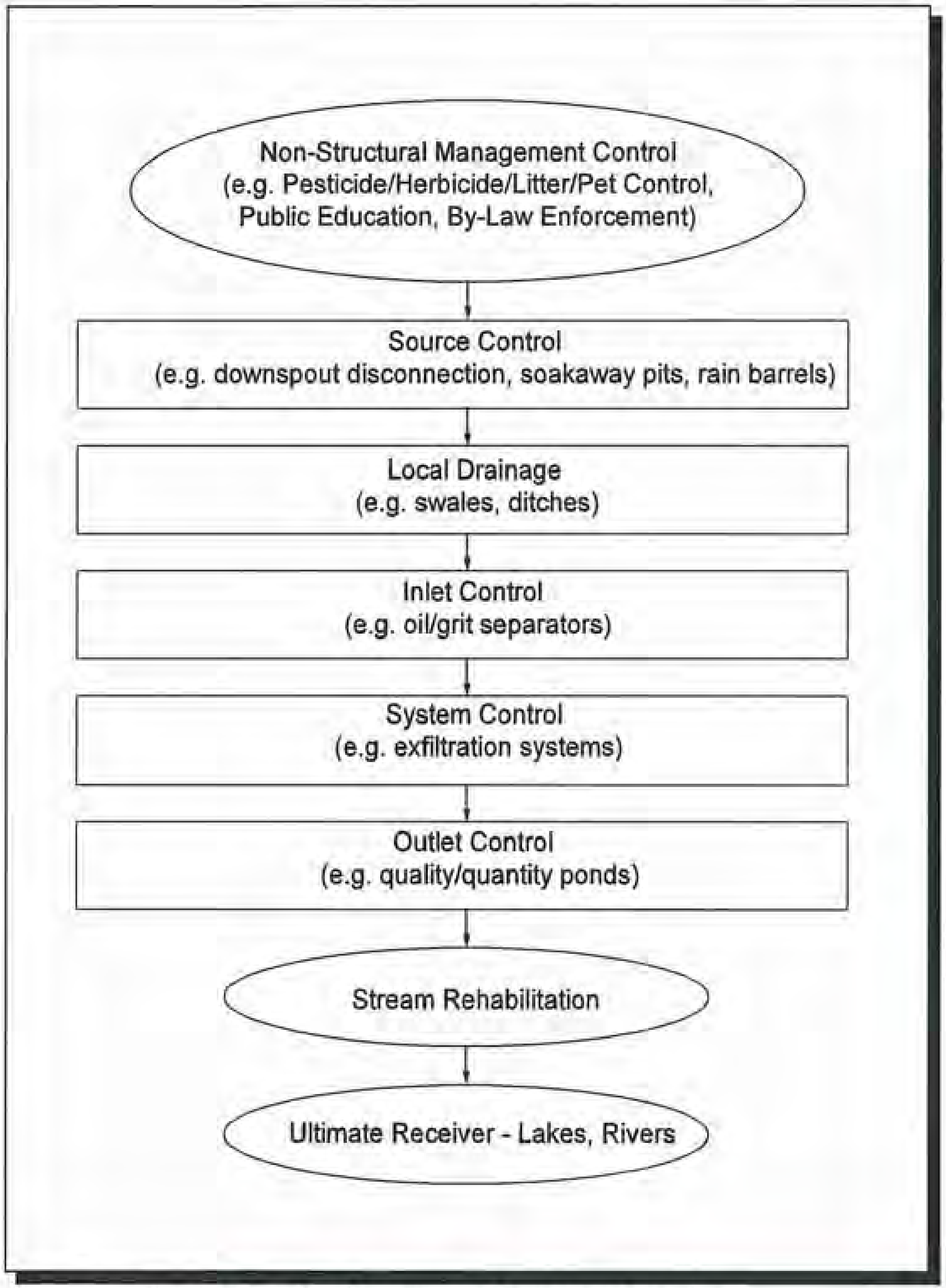


Figure 1 Preferred Hierarchy of Stormwater Management Practices

2. *Source Controls*

Source controls involve measures to reduce and/or treat stormwater before it reaches the local conveyance systems. An extensive pipe or ditch storm drainage system is not required where the surface runoff can be contained within the limits of the property from which it originated and in such a manner that the stormwater shall not cause erosion, sedimentation or endanger any person or create the risk of property damage. Since source controls are lot-level measures, the implementation of these practices requires the participation and co-operation of lot landowners in retrofit situations and new development scenarios.

a. Down Spout Disconnections in Areas of Existing Development

The Municipality encourages the disconnection of downspouts from the storm or sanitary sewer system, or from draining onto impervious surfaces such as driveways (dependent on groundwater table levels, soil porosity, development density/setback ratio of impervious to total site area, and other uses, i.e. pools, landscaping sheds, etc). Rain barrels are supported to contain and store rainfall collected from the disconnected downspout (during non-freezing periods).

b. New Development Requirements for Down Spouts

The Municipality requires roof leaders to be discharged to the surface with flows to be collected in rain barrels (during non-freezing periods) and/or to be directed away from the building in such a way as to prevent seepage into weeping tile. Soakaway pits may be implemented in conjunction with roof leader discharge as part of the stormwater management design. Where flat roofs are used, as in commercial or industrial sites, detention roof hoppers requiring smaller or fewer roof leaders may be implemented as part of the stormwater management design. The proponent must justify the need to connect the down spout to the storm sewer system where the above is not achievable.

c. Foundation Drains

Where feasible, sump pump drainage will be discharged to the lot surface or to soakaway pits located on the property.

In cases where weeping tile drains will be connected to the storm sewer system, the elevation of the basement floor shall be at least 1.0 metre above the elevation of the storm sewer obvert at that point and preferably 150 mm above the hydraulic grade line generated by the 1 in 100 year storm. For building connections located close to the point where the storm sewer discharges into the major system, there is the additional requirement that the basement floor elevation must be above the 1 in 100 year flood elevation at the point of discharge. These conditions are required unless the proponent can prove alternative designs can prevent surcharging during a 1 in 100 year event.

3. Inlet Controls

Inlet controls are treatment devices which are designed to remove sediments, oil and other pollutants in runoff before they enter a storm sewer system.

a. Catchbasins

In areas of new development, pervious catchbasins are recognized as a potential stormwater management option in areas suitable for this management practice.

All catchbasins shall be designed and spaced along the street to ensure that the discharge rate does not exceed the design capacity of the storm sewer and thereby cause surcharging. Spacing of the basins will, however, be such to capture the gutter flow for all storms up to the 1 in 5 year storm event. In instances where catchbasins are not used as inlet controls, the maximum allowable spacing shall be 90 m.

All other considerations for catchbasin design standards shall be derived from the Municipality's Development Standards Manual.

b. Alternative Inlets

Inlet control such as oil/grit separators are acceptable alternatives for restricting flows and improving runoff quality into a stormwater conveyance system. All such designs, however, must be supported with data illustrating their potential for stormwater quality improvement based on design criteria and meet with approval from the Municipality's Engineer.

4. System Controls

System controls are used primarily to treat stormwater runoff from several properties, as opposed to source controls that are utilized primarily for a single building and lot.

a. Storm Sewers and Ditch Systems

The Municipality supports implementation of alternative stormwater conveyance system designs such as infiltration trenches, pervious pipe systems, grassed swales and ditches. In the absence of a master drainage plan, the design storm frequency to be adopted for the planning and design of minor storm drainage facilities shall be 1 in 5 years for all sewers. The general design of the sewers shall be to current Municipal standards using runoff coefficients that are appropriate for the land use zoning and ignoring the effects of private detention. A composite runoff coefficient based on the actual site characteristics will be permitted.

All other considerations for storm sewer design standards shall be derived form the Municipality's Development Standards Manual.

5. Outlet Controls

All outlet controls will be designed to retain a 1 in 2 year storm and detain a 1 in 100 year storm and will be designed within a watershed context to ensure that all retrofit possibilities are considered. Proponents must demonstrate that all retrofit possibilities have been considered and integrated into the planning exercise.

Standards for these outlet controls will be supported by the Municipality's Development Standards Manual.

6. Alternative Stormwater Management Designs

Stormwater management proposals for new developments need not be constrained to the aforementioned management options. Alternative stormwater management designs will be accepted as long as the proponent:

- can provide established proof that the proposed design is capable of treating stormwater to a level equal to or greater than traditional stormwater management practices; or
- is willing to test the design in place with provisions for retrofitting the system should the design prove unsuitable.

Protocol for Implementation of Infrastructure Improvement Projects

The Severn Sound Urban Stormwater Management Strategy (1998) recommended that all proposed road/sewer improvement projects and new development proposals be reviewed with respect to opportunities, technical feasibility and costs of implementing stormwater management measures as part of the proposed project. The purpose is to identify available opportunities to control the amount of contaminants carried by storm conveyance systems to outlets on Severn Sound and Little Lake.

This protocol sets out a procedure for systematic review of each project with regards to stormwater control opportunities in retrofit and new development scenarios. The review process results in a decision as to whether various types of stormwater control and treatment can and should be implemented in the proposed project. Although the Severn Sound Urban Stormwater Management Strategy has identified areas suitable for retrofit stormwater improvements, this process will help refine and support those projects.

Figure 2 illustrates the decision-making process that would be followed on each project during the design and cost-estimation process. This process consists of a sequence of questions that lead to a decision as to whether conveyance controls for stormwater pollution should be included as part of the project.

Question 1:
DOES THE PROJECT INCLUDE THE STORM DRAINAGE SYSTEM?

Will the proposed roadway or infrastructure project include any modification, redesign or rearrangement of the storm drainage system. If the answer to this is YES, there may be an opportunity to retrofit the system to provide stormwater quality control.

Question 2:
IS THE PROJECT IDENTIFIED IN THE SEVERN SOUND REMEDIAL ACTION PLAN URBAN STORMWATER MANAGEMENT STRATEGY FINAL REPORT AS BEING A FEASIBLE STORMWATER CONVEYANCE CONTROL OPTION?

If the project has already been identified as suitable for conveyance control retrofit, implementation can take place without further analysis.

Question 3:
IS THE PROJECT LOCATED WITHIN A DRAINAGE CATCHMENT IDENTIFIED AS A PRIORITY WITH RESPECT TO WATER QUALITY CONCERNS?

The Severn Sound Remedial Action Plan Urban Stormwater Management Strategy has determined that all outfalls discharging into Severn Sound contribute to loadings of phosphorus exceeding the Ontario Provincial Water Quality Objectives for open water. Therefore, stormwater management controls are preferred in all catchments in which new development or retrofit activities are taking place (in addition to those already identified within the final report).

Question 4:
DOES THE MUNICIPALITY HAVE A LONG-TERM STORM DRAINAGE IMPROVEMENT PLAN AND CAPITAL BUDGET FOR THE CATCHMENT THAT WILL RESULT IN TREATMENT OF THE PROJECT AREA AT A LOCATION OR FACILITY OUTSIDE THE PROJECT LIMITS?

It is possible that the municipality will consider an overall drainage improvement project not identified in the Severn Sound Remedial Action Plan Urban Stormwater Urban Stormwater Management Strategy Final Report for a catchment or a portion thereof. If this is the case, there may be an opportunity to design the improved system to provide for enhanced stormwater treatment for the catchment.

Question 5:
CAN STORMWATER TREATMENT BE PROVIDED AT EXISTING OR PROPOSED END-OF-PIPE FACILITIES THAT HANDLE THE ENTIRE CATCHMENT?

Is there an existing end-of-pipe treatment facility at the catchment outfall(s) or is there one proposed for the outfall(s)? If the answer is YES, proponents of new developments may be able to contribute to the construction of this facility or expand it to accommodate increased runoff.

Question 6:
ARE STORMWATER QUALITY CONVEYANCE CONTROLS TECHNICALLY FEASIBLE WITHIN THE PROJECT?

In the case of new development, if the answers to Questions 2 and 5 are NO, then stormwater conveyance controls (if considered) must be handled within the project area.

Question 7:
IS THE COST OF THE BEST OPTION ACCEPTABLE?

The best control option for the increased runoff associated with new development should be based on cost, ease of maintenance, effectiveness and general practicality.

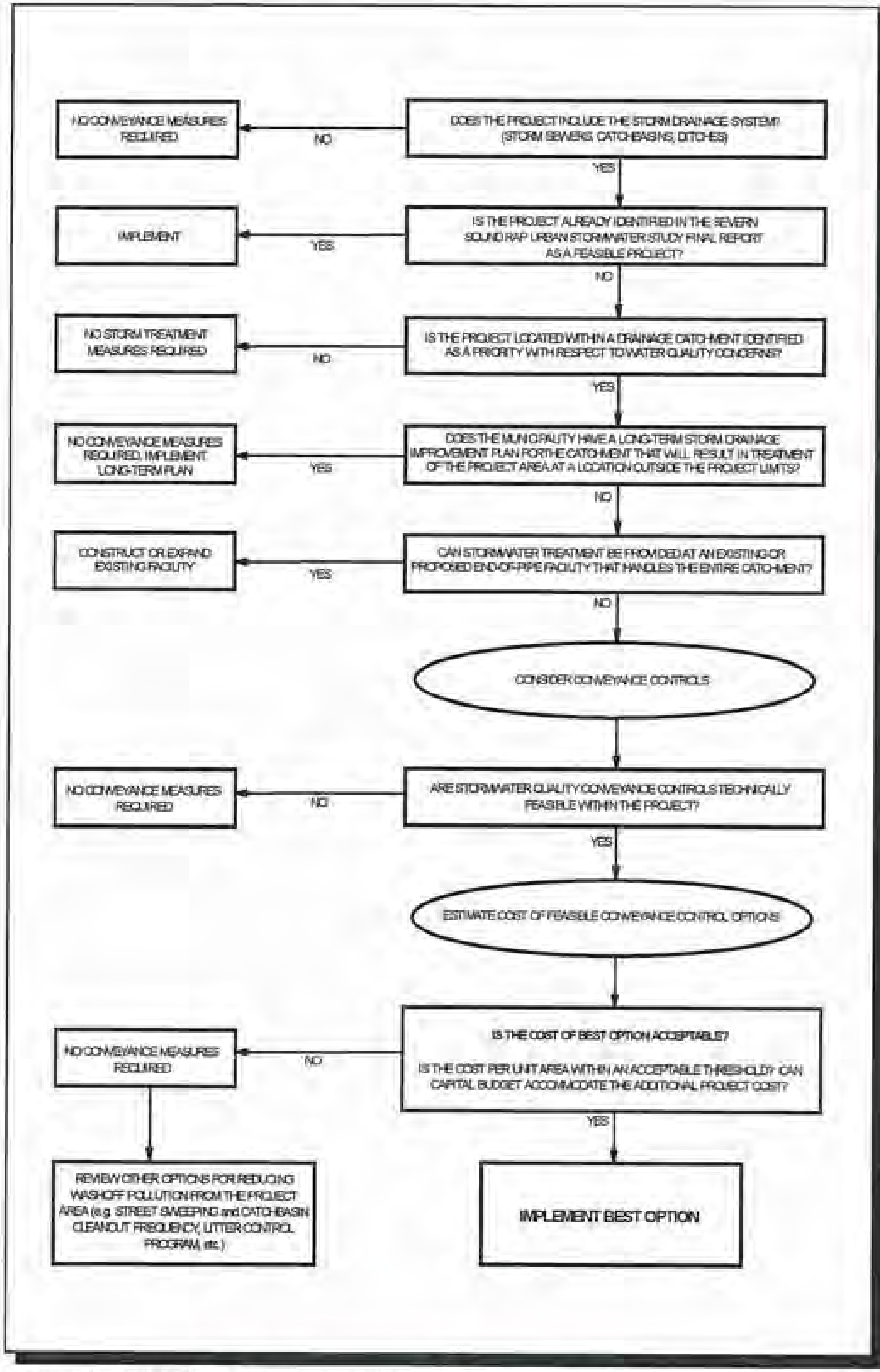


Figure 2 Protocol for Implementation of Infrastructure Improvement Projects