Clean Up Rural Beaches (CURB) Plan for the Nottawasaga River Watershed

Chris Jones

Byron Wesson

March 23, 1995

Produced by the Nottawasaga Valley Conservation Authority

For the Ontario Ministry of the Environment and Energy

EXECUTIVE SUMMARY

This document is the CURB Plan for the Nottawasaga Valley Conservation Authority and is the result of the NVCA Rural Beaches Program. The purpose of this report is to assess the pollution content of watercourses throughout the NVCA watershed and to suggest measures to reduce the potential health risks associated with fecal contamination of swimming water.

The beaches considered include Wasaga Beach, which is the world's largest fresh water beach and is located along the shoreline of Georgian Bay. Several reservoir beaches are also discussed. The reservoir beaches include those at Earl Rowe Reservoir, Tottenham Reservoir, Utopia Reservoir and New Lowell Reservoir.

The CURB model for the Boyne River sub-watershed showed that most of the bacteria arriving at Earl Rowe Reservoir were due to agricultural impacts. Table 1 gives a breakdown of the sources impacting on the reservoir and the costs associated with their clean up.

Table 1: Sources of *E. coli* in the Boyne River sub-watershed and the associated costs of remediation.

Source Type	# Occurring	% of *E. coli* load	Cost of Remediation ($)
Livestock Access	16	84.2	118,400
Urban Non-point	1	9.4	N/A
Septic Systems	100	2.7	500,000
Barnyard/Manure Storage Run-off	25	2.3	1,196,000
Manure Spreading	84	0.5	N/A
Milkhouse Wastewater	6	0.5	30,000
Geese	300 geese	0.5	N/A
Sewage Plants	1	0	N/A
Total Cost of Remediation:			**$1,844,400**

Based on CURB modelling, if all CURB Eligible capitol projects were completed (and corresponding "best management practises" utilized) in the Boyne River sub-watershed, *E. coli* counts would decrease by as much as 90%, from 222/100 ml to 22/100 ml.

A breakdown of the bacterial sources in the Beeton Creek, Tottenham Reservoir sub-watershed and a summary of the costs associated with their remediation is given in table 2.

Table 2: Sources of *E. coli* in the Beeton Creek sub-watershed and the associated costs of remediation.

Source Type	# Occurring	% of E. coil load	Cost of Remediation ($)
Barnyard/Manure Storage Run-off	1	64	26,000
Livestock Access	1	21.9	7,400
Septic Systems	10	0.8	50,000
Manure Spreading	1	16.4	N/A
Gulls	70 Gulls	9.4	N/A
Geese	150 Geese	0.8	N/A
Beavers	40 beavers	0	N/A
Total Cost of Remediation:			**$83,400**

If all CURB eligible projects were completed in the Beeton Creek sub-watershed, CURB modelling suggests that *E. coli* counts would decrease from 128 to 13/100 ml, a 90% reduction. Rural sources of *E. coli* acting on Utopia Reservoir, in the Bear Creek sub-watershed along with the associated costs of remediation are shown in table 3.

Table 3: Sources of *E. coli* in the Bear Creek sub-watershed and the associated costs of remediation.

Source Type	# Occurring	% of E. coli load	Cost of Remediation ($)
Livestock Access	9	78.7	29,600
Septic Systems	30	9.2	45,000
Barnyard/Manure Storage Run-off	8	7.8	104,000
Milkhouse Wastewater	2	1.4	10,000
Urban Non-point	1	1.4	N/A
Manure Spreading	24	0.7	N/A
Total Cost of Remediation:			**$188,600**

If all CURB eligible projects in the Bear Creek basin were completed, a reduction in the mean E coli count from 141 to 2/100 ml would result, according to CURB Modelling. This is a 99% reduction.

A summary of the sources and costs associated with the clean-up of the Coates Creek sub-watershed and New Lowell Reservoir is given in table 4.

Table 4: Sources of E. coli in the Coates Creek sub-watershed and the associated costs of remediation.

Source Type	# Occurring	% of E. coli load	Cost of Remediation ($)
Livestock Access	6	60.4	44,400
Septic Systems	20	17.2	100,000
Gulls	30	12.7	N/A
Barnyard/Manure Storage Run-off	6	4.5	286,000
Milkhouse Wastewater	6	3.7	30,000
Geese	25	0.7	N/A
Manure Spreading	21	0.7	N/A
Beavers	50 Beavers	0	N. A
Total Cost of Remediation:			**$460,400**

If all of the CURB eligible sources in the Coates Creek sub-watershed were remediated, CURB modelling suggests that an 87% reduction in *E. coli* loadings to New Lowell reservoir would result. E. coli counts would be reduced from 134/100m1 to 18/100ml.

Sources of E. coli in the Nottawasaga River basin, that impact on water quality at Wasaga Beach, as well as the estimated costs of cleaning up these sources are given in Table 5.

Table 5: Sources of E. coli in the Nottawasaga River watershed and the associated costs of remediation.

Source Type	# Occurring	% of E. coli load	Cost of Remediation ($)
Livestock Access	60	84.4	1,613,200
Urban Non-point	11	9.0	N/A.
Septic Systems	328	4.0	8,200,000
Barnyard/Manure Storage Run-off	146	2.4	11,154,000
Milkhouse Wastewater	13	0.2	465,000
Manure Spreading	354	0.06	N/A
Sewage Plants	2	0.0006	N/A
Total Cost of Remediation:			$21,432,200

If all CURB eligible projects were completed in the Nottawasaga River watershed, CURB modelling suggests an E. coli reduction from 106 to 10/100 ml in the water reaching Nottawasaga Bay vis the mouth of the Nottawasaga River, a 91% reduction.

The total cost of remediating all CURB eligible pollution sources affecting Wasaga Beach and the four reservoir beaches is $24,411,000. Up to $11,656,000 of this is eligible for funding under the CURB program in the form of grants to landowners.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Elevated bacterial counts in the water at rural swimming beaches signify a potential health risk to swimmers. Beach postings that follow the detection of these high bacterial concentrations have meant substantial losses for the Ontario tourism industry and lost recreational opportunities for all Ontario residents. For these reasons, the reduction of fecal inputs into watercourses has been a serious concern of the Ontario Ministry of the Environment and Energy (MOEE) since the early 1980's. In 1985, the MOEE initiated the Provincial Rural Beaches Management Strategy to deal with the problem of closed beaches across the province. Under this strategy, the Rural Beaches Program was set into motion.

The Rural Beaches Program provides financial support to Conservation Authorities who express an interest in studying the impacts of rural pollution sources on public swimming beaches within their watershed jurisdictions. At the completion of the Rural Beaches Study, Conservation Authorities complete a Clean Up Rural Beaches (CURB) Plan. The CURB Plan document prioritizes rural pollution sources which impact upon watershed beaches. It also discusses the costs associated with various suggested remedial measures. After completion of the CURB Plan, Conservation Authorities proceed into an implementation stage called CURB wherein watershed residents can apply for financial assistance after completing water quality improvement projects on their own properties. CURB eligible water quality improvement projects include:

- upgrades to private septic systems
- construction of new manure storages or upgrades to existing storages
- construction of facilities to treat milkhouse wastewater or store it for future field application
- installation of exclusion fencing to restrict livestock access to watercourses

The CURB program is a MOEE initiative that provides $57 million in landowner incentives over a ten year period from 1991 to 2001. This document is the CURB Plan for the Nottawasaga Valley Conservation Authority (NVCA).

The NVCA began a Rural Beaches Study under the MOEE Provincial Rural Beaches Management Strategy in 1993. The purpose and goals of the study were as follows:

1) To determine if beach closures were causing losses in revenues and recreational opportunities in the NVCA Watershed.
2) To identify the nature of (bacterial) pollution sources that were impacting upon swimming beaches in the NVCA Watershed.
3) To recommend remedial measures and predict the associated costs, based on the nature of bacterial sources affecting the beaches.

The primary focus of the NVCA Rural Beaches Study was Wasaga Beach, the world's largest freshwater beach which lies on the shore of Nottawasaga (Georgian) Bay surrounding the mouth of the Nottawasaga River. Since the dispersion of pollutants into Georgian Bay from the Nottawasaga River is subject to many factors, the beaches lying to the north-east of Wasaga Beach (New Wasaga Beach to Balm Beach) were also considered in this study.

The NVCA Rural Beaches Study also focused on four reservoir beaches located on tributaries of the Nottawasaga River:

Earl Rowe Reservoir, located on the Boyne River
Tottenham Reservoir, located on the Beeton Creek
Utopia Reservoir, located on Bear Creek
New Lowell Reservoir, located on Coates Creek

2.0 METHODOLOGY

The NVCA Rural Beaches Study was a two year study which involved the following:

- review of bacteriological data gathered during swimming seasons at the beaches of concern.
- review of existing water quality data available from the MOEE Provincial Water Quality Monitoring Network.
- water quality monitoring carried out by NVCA staff in watercourses leading to swimming beaches.
- identification of possible rural non-point pollution sources through landowner interviews.
  quantification of rural non-point pollution sources through mathematical modelling techniques.
- making recommendations regarding remedial measures to reduce the frequency of beach postings in the NVCA watershed.

The following sections outline the methodology used for each aspect of the NVCA Rural Beaches Study. For greater detail refer to Appendix C.

2.1 Landowner Interviews

To complement water quality monitoring data, landowner interviews were conducted throughout the watershed. The purpose of the landowner survey program was to identify land use patterns across the watershed, to assess the pollution potential of individual properties located close to watercourses and to develop the working relationship with landowners that is vital to CURB implementation. Approximately 800 property owners were interviewed during the 1993-1994 interview process. Surveying activities focused on areas of direct influence to beaches and areas where CURB uptake was expected to be high. These included:

- the Lower Nottawasaga River area including the Lamont/McIntyre Creek, Willow/Matheson Creek, Marl Creek and Sturgeon Creek sub-watersheds as well as the Batteaux River watershed.
- the sub-watersheds containing reservoir beaches, including the Boyne River (Earl Rowe Reservoir), Beeton Creek (Tottenham Reservoir), Bear Creek (Utopia Reservoir) and Coates Creek (New Lowell Reservoir) basins.
- The Innisfil/Beeton Creek system which indirectly impacts upon Wasaga Beach and is known to carry a high pollution load relative to its discharge (according to historic MOEE data and 1993 NVCA monitoring results).

During the landowner interview process, landowners were visited at their residences by NVCA staff who provided information about the Rural Beaches and CURB programs and asked questions to assess the pollution potential of each property. A copy of the landowner questionnaire is provided in Appendix E. Properties chosen for interviews included private residences, farms and several "special use" properties such as trailer parks. Individual locations for interviews were chosen primarily according to their proximity to watercourses. Landowners who called in to the NVCA office wishing information on the CURB Program or expressing interest in other ways, were also interviewed.

2.2 Water Sampling Protocol and Site Selection

Sampling was conducted throughout the swimming season for a minimum of 90 days from June 15 until September 15. In the first year of the NVCA Rural Beaches Program (1993), monitoring stations were spread out over the watershed in a very broadly based manner (see Fig.1). These stations were intended to provide general baseline data for most of the tributaries of the Nottawasaga River including those in the Boyne River, Coates Creek, Beeton Creek and Bear Creek sub-watersheds which contain the reservoir beaches.

Discharge data was collected in conjunction with water quality data so that loading rates of water quality parameters from monitoring stations across the watershed could be compared on a level playing field.

Once baseline water quality conditions in the watershed had been established and reported (Jones and Wesson 1994) after the 1993 field season, it was necessary to focus sampling in on the watercourses directly impacting on swimming beaches. The 1994 monitoring stations (see Figures 1, 2 and 3) were divided between the reservoir beaches and Wasaga Beach. Table 1 shows the monitoring allocations for the reservoir beaches in 1994.

Table 1: 1994 allocation of monitoring stations for the reservoir beaches.

Sub-watershed	Beach	# of stations
Coates Creek	New Lowell Reservoir	3
Boyne River	Earl Rowe Reservoir	7
Beeton Creek	Tottenham Reservoir	3
Bear Creek	Utopia Reservoir	3

Monitoring at the Wasaga Beach stations was carried out in the same manner as at the stations above the reservoir beaches. These weekly stations are shown in figure 1 (see also Appendix C). In addition to weekly stations, several watercourses in and around the Town of Wasaga Beach were also sampled (after rain events) to assess the bacterial loading of storm water run-off in this area.

2.3 Quantification of Suspected Sources (Mathematical Modelling)

Baseline data from rural beaches monitoring in 1993 and 1994 provided information about the water quality in watercourses impacting on all of the beaches in this study. Similarly, land use

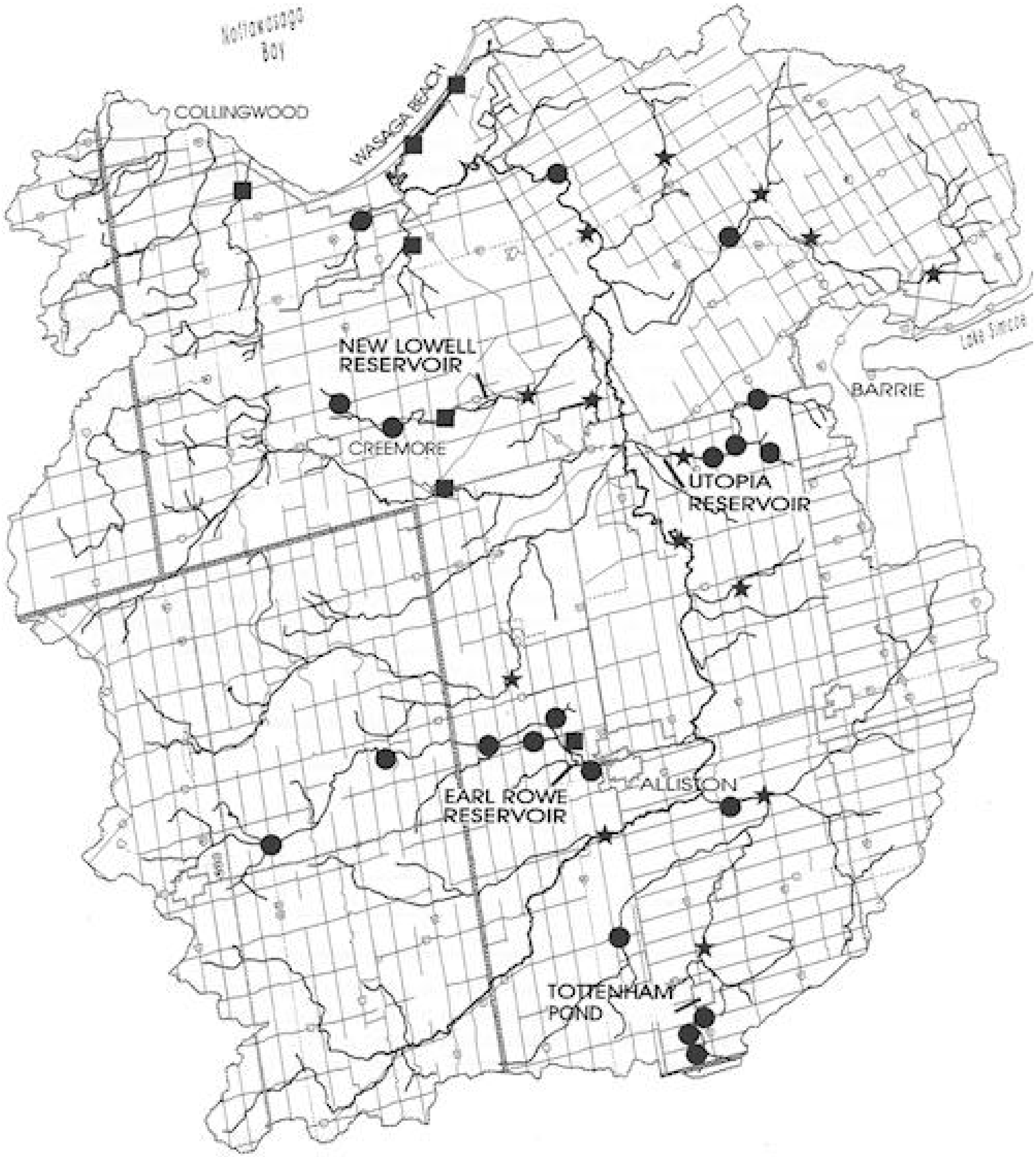

Figure 1: Location of the Nottawasaga Watershed and beaches of concern. Monitoring sites used during the rural beaches study are also shown. 1993 sites are indicated by a ★symbol and the 1994 sites by a ● symbol. Sites used both years are marked with a ■. Map not to scale.

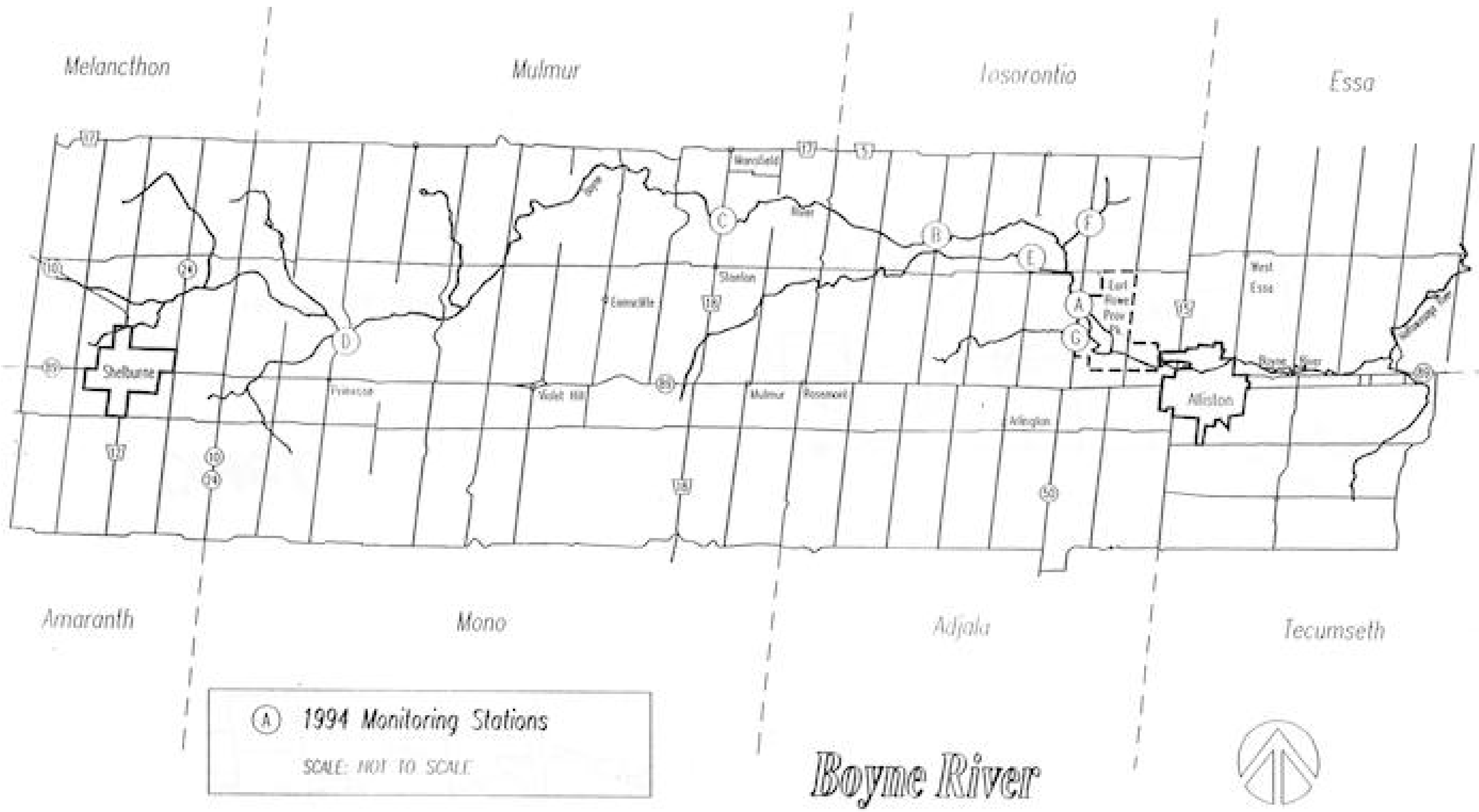

Figure 2: Boyne River sub—watershed showing Earl Rowe Reservoir and the 1994 monitoring stations.

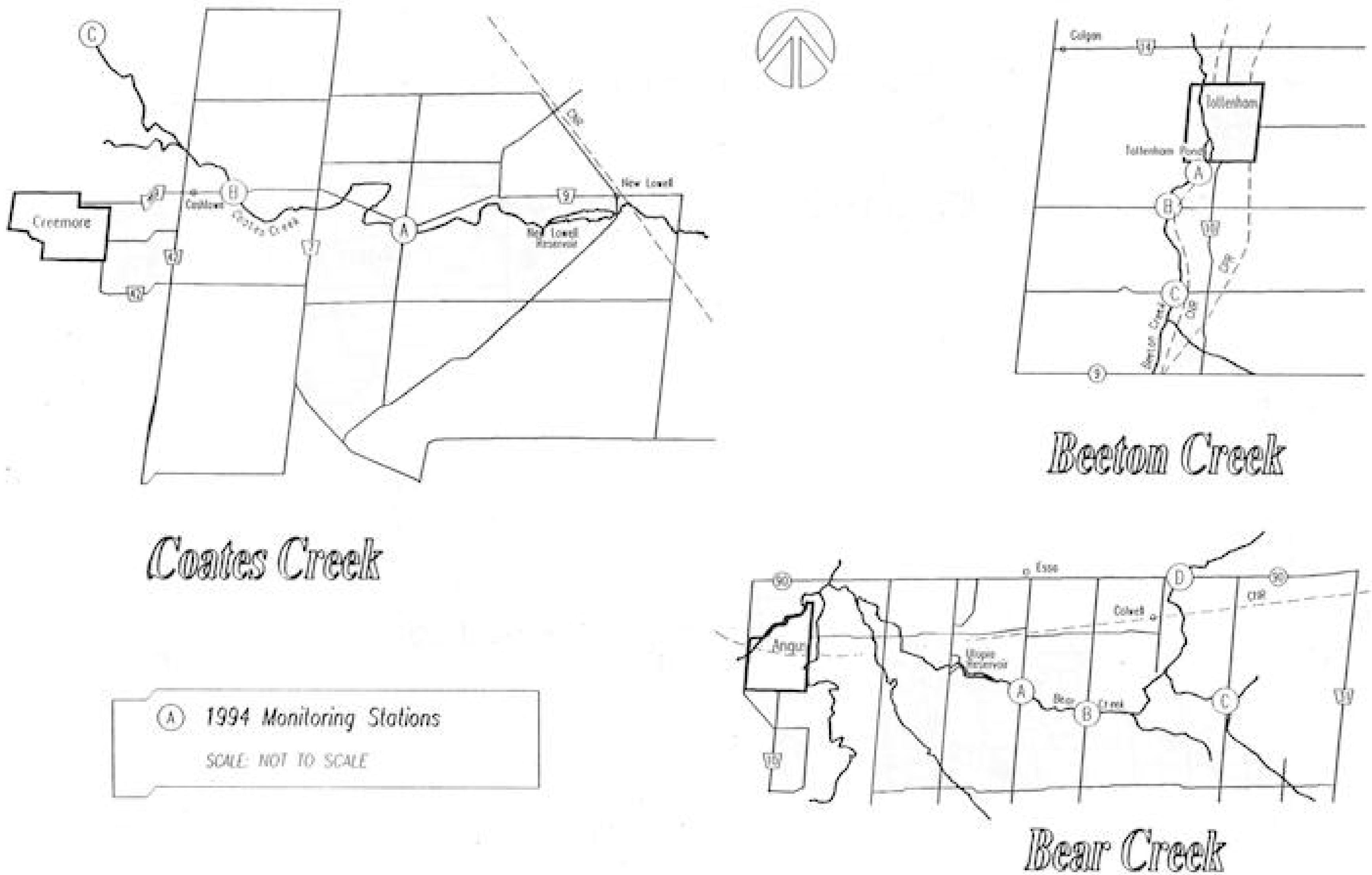

Figure 3: Coates, Beeton and Bear Creek sub-watersheds showing the 1994 monitoring stations.

information for most of the watershed was obtained from OMAF (1992), County of Simcoe (1993) and from landowner interviews that were conducted throughout the watershed in 1993 and 1994. In order to investigate the sources of the pollution that was detected, it was necessary to integrate water quality data and land use information. In the case of the reservoir beaches, this was done by employing standard CURB models (Mar 1991 and Brunatti 1993) that were developed from earlier (MOEE funded) research in other watershed jurisdictions. CURB standard algorithms were used to quantify (model) the loadings of bacteria to each of the reservoirs from the following sources:

- livestock and wildlife access to the beach and/or watercourse
- failing septic systems
- contaminated run-off from manure stacks and barn-yards
- contaminated run-off from farm fields spread with manure
- surface and subsurface discharge of milkhouse wastewater
- storm water run-off from urban areas
- effluent discharges from sewage treatment plants

Refer to Appendices B, C and D for further details concerning the CURB model.

2.4 Recommendations

Recommendations for each beach were made based on the results of water quality monitoring and mathematical modelling. The remediation of all CURB eligible pollution sources was recommended even though, according to modelling, it would not be necessary to remediate all sources to ensure satisfactory Water quality (i.e. $\leq$100 *E. coli*/100 ml under normal circumstances) at each beach. This recommendation was made since participation in remedial projects under the CURB Program is voluntary and 100% uptake by landowners who have pollution concerns on their properties is unlikely. The costs of remedial projects in each watershed was estimated based on "average" costs of materials in Simcoe County (See Table 2) and the number of suspected sources occurring. See Appendix C for details.

Table 2: Assumptions used when estimating remedial project costs in the NVCA Watershed.

Project Type	Average Project Cost ($)	Assumptions and References
livestock access restriction	7,400	Assume 300 m of 5 strand high tensile fence, watering device and crossing per project (Pers. Comm. Floyd Brubacher 1994)
manure storages	26,000	Assume uncovered solid manure storage with earthen run-off containment, or equivalent (Pers. Comm. Marilyn Bidgood 1994)
septic systems	5,000	Assume septic tank and tile bed replacement (Pers. Comm. Julie Eisses 1994)
milkhouse wastewater facilities	5,000	Assume new tank and treatment trench system or upgrade to existing manure storage (Pers. Comm. Marilyn Bidgood 1994).

In recommending the completion of CURB eligible projects as remedial measures, it was assumed that landowners would adopt appropriate management practises to accompany any capitol projects. This is an important assumption since any structure will only reduce contamination to watercourses if it is used appropriately and within the context of the management scheme of the landowner.

For some of the beaches, in addition to the regular CURB eligible projects, site specific recommendations, like those dealing with beach management, were made. The assumptions associated with these recommendations are discussed along with the specific recommendations in later sections.

3.0 RESULTS

3.1 Reservoir Beaches

3.1.1 Boyne River/Earl Rowe Reservoir

3.1.1.1. 1994 Water Sampling Results

The 1994 seasonal mean *E. coli* loadings in the Boyne River sub-watershed are given in Table 3. Refer to figure 2 for monitoring station locations. The complete data set for the Boyne River is given in Appendix A.

Table 3: 1994 seasonal mean *E. coli* loadings in the Boyne River. Loadings are separated into rainfall event (Wet) and non-rainfall event (Dry) related categories.

	E. coli (#/s)	
Station	Dry	Wet
Boyne D	1075	1626
Boyne C	1413	2363
Boyne B	8131	5456
Boyne A	9640	14974
Boyne E	1248	2306
Boyne F	8	27
Boyne G	46	53

In general, *E. coli* loadings increased as one travelled downstream from the headwaters of the Boyne River. Loadings following rainfall events were higher than loadings under low flow conditions. Table 4 summarizes the changes in *E. coli* loadings that occurred between stations on the main channel of the Boyne River in 1994.

Table 4: Changes in *E. coli* loadings between stations on the Boyne River in 1994. Values represent differences in mean (non-rainfall related) loadings over the summer, Positive values indicate an increase in load at the downstream station while negative values indicate a reduced load. Only impacts to the main channel are considered.

Section of Watercourse	Δ *E. coli* (#/s)
Station D-C (13.3 km)	338
Δ load/km	25.4
Station C-B (5.6 km)	6718
Δ load/km	1200
Station B-A (3.4 km)	1509
Δ load/ km	444

The largest per km loading increases of *E. coli* occur in the region between stations C and B, an area of primarily agricultural land-use.

3.1.1.2 Historical Overview of Beach Water Quality

High levels of bacteria in Earl Rowe reservoir occur frequently throughout the summer each year. Bacterial counts in Earl Rowe Reservoir exceeded MOEE recreational guidelines (MOEE 1978) for most of June and August in both 1993 and 1994. There is a serious problem with fecal contamination in Earl Rowe Reservoir. Figure 4 shows 1993 and 1994 monitoring data from the beaches at Earl Rowe Provincial Park.

3.1.1.3 Quantification of Suspected Sources (modelling)

Table 5 shows the outcome of CURB modelling for the Boyne River and it's tributaries. Results are expressed in terms of the number of bacteria carried to the beach from each source over the swimming season. Refer to Appendices B and C for further modelling details.

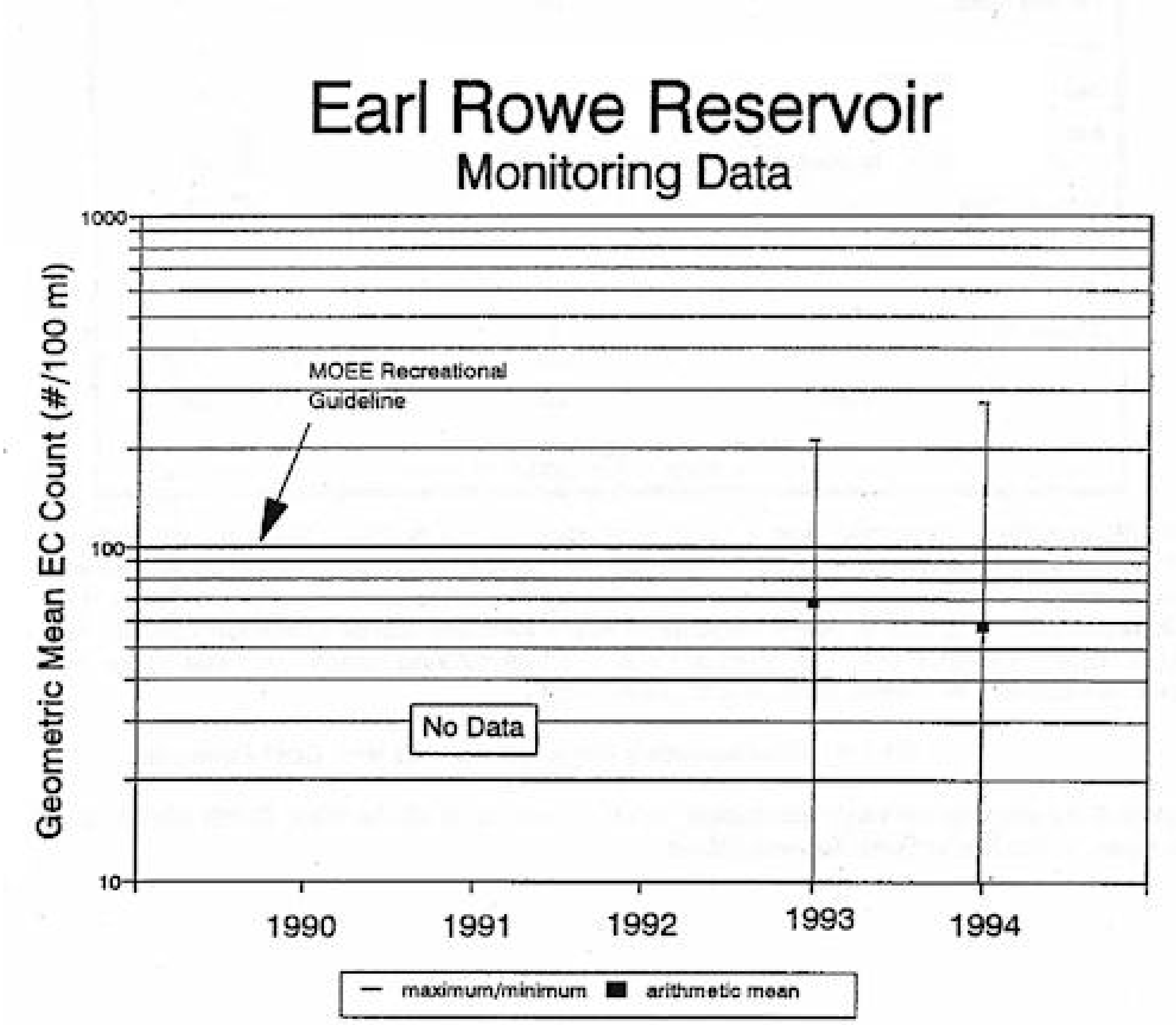

Figure 4: 1993 and 1994 beach water quality data from Earl Rowe Reservoir.

Table 5: Modelling results for suspected rural pollution sources in the Boyne River Sub-watershed. Theoretically, each source contributes a proportion of the seasonal mean *E. coli* count at Boyne River Station "A". Values shown represent these proportions.

Source	*E. coli* contribution to Boyne "A" (#/100ml)	% of total
Livestock Access	187	84.2
Urban non-point	21	9.4
Septic Systems	6	2.7
Barnyard/manure storage run-off	5	2.3
Milkhouse Wastewater	1	0.5
Geese	1	0.5
Manure Spreading	1	0.5
Sewage Plants	0	0
Total	222	100

* seasonal mean *E. coli* concentration at Boyne "A" was 210/100 ml

CURB modelling suggested that a large proportion of the bacterial loading to Earl Rowe Reservoir was coming from livestock access to watercourses. This finding was in agreement with monitoring data that showed high increases of *E. coli* loadings in the area of the Boyne River (between stations C and B) where the majority of the livestock access sites were located. This also helps to explain the high loadings at the Boyne F monitoring station since that station was also downstream of several livestock access locations.

3.1.1.4 Recommended Remedial Actions with Cost Estimates

Table 6 summarizes the costs associated with the clean up of all identified, CURB eligible, rural sources in the Boyne River Sub-watershed.

Table 6: Cost breakdown for the completion of all CURB eligible remedial projects in the Boyne River Sub-watershed. Projections were made using landowner interview and mathematical modelling information.

Project Type	Number Occurring	Cost per Project ($)	Total Cost ($)
Access Restriction	16	7,400	118,400
Manure Storage	46	26,000	1,196,000
Septic Systems	100	5,000	500,000
Milkhouse Wastewater	6	5,000	30,000
Total			**$ 1,844,400**

In the Boyne River basin, projects designed to restrict livestock access are the most cost effective of the CURB eligible remedial actions. Another recommended remedial measure involves raking the beach once a week with a tractor and harrow to expose bacteria to sunlight. Not including the initial capital costs associated with purchasing a tractor and harrow, the estimated cost for this activity is $1 780/season, based on:

* 4 hours of labour/wk.
* 13 wk. swimming season
* $15/hr. for labour
* $ 1,000.00 per season for tractor fuel and repairs

If all CURB eligible projects were completed in the Boyne River Sub-watershed, CURB modelling suggests that seasonal mean *E. coli* counts at Boyne River station A would decrease from 222 to 22/100 ml, a 90% reduction.

3.1.2 Beeton Creek/Tottenham Reservoir

3.1.2.1 1994 Water Sampling Results

1994 seasonal mean *E. coli* loadings measured at the Beeton Creek monitoring stations are summarized in Table 7. Refer to Appendix A for the complete set of 1994 monitoring data for the Beeton Creek. Monitoring station locations are shown in Figure 3.

Table 7: 1994 seasonal mean *E. coli* loadings in Beeton Creek. Loadings are separated into rainfall event (Wet) and non-rainfall event (Dry) related categories**.**

	E. coli (#/s)	
Station	Dry	Wet
Beeton C	486	321
Beeton B	1075	1272
Beeton A	1213	1136

The differences between *E. coli* loadings during wet and dry periods did not exhibit any consistent trend in the Beeton Creek.

E. coli loadings at stations B and A were much higher than at Station C. In fact, Station A was the only location on the Beeton Creek where seasonal mean *concentrations* of bacteria were greater than the MOEE recreational guideline (MOEE 1978). Table 8 shows the changes in mean loadings as a function of the distance between stations.

Table 8: Changes in mean, non-rainfall related *E. coli* loadings between stations on the Beeton Creek in summer 1994. Positive values indicate an increase in load at the downstream station while negative values indicate a reduced load.

Section of watercourse	Δ E. coil (#/s)
Station C-B (1.5 km)	589
Δ load/km	393
Statio B-A (0.8 km)	138
Δ load/km	184

Changes in the loadings of bacterial indicators are higher between Stations C and B, than between Stations B and A.

3.1.2.2 Historical Overview of Beach Water Quality

High bacterial counts occur in Tottenham Reservoir several times each summer. In fact during the 1994 swimming season, bacteria levels at the beach never dropped below 100/100m1 during the month of August. Tottenham Reservoir is posted *infrequently* due to high bacterial counts. Figure 5 summarizes the beach water quality data for the years 1992-1994.

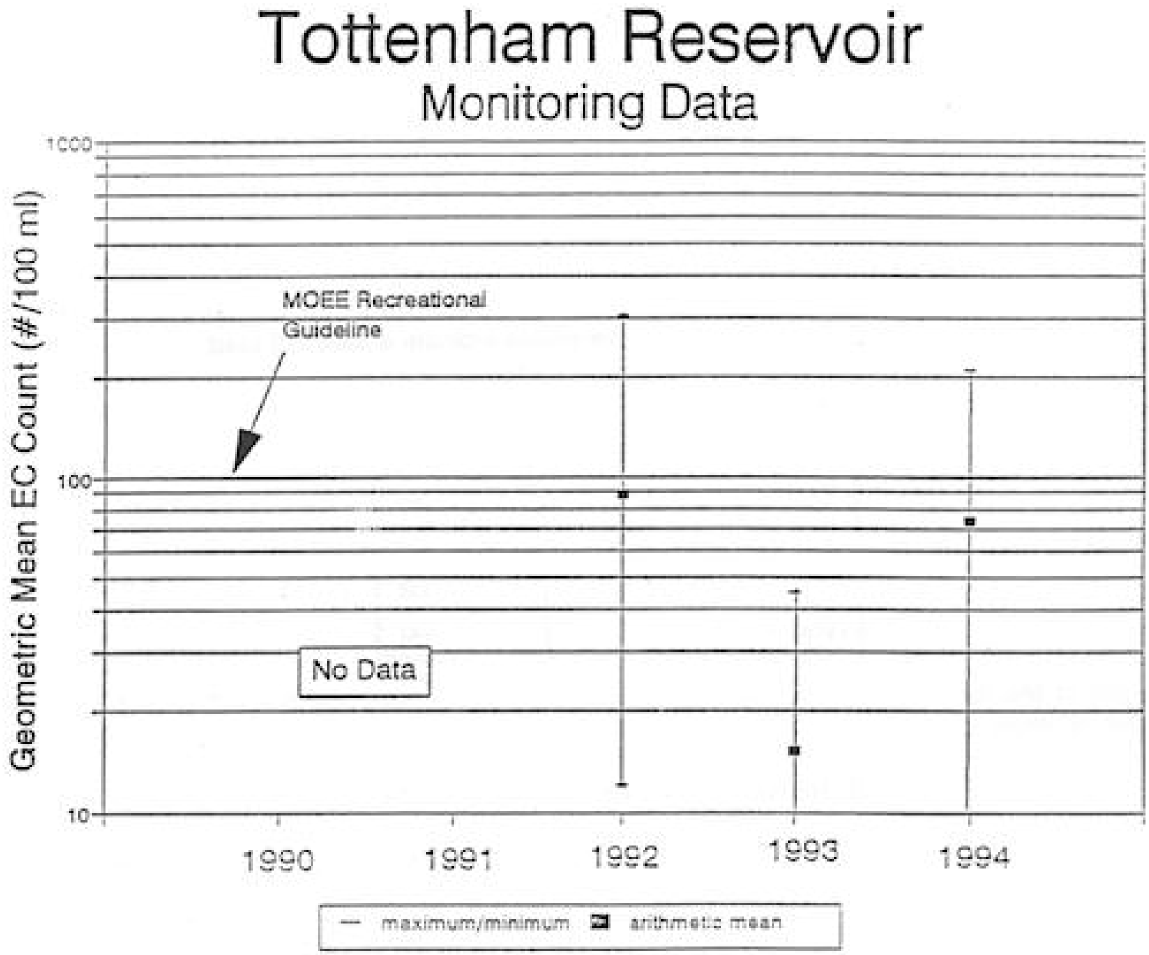

Figure 5: 1993 and 1994 beach water quality data from Tottenham Reservoir.

3.1.2.3 Quantification of Suspected Sources (Modelling)

Modelling results for sources in the upper Beeton Creek sub-watershed are given in table 9.

Table 9: Modelling results for suspected pollution sources in the Beeton Creek Sub-watershed. Theoretically, each source contributes a proportion of the seasonal mean *E. coli* count at Boyne River Station A. Values shown are these proportions.

Source	*E. coli* contribution to Beeton Creek "A" (#/100ml)	% of total
Barnyard/Manure - Stack Run-off	64	50.0
Livestock Access	28	21.9
Manure Spreading	21	16.4
Gulls	12	9.4
Septic Systems	1	0.8
Geese	1	0.8
Beavers	0	0.0
Resultant Count	128	100

The seasonal mean *E. coli* concentration at Beeton Creek A was 123/100 ml.

The CURB Models suggested that the majority of the bacteria carried past Beeton Creek station A arise from agricultural sources, namely barnyard/manure stack run-off, livestock access and manure spreading. wildlife at the beach (gulls) also contributed a significant number of bacteria.

3.1.2.4 Recommended Remedial Actions with Cost Estimates

In the Beeton Creek Basin, the greatest reduction of bacteria would be achieved by preventing barnyard run-off on a nearby farm; however, the most cost effective of the CURB eligible initiatives would be the restriction of livestock access. Due to the large population of geese and gulls at the reservoir, remedial projects designed to reduce wildlife access to the beach or at least interfere with the transport of their feces to the water, would also be justified.

Measures that may alleviate the wildlife problem include raking the beach and planting a goose deterring hedge around the beach. Leaving grass somewhat longer around the beach area may also help to discourage geese. Signs asking beach users to dispose of food waste properly and not to feed geese and gulls would help to reduce the attractiveness of the beach area to wildlife. Estimates of the costs associated with the above non-CURB eligible projects are as follows:

Harrow Beach	$1,390 per season (2 hr labour/wk, 13 wk season, $15/hr labour + $1000/season for tractor)
Plant goose hedge	$1,000 (200 cedar trees, $5/tree)
Educational Signs	$500

Table 10 summarizes the costs associated with the completion of CURB eligible projects in the Beeton Creek Sub-watershed.

Table 10: Cost breakdown for the completion of all CURB eligible remedial projects in the Beeton Creek Sub-watershed. Projections are based on landowner survey and CURB modelling information.

Project Type	Number Occurring	Cost per Project ($)	Total Cost ($)
Access Restriction	1	7,400	7,400
Manure Storage	1	26,000	26,000
Septic Systems	10	5,000	50,000
Milkhouse Wastewater	0	5,000	0
Total:			**$ 83,400**

If all CURB eligible projects were completed in the Beeton Creek sub-watershed, modelling suggests that *E. coli* counts at Beeton Creek Station A would decrease from 128 to 13/100 ml, a 90% reduction.

3.1.3 Bear Creek/Utopia Reservoir

3.1.3.1 1994 Water Sampling Results

The 1994 bacteriological sampling data for Bear Creek is given in table 11. Refer to Appendix A for the complete Bear Creek monitoring data set. Monitoring station locations are shown in Figure 3.

Table 11: Mean 1994 *E. coli* loadings in Bear Creek. Loadings are separated into rainfall event (Wet) and non-rainfall event (Dry) related categories. Since Bear Creek is split into two distinct channels above Station B, the cumulative effect of both channels was entered as Bear (D+C).

Station	*E. coli* (#/s) Dry	Wet
Bear D	780	831
Bear C	2898	3795
Bear (D+C)	3678	4626
Bear B	499	2836
Bear A	1258	5310

The loadings observed on rain event related dates in Bear Creek were higher than those associated with dry weather. This would suggest that event related sources are of importance to Bear Creek. Also, loadings of bacteria at the upstream stations (D and C) were higher than those nearer the reservoir. Table 12 shows the changes in *E. coli* loadings between stations on Bear Creek.

Table 12: Changes in mean, non-rainfall related *E. coli* loadings between monitoring stations on Bear Creek. Positive values indicate an increased load at the downstream station while negative values indicate a reduced load.

Section of Watercourse	Δ *E. coli* (#/s)
Station (D+C)-B (2.0 km)	-3179
Δ load/km	-1590
Station B-A (1.6 km)	759
Δ load/km	474

Very high bacterial loadings were observed at Stations D and C. These stations were located on 2 separate channels of Bear Creek, each of which drains areas of agricultural land use. A reduction in agricultural land use between Stations D and C and Station A, may account for the reduced *E. coli* loadings between these stations, due to die-off of bacteria. There are small increases in bacterial loads downstream of station B but these are not substantial compared to the magnitude of loading already present at stations C and D.

3.1.3.2 Historical Overview of Beach Water Quality

The Utopia Reservoir has been closed to swimmers for the last few seasons due to water quality concerns; therefore, no recent water quality data is available. Further information regarding the history of water quality problems at Utopia Reservoir can be found in the NVCA Year 1 Rural Beaches Study Report (Jones and Wesson 1994).

3.1.3.3. Quantification of Suspected Sources (Modelling)

Modelling results for Bear Creek are summarized in Table 13. Refer to Appendix B for details on the calibration and execution of the modelling algorithms.

Table 13: Modelling results for suspected rural pollution sources in the Bear Creek Sub-watershed. Theoretically, each source contributes a proportion of the seasonal mean *E. coli* count at Bear Creek Station A. Values shown represent these proportions.

Source	*E. coli* contribution to Boyne "A" (#/100ml)	% of total
Livestock Access	111	78.7
Septic Systems	13	9.2
Barnyard/Manure Stack Run-off	11	7.8
Urban Non-point	2	1.4
Surface discharge of milkhouse waste	2	1.4
Manure Spreading	1	0.7
Total	141	100

Seasonal mean *E. coli* concentration at Bear A was 105/100 ml.

Modelling suggests that agricultural impacts, particularly those from livestock access were contributing the greatest numbers of bacteria to Utopia Reservoir. This is in agreement with monitoring data that showed the highest loadings at Stations D and C which were located immediately downstream of areas where livestock access occurred. Faulty septic systems, possibly located near the City of Barrie and also downstream, between stations D and B, could also be contributing significant numbers of bacteria to Utopia Reservoir.

3.1.3.4 Recommended Remedial Actions with Cost Estimates

As in the other sub-watersheds discussed so far, livestock access restriction remains the most cost effective of the CURB eligible projects in the Bear Creek Basin. Table 14 describes the costs of cleaning up the CURB eligible *E. coli* sources affecting Utopia Reservoir.

Table 14: Cost breakdown for the completion of all CURB eligible remedial projects in the Bear Creek Sub-watershed. Projections are based on information from landowner interviews and mathematical modelling.

Project Type	Number Occurring	Cost per Project ($)	Total Cost ($)
Access Restriction	9	7,400	29,600
Manure Storage	14	26,000	104,000
Septic Systems	30	5,000	45,000
Milkhouse Washwater treatment	2	5,000	10,000
Total:			**$188,600**

CURB Modelling suggests that upon completion of all CURB eligible projects in the Bear Creek basin, seasonal mean *E. coli* counts would be reduced by 99%, from 141 to 2/100 ml.

3.1.4 Coates Creek / New Lowell Reservoir

3.1.4.1 1994 Water Sampling Results

The location of the Coates Creek monitoring stations are shown in fig. 3. Complete data for all stations is listed in Appendix A. Table 15 outlines the 1994 results for Coates Creek.

Table 15: 1994 mean, *E. coli* loadings in Coates Creek. Loadings were separated into non-rainfall (dry) and rainfall event (wet) related categories.

	E. coli (#/s)	
Station	Dry	Wet
Coates C	1047	409
Coates B	285	1811
Coates A	782	683

The highest loadings of *E. coli* occurred at Coates Creek C, in the headwater areas. This station was located immediately below a pasture field in which cattle had access to the watercourse. *E. coli* loads decreased slightly with distance downstream of station C. Table 16 gives a summary of the changes in mean loadings observed between stations on Coates Creek.

Table 16: Changes in mean, non-rainfall related *E. coli* loadings between stations on Coates Creek in 1994. Positive values indicate an increase in load at the downstream station while negative values indicate a reduced load.

Section of Watercourse	Δ E. coli (#/s)
Station C-B (4.5 km)	-762
Δ load/km	-169
Station B-A (5.0 km)	497
Δ load/km	99

There appears to be an overall decrease in *E. coli* loadings as one moves downstream from station C to B.

3.1.4.2 Historical Overview of Beach Water Quality

In most years, bacterial counts in New Lowell Reservoir reach unacceptable levels several times over the swimming season. Algal blooms also occur periodically, especially during hot, dry periods. Figure 6 summarizes the 1994 bacterial data from New Lowell Reservoir. Data collected prior to 1994 is not on record.

3.1.4.3 Quantification of Suspected Sources (Modelling)

Table 17 summarizes the modelling results for Coates Creek. Refer to Appendices B and C for information on the model parameters.

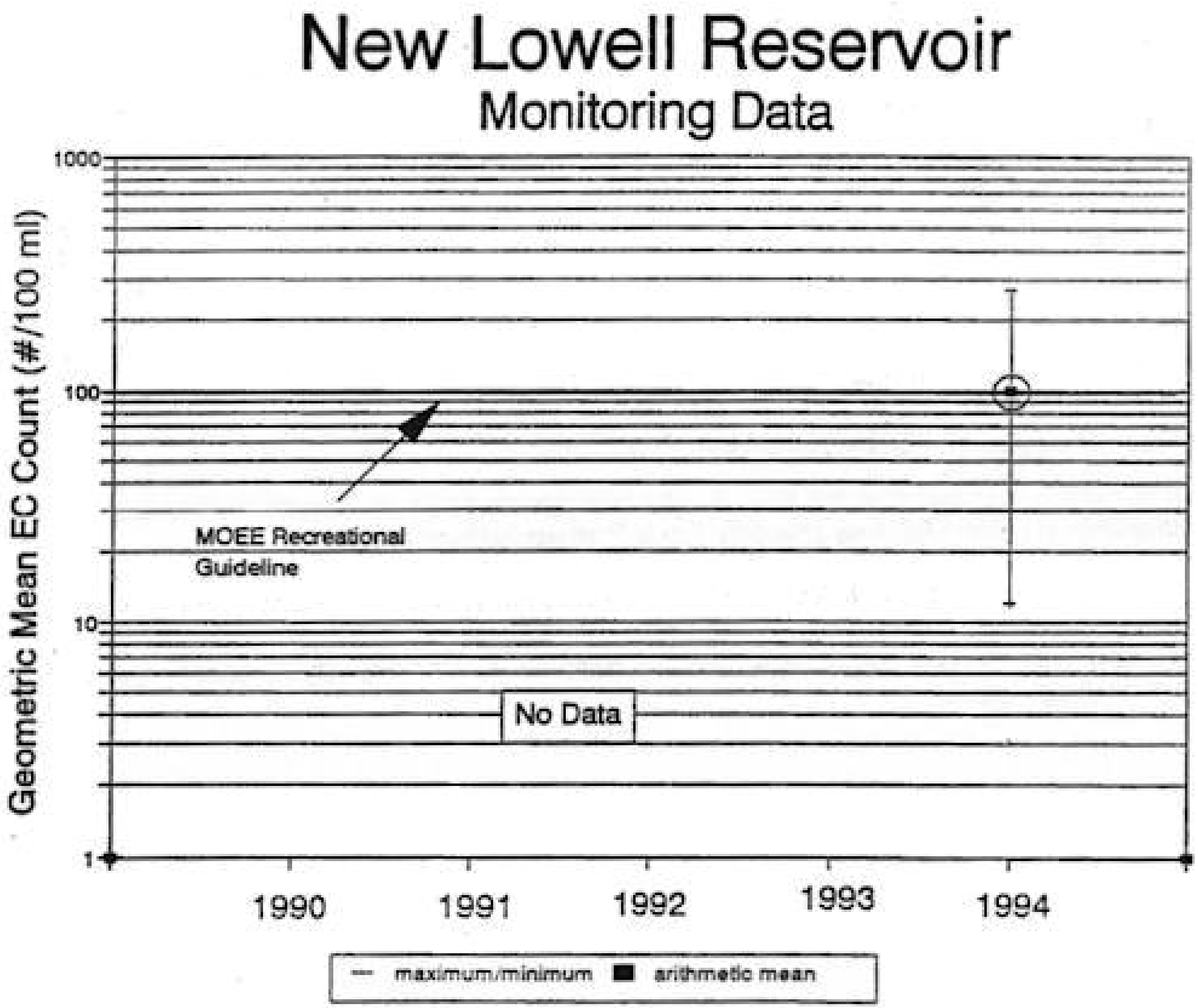

Figure 6: 1993 and 1994 beach water quality data from New Lowell Reservoir.

Table 17: Modelling results for suspected rural pollution sources in the Coates Creek Sub-watershed. Theoretically, each source contributes a proportion of the seasonal mean *E. coli* count at Boyne River Station A. Values shown are these proportions.

Source	E. coli contribution to Coates Creek "A" (#/100ml)	% of total
Livestock Access	81	60.4
Septic Systems	23	17.2
Gulls	17	12.7
Barnyard/Manure Stack Run-off	6	4.5
Milkhouse Wastewater	5	3.7
Manure Spreading	1	0.7
Geese	1	0.7
Beavers	0	0
Resultant Count	**134**	**100**
Seasonal mean *E. coli* concentration at Coates A was 106/100 ml.		

CURB models suggest that the high *E. coli* loadings found in the Upper Coates Creek area (particularly at station C), may primarily result from agricultural inputs.

3.1.4.4 Recommended Remedial Actions with Cost Estimates

Table 18 shows the costs associated with the clean-up of all CURB eligible sites in the Coates Creek drainage basin.

Table 18: Cost breakdown for CURB eligible remedial projects in the Coates Creek Sub-watershed. Projections are based on information from landowner surveys and CURB modelling.

Project Type	Number Occurring	Cost per Project ($)	Total Cost ($)
Access Restriction	6	7,400	44,400
Manure Storage	11	26,000	286,000
Septic Systems	20	-5,000	100,000
Milkhouse Wastewater	6	5,000	30,000
Total:			**$460,400**

If all CURB eligible remedial projects were completed in the Coates Creek basin, CURB modelling suggests that seasonal mean *E. coli* concentrations at Coates Creek station A would be reduced from 134 to 18/100 ml, an 87% reduction.

3.2 Wasaga Beach

3.2.1 1994 Water Sampling Results

Weekly Monitoring Stations

Data from the regular weekly stations (see Fig. 1) is given in Appendix A. The mean summertime *E. coli* loadings for each of the Wasaga Beach monitoring stations are given in Table 19. For those monitoring stations that were only used during the 1993 study, raw data was included in the NVCA Year 1 Rural Beaches Study Report (Jones and Wesson 1993).

Table 19: 1993 and 1994 *E. coli* loadings at weekly Wasaga Beach monitoring stations. Also shown are theoretical sub-watershed *E. coli* loadings to Nottawasaga Bay based on sampling data.

Tributary/ Sub-watershed	mean *E. coli* load at source (#/d)	Travel Time from source to Nottawasaga Bay (d)	*E. coli* load delivered to Nottawasaga Bay (#/d)
Willow/Matheson Creeks (1994)	$1.86*10^{12}$	2.4	$4.67*10^{11}$
Pine River (1993)	$1.40*10^{11}$	3.2	$2.22*10^{10}$
Upper Nottawasaga River, Sheldon Ck. and above (1993 and 1994)	$2.94*10^{11}$	4.7	$1.96*10^{10}$
Boyne River (1993)	$9.50*10^{10}$	3.9	$1.01 *10^{09}$
Coates Creek (1993)	$2.72*10^{10}$	2.1	$8.12*10^{09}$
Lamont/McIntyre Creek (1993 and 1994)	$9.97*10^{09}$	0.6	$7.06*10^{09}$
Beeton/Innisfil Creeks (1994)	$5.58*10^{10}$	4.1	$5.27*10^{09}$
Bear Creek (1993)	$2.08*10^{10}$	2.7	$4.40*10^{09}$
Sturgeon Creek (1994)	$1.64*10^{09}$	0.3	$1.38*10^{09}$
Mad River (1993 and 1994)	$1.20*10^{09}$	2.8	$2.39*10^{08}$
Marl Creek (1993)	$6.75*10^{08}$	2.1	$2.02*10^{08}$

Rain Event Sampling

The results from several rain event sampling stations are given in Table 20. In this case concentrations are given rather than loadings due to the very low discharges found in these watercourses.

Table 20: Mean *E. coli* counts observed in watercourses in the Town of Wasaga Beach. Data was collected during the summer of 1994, following rainfall events.

Watercourse	mean *E. coli* (#/100m1)
Cedar Lane creek (enters Nottawasaga Bay @ Allenwood Beach)	47
Municipal Drain (enters Nottawasaga Bay @ Brock's Beach)	10,100
Sturgeon Creek (enters Nottawasaga River, 200m upstream of the mouth.	227

Compared to the loadings reaching Nottawasaga Bay from the sub-watersheds considered in section 3.3.2.1, the loadings measured in watercourses sampled during the rain event sampling were very small. This was the case in spite of frequently high *E. coli* counts, since discharges were small.

3.2.2 Historical overview of Beach Water Quality

Figure 7 summarizes the bacterial sampling results from Wasaga Beach over the last few seasons. Trends in the data suggest that water quality at Wasaga Beach has been improving over the last few seasons. Unfortunately, it is more likely that this trend reflects changes in sampling protocol rather than actual improvements in water quality.

3.2.3. Quantification of Suspected Sources (Modelling)

Modelling results for each sub-watershed that contributes to the *E. coli* load at the mouth of the Nottawasaga River are provided in Appendix B. A description of the modelling algorithms is provided in appendix C. Table 15 summarizes modelling results for the entire Nottawasaga River watershed.

Table 21: Summary of modelling results for Wasaga Beach. Theoretically, each source contributes to the seasonal mean *E. coli* concentration at the mouth of the Nottawasaga River. Values shown represent these proportions.

E. coli Source	Estimated # of Sources Occurring	Resulting E coil Count at Nottawasaga R. Mouth (#/100ml)	% of Total Estimated E. coil Count
Livestock Access to watercourses	218	89.094	84.4
Septic Systems	1640	4.177	4.0
Barnyard/Manure Stack Run-off	273	2.580	2.4
Milkhouse Wastewater	93	0.186	0.2
Manure Spreading	622	0.059	0.06
Urban Non-point Run-off	8	9.528	9.0
Sewage Treatment Plant Effluent	1	0.0006	0.0006
Totals	2855	105.6 (actual seasonal mean for 1994 was 87)	100

3.2.4 Recommended Remedial Measures and Costs

Table 22 gives the cost estimates associated with the clean-up of all CURB eligible sources of fecal contamination in the Nottawasaga River watershed.

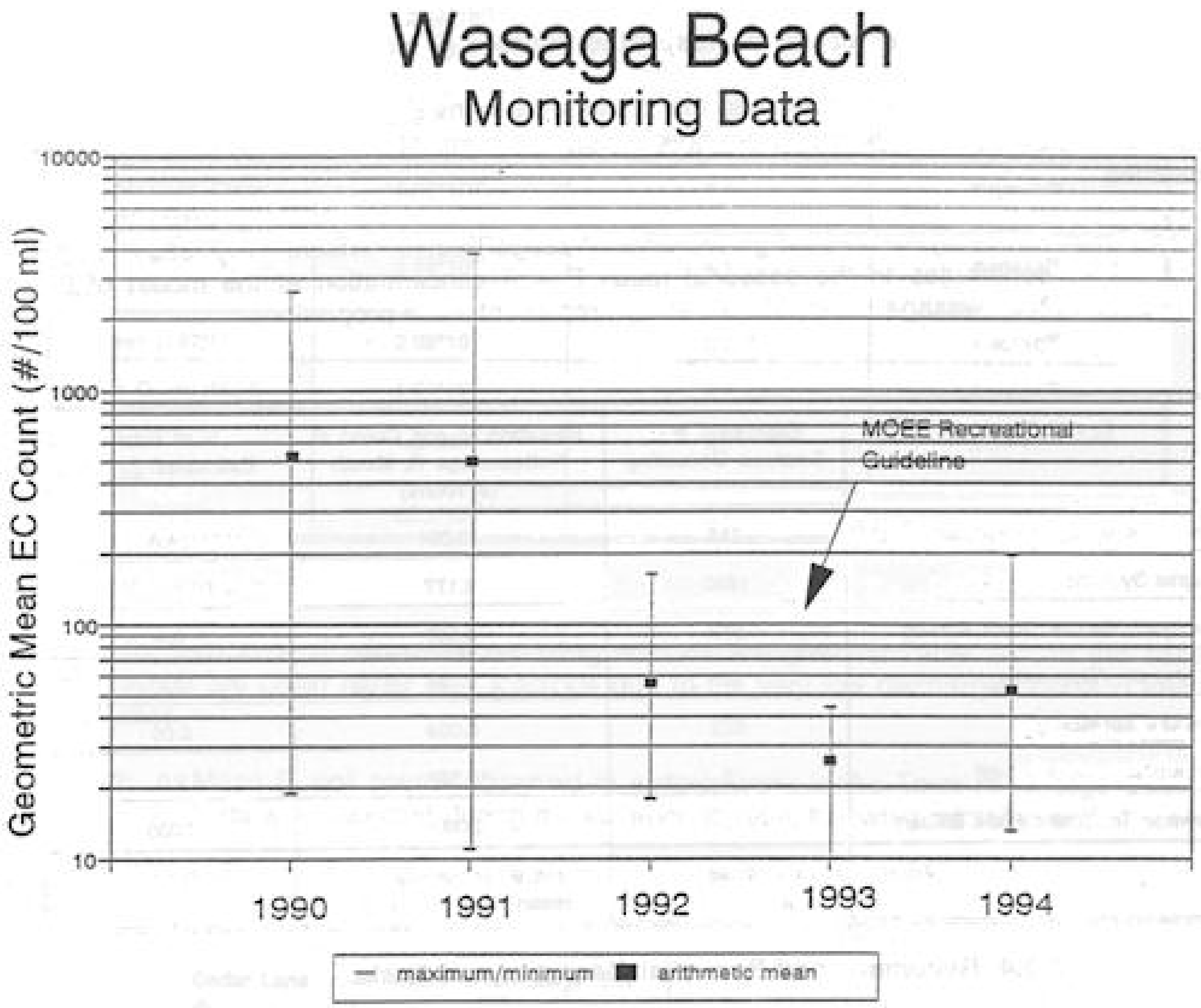

Figure 7: 1993 and 1994 beach water quality data from Wasaga Beach.

Table 22: Cost breakdown for CURB eligible remedial projects in the NVCA watershed. Sources within the Bear Creek, Boyne River, Beeton Creek and Coates Creek drainage basins are excluded since these are dealt with in greater detail in previous sections.

Project Type	Number Occurring	Cost per Project ($)	Total Cost ($)
Access Restriction	218	7,400	1,613,200
Manure Storage	429	26,000	11,154,000
Septic Systems	1640	5,000	8,200,000
Milkhouse Wastewater	93	5,000	465,000
Total:			**$ 21,432,200**

In addition to the CURB eligible remedial projects discussed above, a number of projects could be undertaken at the Nottawasaga Bay beaches themselves in order to reduce fecal contamination. For example, signs could be posted that ask beach users to properly dispose of garbage and adopt appropriate hygienic practices while using the beach. These practises may reduce the number of bacteria introduced by swimmers and by gulls that feed on garbage left behind by beach users.

Constructing new washroom/shower facilities in Wasaga Beach Provincial Park could improve the chances of patrons using the appropriate facilities before swimming. The estimated cost of constructing a dual male/female change room with showers and toilets is $40 000 per structure. Several of these facilities should be constructed in areas of Wasaga Beach Provincial Park, particularly in the areas along the "main drag" where the heaviest beach use occurs. Wasaga Beach Provincial Park staff currently rake the beach periodically. This activity should be maintained in the future to facilitate the killing action of UV rays on bacteria in the sand.

4.0 CURB RECOMMENDATIONS

4.1 The Reservoir Beaches

A breakdown of the projected costs associated with the clean-up of the reservoir beaches is given in Table 23.

Table 23: Cost breakdown associated with the completion of all CURB eligible projects in the reservoir containing sub-watersheds, including the Boyne River, Beaton, Bear and Coates Creek basins.

Projects Required	Cost Per project ($)	# Required	Total Cost ($)	mean *E. coli* Reduction (%)
Livestock Access Restriction	7,400	32	236,800	61.3
Manure Storages	26,000	72	1,872,000	24.1
Septic System Upgrades	5,000	160	800,000	7.5
Milkhouse Wastewater Treatment Facilities	5,000	14	70,000	1.6
Total:			**$2,978,800**	

According to our assumptions (refer to Appendix C, Part D), the total cost for the clean-up of all CURB eligible sources in the four reservoir containing sub-watersheds is $2,978,800. Up to $1,490,800 of this is eligible under the CURB Program in the form of grants to landowners. CURB modelling suggests that the completion of these remedial projects would lead to an average 91.5% reduction in bacterial loadings to each reservoir.

4.2 Wasaga Beach

A breakdown of the costs associated with the clean-up of Wasaga Beach is given in Table 24.

Table 24: Cost breakdown associated with the completion of all CURB eligible projects in the drainage basin feeding Wasaga Beach. Projects required in the modelling sub-watersheds are not included.

Projects Required	Cost Per project ($)	# Required	Total Cost ($)	*E. coli* Reduction (%)
Livestock Access Restriction	7,400	218	1,613,200	84.4
Manure Storages	26,000	429	11,154,000	2.5
Septic System Upgrades	5,000	1640	3,200,000	3.9
Milkhouse Wastewater Treatment Facilities	5,000	93	465,000	0.2
Total:			**$21,432,200**	

According to our assumptions (refer to Appendix C, Part D), the total cost for the clean-up of a CURB Eligible sources in the Nottawasaga River Basin is $21,432,200. Up to $10,506,200 of this is eligible under the CURB Program in the form of grants to landowners. CURB modelling suggests that the completion of these remedial projects would reduce *E. coli* loadings to the mouth of the Nottawasaga River from 106 to 10/100 ml, a 91% reduction.

The total cost associated with the clean-up of all beaches is $24,411,000. Approximately 48% of this, or $11,656,000 is eligible under the CURB Program in the form of grants to landowners.

4.3 Budgeting for the Clean-up.

Approximately $11,656,000 in CURB grants are required to remediate rural pollution sources in the NVCA Watershed. Assuming a 5 year implementation period and 50% landowner uptake, a $1,165,600 budget (excluding administration costs) is required per annum to finance the CURB Program in the NVCA Watershed.

REFERENCES

Agriculture Canada and OMAFRA. 1994. Best Management Practises: Livestock and Poultry Waste Management. Agriculture Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs.

Balogh, L.J. 1994. Nottawasaga Valley Conservation Report-Water. Ontario Ministry of Natural Resources, Conservation Authorities Branch. Toronto, Ontario.

Brunatti, R. 1993. Tri-Authority Rural Beaches Study Program Clean Up Rural Beaches (CURB) Plan. Lower Trent Region Conservation Authority, Moira River Conservation Authority and Napanee Region Conservation Authority.

Burger, C.A. 1983. Lakeshore Capacity study-Microbiology. Ontario Ministry of Municipal Affairs and Housing. Queens Printer for Ontario. Toronto.

Camp, T.R. and R.L. Meserve. 1974. Water and its Impurities 2nd edition. Dowden, Hutchinson and Ross, Inc. Stroudsburg, Pa.

Clark, E.H., J.A. Heaverkamp and W. Chapman. 1985. Eroding Soils: The off-farm Impacts. The Conservation Foundation. Washington, D.C.

County of Simcoe. 1993. Statistical Information-The County of Simcoe. County of Simcoe Regional Assessment Office. Midhurst, Ontario.

Demal, L. 1982. An Intensive Water Quality Survey of Stream Cattle Access Sites Technical Report R-19. Stratford/Avon River Environmental Management Project.

Doran, J.W. and D.M. Linn. 1979. Bacteriological Quality of Runoff Water from Pastureland. Applied and Environmental Microbiology, 37(5). pp.985-991.

Ecologistics. 1988. PLOP Model-A planning tool to Evaluate the Pollution Potential of Livestock Operations in Southern Ontario. Waterloo, Ontario.

Environment Canada. 1983. Sampling for Water Quality. Water Quality Branch, Inland Waters Directorate. Ottawa, Ontario.

Fuller, R. and M.E. Foran. 1989. CURB Plan for Lake Huron Beaches in the Maitland Valley Conservation Authority Watershed. Maitland Valley Conservation Authority. Wroxeter, Ontario.

Gale, D. 1992. CURB Plan for the Sixteen Mile Creek Watershed. Halton Region Conservation Authority. Milton, Ontario.

King, D.L., G.C. Watson and G.J. Wall. 1994. Impact of Liquid Manure Application and Soil

Management on Water Quality *in* Great Lakes Water Quality Program-Summary of Achievements 1989-1994. Agriculture and Agri-Food Canada. Guelph, Ontario.

MacDonald, KB., F. Wang and I. Jarvis. 1994. Regional Agricultural Practices and their Potential for Land and Water Contamination *in* Great Lakes Water Quality Program-Summary of Achievements 1989-1994. Agriculture and Agri-Food Canada. Guelph, Ontario.

Maclaren Plansearch. 1988. Report—Watershed Hydrology Study for Nottawasaga, Pretty and Batteaux Rivers, Black Ash, Silver and Sturgeon Creeks. Toronto, Ontario.

Mar, P. 1991. CURB Plan for the East Humber River, Centerville Creek and Bruce Creek Watersheds. Metro Toronto Region Conservation Authority. Downsview, Ontario.

MOEE. 1978. Water Management-Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. Ontario Ministry of the Environment and Energy. Toronto,' Ontario.

MOEE. 1993. A Guide to The Collection and Submission of Samples for Laboratory Analysis, 7th edition. Customer Services Unit, Laboratory Services Branch, Ontario Ministry of the Environment and Energy. Etobicoke, Ontario.

OMAF. 1992. 1991 Agricultural Statistics for Ontario. Statistical Services Unit, Policy Analysis Branch, Ontario Ministry of Agriculture and Food. Publication 20.

OMAF. 1992. Ontario Soils: Physical, Chemical and Biological Properties and Soil Management Practices. Ontario Ministry of Agriculture and Food, Publication 492. Guelph, Ontario.

OMAFRA. 1994. Agricultural Pollution Control Manual. Ontario Ministry of Agriculture, Food and Rural Affairs. Toronto, Ontario.

Steel, Robert G. D. and James H. Torrie. 1980. Principles and Procedures of Statistics, A Biometrical Approach. McGraw-Hill, Inc. New York. 633 pp.

Teal, R.A. 1981. Hydrometric Field Manual — Measurement of Streamflow. Water Resources Branch, Inland Waters Directorate, Environment Canada. Ottawa, Ontario.

Watson, J., E. Hassinger, K. Reffruschinni, M. Sheedy and B. Anthony. 1994. Best Management Practises Meeting Water Quality Goals. Supplement to the Journal of Soil and Water Conservation, 49(2),39-43.

Weselan, A.M. 1991. CURB Plan for the Highland Creek and Coldstream Watersheds. St. Clair Region Conservation Authority. Strathroy, Ontario.

Wesson, B. and C. Jones. 1994. Nottawasaga Valley Conservation Authority Water Quality Study: 1993 Progress Report. Ontario Ministry of the Environment and Energy. Toronto, Ontario.

PERSONAL COMMUNICATIONS

Maureen Beagle. 1994.
Supervisor, Recreation Department, Township of New Tecumseth.

Marilyn Bidgood. 1994.
Crops Advisor, OMAFRA, Barrie Office

Dr. Maartin Bokhout. 1994.
Medical Officer of Health, Huron County.
Member of the Provincial Biosolids Utilization Committee.

Floyd Brubacher. 1994.
President, F.M. Brubacher Mfg. Inc.

Perry Bull. 1994.
Public Health Inspector, Simcoe County District Health Unit.

Julie Eisses. 1994.
Eisses Brothers Excavating.

Robert Herbst. 1994.
Wasaga Beach Provincial Park, Ontario Ministry of Natural Resources.

Barb Johnston. 1993.
Ecologist. Algonquin Research Station. Algonquin Provincial Park.

Brian Russell. 1994.
Hydrologist. Water Survey of Canada. Environment Canada.

Larry Schleen. 1993.
Control Supervisor, Sea Lamprey Control Centre, Fisheries and Oceans Canada.

Larry Slomka. 1994.
Assistant Director of Environmental Health Services, Simcoe County District Health Unit.

GLOSSARY

Arithmetic Mean: An average of a set of observations. Arithmetic mean=sum of n observations/n, where n is the number of observations. For example: five rolls of a die yield the following results: 1, 3, 5, 6 and 6. The mean of the five observations would be calculated in the following manner:

arithmetic mean= (1 +3+5+6+6)/5=4.2

Bacterial Loading Rate (loading): The bacterial content of a watercourse. Expressed in # of bacteria per unit time (see **Loading Rate).**

Continuous Source: A Continuous source of pollution is one that impacts upon water quality at all times i.e. is not flow related. An example of a continuous source is a failing septic system that leaks effluent to a stream every day.

CURB Uptake: The proportion of properties in the NVCA watershed:

(a) that are presumed to be contributing to pollution according to CURB Modelling and landowner survey information.

(b) upon which landowners are interested in correcting the pollution problem and applying for Grants under the CURB Program.

d: Symbol for days (unit of time). Generally used in formulas.

DFO: Department of Fisheries and Oceans Canada.

Discharge: The rate of flow in a watercourse. Usually measured in m^3/s.

DOE: Department of the Environment. Environment Canada.

Dry: Dry generally refers to the calculation of means. For example a mean *dry E. coli* concentration would represent the mean concentration of bacteria found at a sample station on days not influenced by rainfall (i.e. 10 mm rainfall in the 48 hrs. prior to sampling).

***E.coli*:** A species of bacterium. This organism is considered to be an excellent indicator of fecal contamination in water.

Geometric Mean: An average of a set of observations. The geometric mean is often used when observations in the data range over several orders of magnitude (powers of ten). Geometric mean=the nth root of the product of n observations. Consider the example of a die rolled five times to yield the following observations, 1, 3, 5, 6 and 6. Calculate the geometric mean according to the following:

geometric mean= $(x_1 * x_2 * x_3....x_n)^{1/n} = (1*3*5*6*6*)^{1/5} = 3.52$

Hydrometric: Referring to the measurement of streamflow (discharge).

Laminar: The opposite of turbulent. Refers to water that is flowing in a straight line path.

Loading Rate (loading): The pollution content of a watercourse. Intuitively, loading rate is equivalent to the amount of pollutant carried past any given point along the watercourse per unit time. Bacterial loading rates are measured in numbers of bacteria per unit time (i.e. # bacteria/s).

MOEE: Ontario Ministry of the Environment and Energy.

Non-point Pollution Source: A source of pollution that emits contaminants over a large area or diffusely. This is the opposite of a point source which would deliver pollutants into a very specific area, such as out the end of a pipe. A barnyard that does not contain or safely store its run-off is an example of a non-point pollution source.

NVCA: Nottawasaga Valley Conservation Authority.

OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs. Prior to 1994 this government agency was called the Ontario Ministry of Agriculture and Food (OMAF).

Recalibration: The adjustment of an instrument to a standard of known magnitude. This is done so that measurements can be made based on deviation from this known standard. For example, a thermometer is calibrated by immersing it in a solution that is known (or is, by definition) to be 0°C. Graduations can then be made on the instrument on either side of the level of mercury at 0°C, based on the amount of displacement which takes place per Celsius degree of temperature change.

Pollution Potential: The likelihood that a property is contributing to the pollution content of a watercourse.

Riffle: A section of stream channel characterized by a shallow depth and fast flowing water.

Run: A straight section of stream channel characterized by moderate to shallow depth and highly laminar flow.

s : Symbol for seconds (unit of time). Generally used in formulas rather than the abbreviation, *sec.*

Sub-watershed: A portion of the Nottawasaga River drainage basin. Generally refers to the drainage basin of a tributary of the Nottawasaga River.

Verticals: When measuring the discharge (flow) in a stream channel, a tape measure is stretched across the stream channel perpendicular to the direction of flow. Then measurements of current speed are made at intervals across the stream channel. *Verticals* refer to the specific locations where these speed measurements are made.

Wet: Wet generally refers to the calculation of means. For example a mean wet *E. coli* concentration would represent the mean concentration of bacteria found at a sample station following rainfall events (i.e. more than 10 mm of rainfall in the 48 hrs. prior to sampling).