CREDIT VALLEY CONSERVATION AUTHORITY

CLEAN UP RURAL BEACHES (CURB) PLAN

FOR THE WEST CREDIT RIVER WATERSHED

PREPARED BY
MARTA SOUCEK

PREPARED FOR
THE ONTARIO MINISTRY OF ENVIRONMENT AND ENERGY

MARCH 1994

DISCLAIMER

FOREWORD

This report is one of a series produced under the Provincial Rural Beaches Program. The objective of the Program is to identify the relative impact of pollution sources, and develop a course of action leading to the restoration and long term maintenance of acceptable water quality at provincial rural beaches.

Significant enrichment and bacterial contamination in southern Ontario rivers and lakes originates from rural sources. The discharge of waste material to streams can result in elevated bacterial concentrations, nuisance algae blooms, fish kills, and present a potential health hazard to humans and livestock using the water. Watershed studies have found that a multitude of pollution sources and pathways may affect beaches in Ontario. These include:

1) Urban sanitary and stormwater runoff,
2) Direct livestock manure access to watercourses,
3) Inadequate manure management practices,
4) Direct discharge of milkhouse wastes,
5) Contaminated field tile systems, and
6) Faulty septic systems

The impact upon beaches of any of these sources, either singly or in combination, can range from a few days of elevated concentrations to complete seasonal closures.

Numerous beach closings in 1983 and 1984, drew public and government attention to the severity of this water quality problem. In 1985, the Ontario Ministry of the Environment's (MOE) Water Resources Branch formulated the Provincial Rural Beaches Strategy Program. Directed by the Provincial Rural Beaches Planning and Advisory Committee, it includes representatives from MOE, Ministry of Agriculture and Food (OMAF), and Ministry of Natural Resources (MNR).

With financial and technical assistance from the MOE, local Conservation Authorities carry out studies under the direction of a local technical steering committee. Chaired by an MOE regional staff, the committees typically include representation from OMAF, MNR, the Medical Officer of Health, Conservation Authority, the local Federation of Agriculture, and a local farmer. The chairs of the local committees assure communication between all the projects by participating on the Provincial Committee.

The primary objective of each local study is to identify the relative impact of pollution sources, their pathways to beaches, and to develop a Clean Up Rural Beaches (CURB) plan specific to the watershed upstream of each beach. The CURB plan develops remedial strategy options and respective cost estimates for each beach through:

1) Field inspections,
2) Farmer consultations,
3) Water quality monitoring, and
4) Basic mathematical modelling techniques.

Recommended actions will include both measures for specific beaches and broader scale Provincial measures based on cumulative results of component studies.

The following related research projects were also MOE funded and undertaken by various Conservation Authorities to improve our understanding of bacterial and nutrient dynamics:

1) *In-situ* bacterial survival studies determine longevity: in watercourses, offshore of beaches, in sediments, and in milkhouse washwater tiles.
2) Biotracer studies determine the speed and nature of travel for bacteria introduced into a watercourse.
3) A liquid manure spreading study examines bacterial movement through the soil column and exiting field tile drains.
4) A target sub-basin study evaluates the effectiveness of a watershed with comprehensive remedial measures.

Numerous demonstration farms have been established with the cooperation of local farmers to display innovative management practices. Research continues on their effectiveness at improving water quality.

Comments and/or questions on this report are welcome. Please send written comments to:

Chairman
Provincial Rural Beaches Planning and Advisory Committee
c/o Environment Ontario
Water Resources Branch
135 St. Clair Ave. W.
Suite 100
Toronto, Ontario M4V 1P5

ACKNOWLEDGMENTS

The Credit Valley Conservation Authority Rural Beaches Study Program has been made available through financial assistance of the Ontario Ministry of Environment and Energy's Provincial Rural Beaches Program.

The author would like to extend thanks to all individuals ho provided information and assistance in preparation of this document.

Many thanks go to Robert Morris for his guidance and sharing of his knowledge important to the successful completion of the study. Additional thanks are extended to the CVCA staff who contributed to this study.

I especially wish to thank Peter Mar for continued guidance and support during the two year study.

Many thanks to the Steering Committee members for their input to the compilation of this report. Members include:

Peter Mar	Ministry of the Environment and Energy
Ken Owen	Credit Valley Conservation Authority
Robert Morris	Credit Valley Conservation Authority
Hazel Breton	Credit Valley Conservation Authority
Jim Myslik	Ontario Ministry of Agriculture and Food
Mark Janiec	Ontario Ministry of Agriculture and Food
Rob Thompson	Wellington-Dufferin-Guelph Health Unit
Paul Callanan	Peel Health Department
John Benham	Ontario Soil and Crop Improvement Association
Blyth Meek	Ontario Soil and Crop Improvement Association
Murray Clarke	Erin Township
Cathryn Ironmonger	Erin Village

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

In the spring of 1992 the Credit Valley Conservation Authority (CVCA) became involved in the Ontario Ministry of Environment and Energy's (MOEE) Clean Up Rural Beaches (CURB) Program in order to address rural bacterial sources impacting on the West Credit River and the downstream swimming beach at the Belfountain Conservation Area.

Within the two year Rural Beaches Study, extensive research that included water quality monitoring, field, stream and farm surveys, was undertaken to assess water quality impairment and sources of bacterial pollution.

As a result of the data gathered during the two year study a CURB Plan for the West Credit River Watershed was developed. Based on a mathematical model the CURB Plan predicts bacterial contribution of all identified pollution sources to watercourses and subsequently to the swimming area. The Plan also outlines an estimated cost for the remedial measure projects and provides an implementation strategy.

The CURB mathematical model calculates the contribution of identified pollution sources during the 92 day summer season and also distinguishes dry and wet weather conditions that occurred during this time period.

Under dry weather conditions the CURB model identifies private sewage disposal systems as a major contributor of bacteria to the swimming beach (accounting for 77% of the total load), followed by unrestricted cattle access to the watercourses (15%) and wildlife (8%). Specifically, Erin sewage disposal systems were found contributing about 54% of the total dry weather beach load, Hillsburgh sewage disposal systems were contributing 9% to the seasonal bacteria beach load, while 9% of bacteria originated in Belfountain sewage disposal systems and 5% in rural residences.

The ranking of pollution sources under wet weather conditions was similar to dry weather conditions. Private sewage disposal systems were recognized as a primary contributor of fecal bacteria to the swimming beach, accounting for 57% of the total beach load, while urban non-point sources (stormwater runoff) were found

to be responsible for 21%, unrestricted cattle access for 13%, wildlife for 7% and barnyard runoff for 2% of the total bacteria load to the beach. Of the total 57% sewage disposal system impact the model predicts that 11% originate in Hillsburgh, 37% in Erin, 5% in Belfountain and 4% in rural residences.

The CURB model for the total seasonal bacteria load to the beach predicts that 71% are delivered from faulty sewage disposal systems. Cattle access contributes 14%, urban stormwater 7% and wildlife accounted for 8% of the total load. Barnyard runoff, manure stack runoff and milkhouse washwater disposal systems combined accounted for the remaining 1% of the total beach bacteria load.

Private sewage disposal systems are estimated to be a major contributor of bacterial pollution to the Belfountain beach. Both Erin and Belfountain lie on the main branch of the West Credit River with a short travel time to the beach, while most of the agricultural sources are located on smaller tributaries with a significant travel time from the beach.

In order to improve water quality at the Belfountain Conservation Area reservoir the CURB plan recommends the following remedial measures:

1. Repair or replace substandard sewage disposal systems, improve maintenance, research and consider alternative sewage treatment method for the Village of Erin.

2. Fence cattle out of the watercourses, provide alternate water supplies and revegetate banks.

3. Build proper manure storages and runoff containments or explore less expensive alternatives.

4. Address urban stormwater impact through other programs (Storm Drain Marking Program, stormwater management facilities or artificial wetlands).

The CURB plan calculates costs for the suggested remedial measure projects to be implemented in the study area. The total estimated cost for the West Credit River watershed is $1,025,000 and would result in 85% bacteria reduction at the beach if all projects were completed. Repairing faulty sewage disposal systems was recognized as the most effective method that would decrease bacteria load to the beach by 71%. Fencing cattle out of the watercourses was ranked as the second most important method that would lower the bacteria contribution by 14%. Remedial measures implemented to manure stacks, barnyards and milkhouse washwater disposal systems combined would decrease the beach load only by 1%. Alternative remedial measures should be investigated to eliminate these sources. Building costly manure storages and runoff containments for small operations and hobby farms typical of the study area would not be reasonable.

The CVCA CURB program remedial measure phase will come into effect in the spring of 1994 and will be implemented by a multi-agency steering committee comprised of the MOEE, Ministry of the Agriculture and Food (OMAF), Wellington County and Peel Region Health Units and the Ontario Soil and Crop Improvement Association (OSCIA). With financial, technical and educational assistance to the watershed residents the CURB program should be highly effective and would significantly improve water quality in the West Credit River watershed and Belfountain Conservation Area beach such that swimming is once again a permissible recreational activity.

1.0 INTRODUCTION

In the early 1980's high bacteria counts at rural beaches often exceeded the MOEE water quality guideline and caused their closures. The MOEE introduced the Provincial Rural Beaches Strategy Program in 1985 in response to these rising problems and concerns about degraded water quality. This program was further developed into the Clean Up Rural Beaches Program (CURB) initiated in September of 1991. CURB is a 10 year provincial program that will provide $57 million to clean up rural beaches from bacterial pollution throughout Ontario.

To date 26 Conservation Authorities participate and deliver the program in their local watersheds.

The Credit Valley Conservation Authority joined the program in the spring of 1992 and carried out the two year Rural Beaches Study on the West Credit River watershed. The objectives of the study were to identify the sources of bacterial pollution impacting on watercourses and downstream swimming beach at the Belfountain Conservation Area, to promote the program and educate watershed residents.

This report presents the CURB Plan that on the basis of mathematical modeling assesses the sources of bacterial pollution and predicts their relative contribution to the beach. The Plan also recommends remedial measures and estimates the project costs that would help to improve water quality at the Belfountain beach.

2.0 OBJECTIVES

The primary objective of the Rural Beaches Study is to identify the sources of bacterial pollution that are contributing to the West Credit River and Belfountain Conservation Area swimming beach water quality impairment.

Another objective is to carry out a broad educational program for the watershed residents that would increase public awareness of the rural bacterial sources of pollution and offer explanations and solutions. This information was delivered through newsletters, press releases, public broadcasting and also through personal interviews.

The third objective is to develop a CURB Plan that would, on the basis of mathematical modeling, assess the contribution of identified pollution sources to the beach bacteria load, estimate remedial measure costs and recommend the implementation strategy.

3.0 STUDY AREA

The West Credit River Watershed (106 square kilometers) is mostly located in the eastern portion of the County of Wellington and a small part of the Region of Peel approximately 50 kilometres northwest of Toronto, 30 kilometres northeast of Guelph and 40 kilometres north of Mississauga (Figure 1). The Village of Erin (Population 2,489), Hillsburgh (Population 1,250) and Belfountain (Population 520) are the population centres within the watershed.

The West Credit River rises in the wetlands and woodlots about 2.5 kilometres north of Hillsburgh, flows through Hillsburgh, the Village of Erin, Belfountain and joins the Credit River that eventually outlets at Lake Ontario. The West Credit River contains one of the most important cold water fisheries in Southern Ontario. Although the 19 kilometre long watercourse is mostly well forested and has significant groundwater recharge and discharge areas and wetlands that help to sustain the river system, the river tends to be under increasing pressure resulting from urban development.

3.1 Physiography and Soils

The West Credit River watershed consists of several physiographical formations which are underlain by dolostone of the Amabel and Guelph Formation with sedimentary limestones, shales and sandstones.

Most of the upper part of the watershed is comprised of Orangeville Moraine, Erin Till Plain and glacial spillways. Hillsburgh sandy loam and fine sandy loam soils are prevalent and have good drainage. These thin soils are very susceptible to erosion and small stones appear at the surface in areas when soil loss has occurred. The steepest slopes are those north of Hillsburgh, but knobby hills are more characteristic.

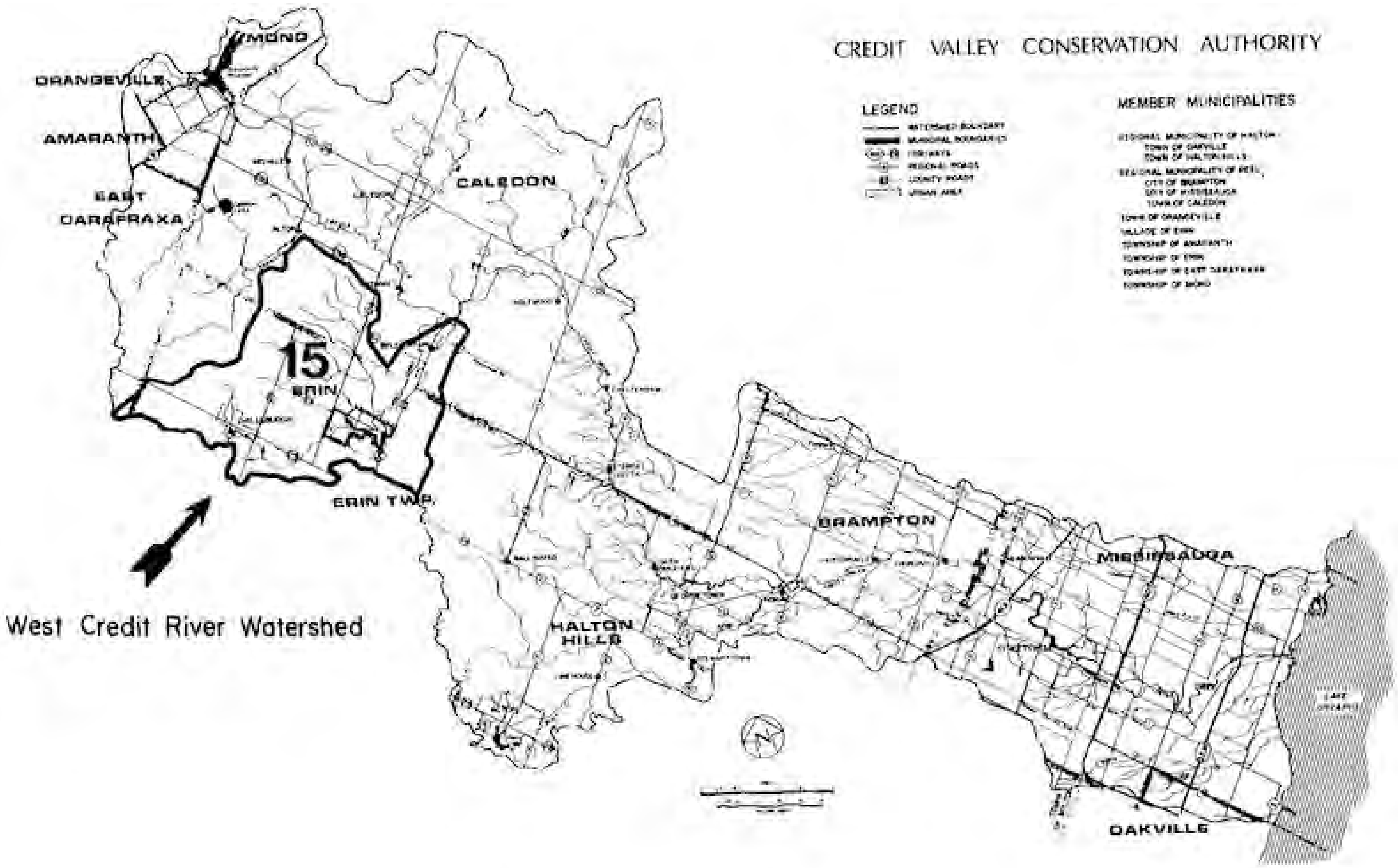


Figure 1: Credit River Watershed

The middle and lower part of the watershed is located in the Guelph drumlin field and Till Moraine in conjunction with the Erin Till Plain. Soils found in this area include well drained Hillsburgh and Caledon fine sandy loam, well drained Harriston loam soils and imperfectly drained Brisbane loam covering a small area in Erin Village. Granular textured well drained Caledon fine sandy loam soils cover the lower part of the watershed including Belfountain.

Generally, the rolling topography and coarse textured soils found within the watershed provide well drained conditions.

3.2 Land Use

The main land use within the West Credit River watershed is agriculture. Approximately 25% of the total area is pasture, 25% row crop (mainly corn, rarely grains and soya beans), 25% hay, 15% woodlots, 5% wetlands and 5% urban.

Agricultural land use is still predominant however the number of active farmers dropped significantly within the last decade. According to a windshield survey there are approximately 20 beef farms, one dairy farm and a large number of hobby horse farms.

Cropping activities in the watershed are dominated by the cultivation of row crops, the most prevalent is corn, and several fields are in small grains and soya beans. The rest of the agricultural area is farmed in hay or used as a pasture.

3.3 Population

Most of the West Credit River watershed lies in Wellington County, the remaining portion is in the Region of Peel.

The Village of Erin, Hillsburgh and Belfountain are the major rural built-up centres within the watershed along with a high number of individual dwellings spread throughout the countryside.

The Village of Erin is the largest of them with a current population of 2,489 people and projected growth to 3,619 residents by the year 2011 (Statistics Canada, Census 1991).

Regional assessment information of 1991 indicated that approximately 1,200 people resided in Hillsburgh. In order to respond to the potential population increase, much of the available land in Hillsburgh has been designated for residential use. If all of this land is developed, some 1,250 people will be added to the community.

In 1992 about 284 people were living in Belfountain (Official Plan Amendment 114 of the Town of Caledon). The population is expected to increase to 520 people by the year 2011.

Water supply to all development in the subwatershed is currently derived from groundwater sources and sewage treatment is through private sewage disposal systems.

4.0 WATER QUALITY HISTORY

4.1. Belfountain Conservation Area Beach

The Belfountain Conservation Area is a public park owned and operated by the Credit Valley Conservation Authority since 1959. The West Credit River passes through the 9.6 ha park where it has been impounded by a dam since the turn of the century. The reservoir occupies the area of 0.5 ha with swimming regulated on one side.

4.2 Beach Posting History

In the past, the Peel Health Department provided seasonal weekly sampling of the reservoir. Since 1987 the swimming area experienced repeated summer closures due to fecal coliform concentrations exceeding the provincial standard for primary contact recreational waters of 100 per 100 mL. Almost all geometric means in the weekly sampling from 1987 through 1990 exceeded the standard (Figures 2,3,4). Thus in 1990 the swimming area was permanently posted and the Peel Health Department recommended that the upstream pollution sources should be addressed and mitigative measures undertaken before the area be re-opened for swimming.

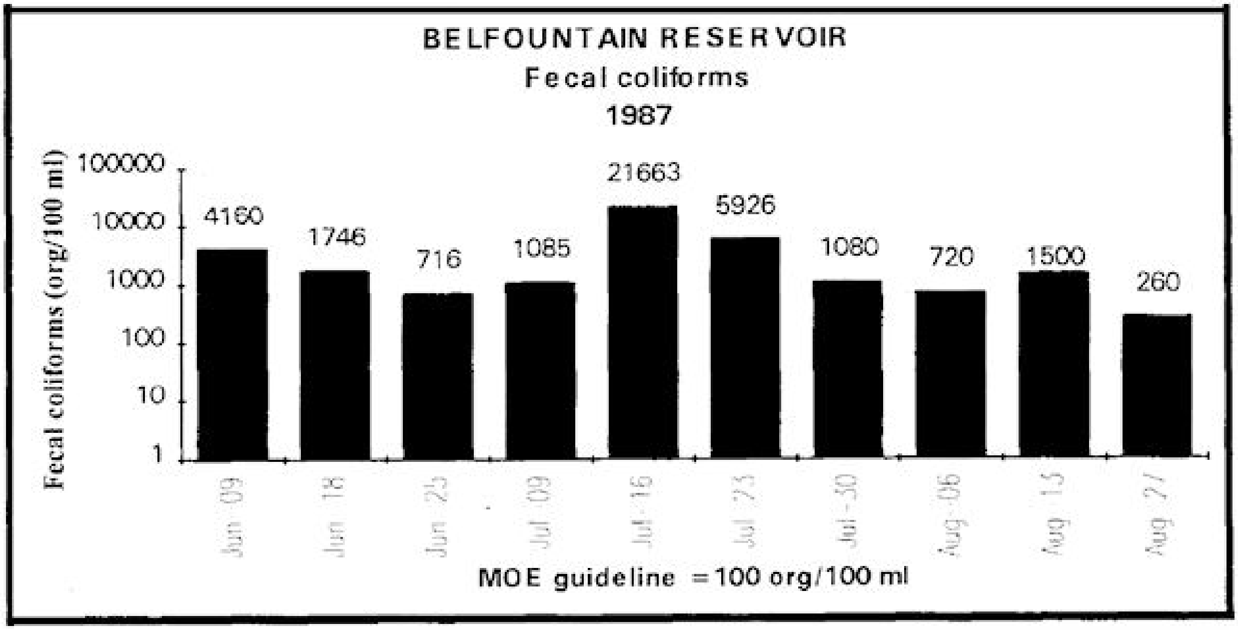


Figure 2: Belfountain reservoir fecal coliform concentrations in 1987.

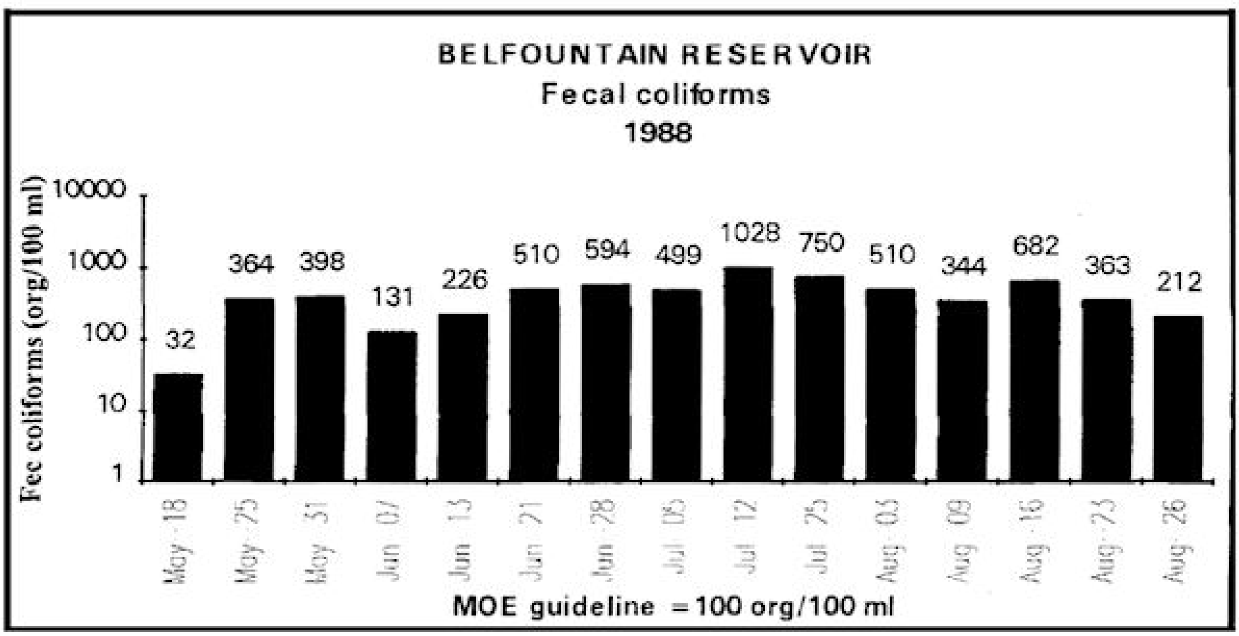


Figure 3: Belfountain reservoir fecal coliform concentrations in 1988.

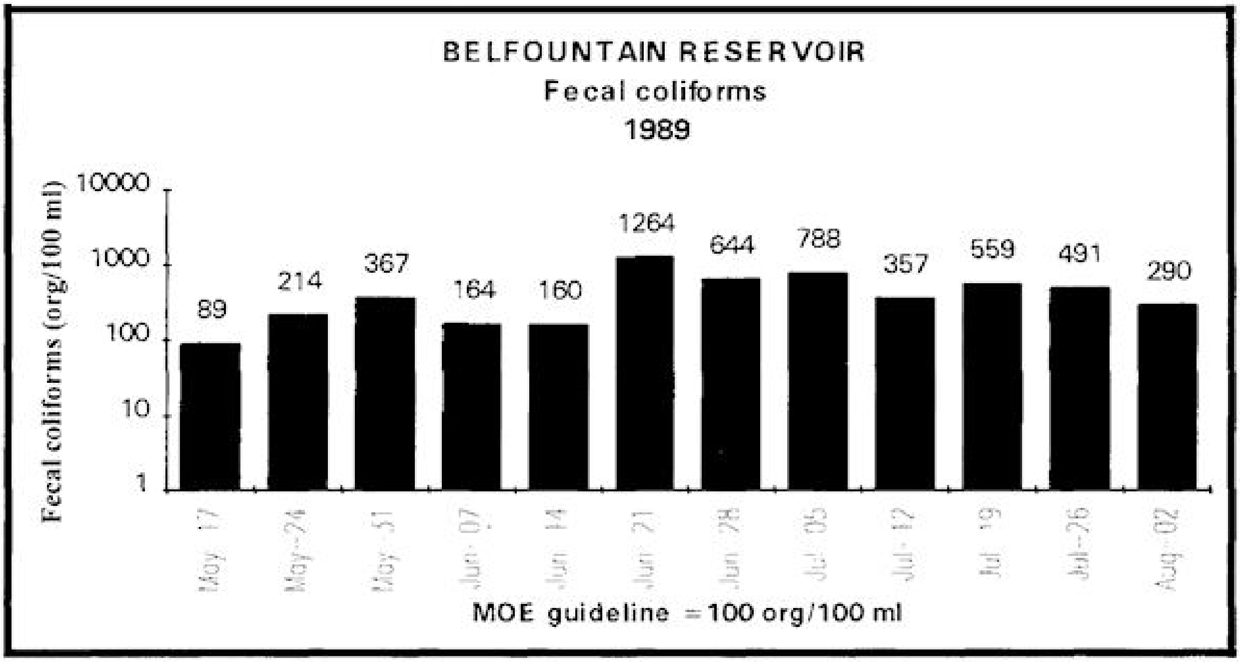


Figure 4: Belfountain reservoir fecal coliform concentrations in 1989.

In February of 1992 the CVCA submitted a proposal to the MOEE in order to participate in the CURB Program. The application was approved and the first year of the Rural Beaches Study was initiated in April of 1992.

5.0 METHODS

5.1 <u>Pollution Source Identification</u>

In an effort to identify the sources of bacterial pollution a wide range of field work and surveys was undertaken within the two year study. These included a land use inventory, water sampling, flow measurements, time of travel measurements, septic systems survey and livestock farmer interviews. Press releases, newsletters, a brochure, TV and radio interviews and an Open House were used to inform the public about the Rural Beaches Program and also encourage the landowners to participate.

5.2 Water Monitoring Network

In the spring of 1992 the sampling network of eighteen stations was established and the monitoring of the West Credit River and its tributaries was carried out on a weekly basis from June through mid September. The streamflow of all stations was measured once during the season by using a pigmy current meter. In addition, there were data available from a permanent gauging station above Erin that measures the main branch stream flow on an hourly basis. Based on the analysis of the 1992 data the sampling design was refined and the weekly monitoring continued from June through mid-September of 1993. Along with the permanent stations, there were some samples taken infrequently at identified agricultural sites, to assess their impact on water quality. Furthermore, stormsewer outfalls in Erin Village were sampled three times and a Hillsburgh stormsewer once during the summer to measure the influence of urban runoff on the river. Two springs that outlet to the Belfountain reservoir and a small tributary rising in Belfountain and joining the river just upstream of the reservoir were tested. The tributary and one of the springs were found to contribute bacteria to the reservoir.

5.3 Water Quality Results

Generally, the 1993 analysis of the bacterial data revealed higher geometric mean *E.coli* concentrations than the 1992 data. This is most likely due to less precipitation and warmer temperatures noted during summer of 1993. Table 1 shows average rainfall and average temperature of 1987-1993 (Ontario Climate Centre) for the study area in comparison with geometric mean fecal coliform (1987-1989) and *E. coli* (1992-1993) of the Belfountain swimming beach.

Table 1: Seasonal average precipitation, air temperature and bacteria concentration (Fecal coliforms = FC for 1987-1989, *E. coli* = EC for 1992-1993) at the Belfountain beach

Year	Rainfall (mm)	Air Temperature (°C)	FC/EC org/100mL
1987	253	19.7	3886
1988	166	19.2	487
1989	228	18.5	700
1992	337	15.8	125
1993	246	18.1	214

Approximately 700 samples were collected at the sampling network during the two year study. At the MOEE Toronto laboratory each sample was analyzed for bacterial, chemical and physical parameters (Table 2).

Table 2: Parameters analyzed for each sample

Bacterial Indicator	Chemical and Physical Parameters
Escherichia coli (E. coli)	Total Phosphorus
Fecal coliforms	Soluble Phosphorus
Fecal streptococci	Total Kjeldahl Nitrogen
Pseudomonas aeruginosa	Ammonium
	Nitrate
	Nitrite
	Chlorides
	Dissolved Oxygen
	Dissolved Organic Carbon
	pH
	Residue Suspended Particles
	Conductivity
	Turbidity
	Temperature

Dissolved oxygen and temperature were measured at the site by using a YSI Model 51 B dissolved oxygen meter.

6.0 CURB MODEL DEVELOPMENT

Information gathered during the study period is utilized in the CURB mathematical model that qualifies and quantifies sources of pollution in the watershed. The mathematical model known as PLOP (Pollution from Livestock Operations Predictor) evaluates pollution potential of livestock operations in Southern Ontario and was developed for the MOEE in 1988 by Ecologistics. Since it was used by different Conservation Authorities, the model algorithms were slightly changed to better suit conditions in each watershed. It was suggested that the CVCA CURB Plan should use the Metropolitan Toronto and Region Conservation Authority (MTRCA, 1991) algorithms, however some other modifications were adopted to reflect specific conditions of the West Credit River watershed.

Generally, the CURB model predicts the seasonal bacteria load delivered to the beach from all identified sources. The first set of algorithms calculates the bacteria load discharged from each source to the adjacent watercourse. These values are then put into the CURB transport model that calculates the final bacteria delivery to the receiving beach while taking into account natural bacteria bacteria die-off and travel time from their point of origin to the receiving beach.

The CVCA CURB model was developed for the following pollution sources identified in the West Credit River watershed:

1. Cattle access to watercourses
2. Barnyard runoff
3. Manure storage runoff
4. Milkhouse washwater disposal systems
5. Private sewage disposal systems
6. Urban stormwater runoff
7. Wildlife

Sites with bacteria contributed from urban private sewage disposal systems, cattle access to watercourses, manure storages/barnyards and milkhouse wastes were modeled as separate sources, while bacteria loads from rural private sewage disposal systems, urban stormwater and wildlife were placed as point sources in the middle of the watershed.

Since the main concern about the beach bacterial pollution and its consequent closure relates to the 92 day summer season, the CVCA CURB model takes into account only this part of the year (from beginning of June through the end of August). In addition, the majority of supportive field data applies to this period. In an effort to reflect different patterns and impacts of the bacteria sources during the summer season, the model is broken into two parts that illustrate dry and wet weather conditions.

6.1 Agricultural Pollution Sources

Livestock operations within the watershed were identified through the windshield surveys. Places not visible from the roads were interpreted from recent airphotos. The landowner survey was conducted only on farms within 150 meters of the watercourse that represent a high pollution potential to water quality.

6.1.1. Landowners Interviews

Livestock operation farmers were interviewed during the summer of 1993 in order to obtain detailed information about their agricultural practices. The questionnaire targeted manure handling practices, livestock watering sources, milkhouse washwater disposal systems as well as barnyard operations. Also necessary farm measurements needed for the mathematical model were taken on a site. The survey was conducted on 20 farms, that had a high pollution potential.

The following agricultural sources were found contributing fecal bacteria to the river system:

1. Cattle access to watercourses
2. Barnyard runoff
3. Manure storage runoff
4. Milkhouse washwater

6.1.2 Cattle Access to Watercourses

Livestock watering in the river was a common practice in the past, but is increasingly no longer acceptable. Cattle not only drink the water, but also frequently urinate and defecate into the watercourse, introducing enormous amounts of fecal bacteria and nutrients to the receiving water. Furthermore, cattle trampling the streambanks cause erosion and siltation of the watercourse and the destruction of aquatic habitat. Contaminated water that carries pathogens also has negative effects on the livestock watering downstream.

6.1.3 Barnyard / Manure Stack Runoff

After a rainfall, contaminated runoff from barnyards and manure stacks reaches the watercourse either by overland flow or subsurface tiles. Manure should be stored in properly designed manure storages and as a valuable fertilizer, be used for further application on cropland. Precipitation runoff must be directed away from barnyards and manure stacks through eavestroughs, berms and surface diversions. Contaminated runoff has to be contained, stored and utilized on the cropland.

6.1.4 Milkhouse Washwater

Direct discharge of milkhouse washwater via surface or subsurface tile drainage has been a common practice on Ontario dairy farms for years. Milkhouse wastes contain excessive amounts of bacteria, phosphorus and other chemicals that originate in washing the milking system. Approximately 35 kilograms of phosphorus is discharged from an average dairy farm herd annually. These contaminants released to a water body represent a health risk to humans and animals alike.

Other potential agricultural pollution sources such as improper manure spreading (overspreading, wrong timing) and manure spills were not detected in the watershed.

6.2 Urban Pollution Sources

The following are urban sources found to impair water quality:

1. Private sewage disposal systems
2. Urban stormwater

Private sewage disposal systems are used to treat the household wastewater on a site in unsewered rural areas. Malfunctioning, improper systems or those illegally connected to a creek or field tiles pose environmental concerns. Failed sewage disposal systems are defined as those that have surface "blowouts", or direct connection to subsurface tiles or storm drains leading into a watercourse or municipal drain. Extreme levels of bacteria and nutrients contained in human sewage eventually enter the open water and could adversely affect human health, aquatic life and animals that utilize this water.

Urban stormwater without any containment or treatment carries bacteria from domestic pets and other contaminants such as road salts to watercourses.

In order to find out about private sewage disposal systems in residential areas, a questionnaire was mailed to all households in Erin Village. Thirty five percent of the questionnaires were returned and the data was summarized according to the following classification system:

1. Private sewage disposal systems more than 30 years old: 5.1%
2. Metal septic tank: 2%
3. 1 compartment septic tank: 4%
4. Septic tanks never pumped: 3.2%
5. Septic tanks not pumped regularly (more than every 8 years): 3.2%
6. Problems of toilet back ups: 3.2%
7. Problems of ponding: 2%
8. Grey water by-pass: 4%

During the past two years the Wellington Health Department conducted a similar survey of certain parts of Hillsburgh and Erin Village.

6.3 Natural Sources

Although wildlife represents a natural component of our pollution sources, different species, especially those related closely to the water environment, contribute bacteria to the watercourses. Wildlife always existed and had certain impact on water quality, nevertheless good management helps to sustain wildlife populations at an acceptable level.

7.0 CURB ALGORITHMS

CURB algorithms predict the total seasonal bacteria load to watercourses from different pollution sources.

7.1 Livestock Access Algorithm

This algorithm calculates the seasonal fecal bacteria load to water courses from cattle access.

ACCESS LOAD = CONC/DEF x EAU x PROB. OF DEF. x EVENTS x # ANIMALS x # DAYS

1. Conc/Def = concentration/defecation; a concentration of 8.9×10^8 *E.coli*/defecation is assumed.
2. EAU = equivalent animal unit; the values are listed in Appendix A.
3. Prob. of def. = probability of defecation; assumed 0.18 (Demal, 1982)
4. Events = the number of access events to a watercourse per day; assumed 2.5 (Demal, 1982).
5. # animals = the number of animals on each farm was obtained from the landowner surveys.
6. # days = access calculated for 92 day summer season

7.2 Manure Stack Runoff Algorithm

This algorithm calculates the total seasonal *E. coli* load from the runoff of manure stacks that were found within 150 metres of the watercourse and had no runoff containment.

STACK LOAD = CONC. x VOL. OF RUNOFF x DELIVERY

1. Conc. = concentration of 7.5×10^9 *E. coli*/ ha-mm was assumed (MVCA, 1989)
2. Vol. of runoff = area of pad (ha) x total seasonal precipitation (mm) x 0.60

i) Area of pad = actual size was obtained from the surveys

ii) Total seasonal precipitation = 246 mm for the 1993 season (data obtained from the Ontario Climate Centre)

iii) assumed runoff from the pad as 60% of seasonal precipitation

3. Delivery = assumed 80% of runoff was entering stream if yard was within 150 m of stream and sloped in that direction

7.3 Barnyard Runoff Algorithm

This algorithm calculates the total seasonal *E. coli* load delivered to watercourses from the runoff of barnyards that were within 150 metres of the stream.

BARNYARD LOAD = CONC. x VOL. OF RUNOFF x DELIVERY

1. Conc. = concentration of 7.5×10^9 *E. coli*/ ha-mm was assumed (MVCA, 1989)
2. Vol. of runoff = area of yard (ha) x total seasonal precipitation x (mm) x 0.60
   - i) Area of yard = actual size was obtained from the surveys
   - ii) Total seasonal precipitation = 246 mm for the 1993 season (data obtained from the Ontario Climate Centre)
   - iii) assumed runoff from the yard as 60% of seasonal precipitation
3. Delivery = assumed 80% of runoff was entering stream if yard was within 150 m of stream and sloped in that direction

7.4 Milkhouse Washwater Algorithm

The following algorithm calculates the total seasonal *E. coli* load discharged to watercourses from dairy farms with improper disposal of milkhouse washwater.

MILKHOUSE WASTES = CONC. x VOL/COW/DAY x # COWS x # DAYS x DELIVERY

1. Conc. = concentration of *E. coli* in milkhouse washwater; assumed to be 2000 *E. coli*/liter (SCRCA, 1991)
2. Vol/cow/day = volume of washwater per cow per day; obtained from the survey
3. # cows = number of cows being milked; obtained from the landowner survey
4. # days = calculated for the 92 day summer season
5. Delivery = % of delivery to the watercourse; 500 % if tile connection, 1 % if draining on the ground (UTRCA, 1989)

7.5 Private Sewage Disposal System Algorithm

This algorithm calculates the seasonal *E. coli* delivery to watercourses from private sewage disposal systems.

SEWAGE DISP. SYS. LOAD = CONC. x VOL/PERS/DAY x # DAYS x SUBBASIN POP. x DELIVERY

1. Conc. = concentration of 1.0×10^7 *E. coli/* litre of effluent at tile outlet was assumed (MVCA,1989)
2. Vol/pers/day = volume of water per person per day was assumed to be 275 L (SCRCA,1990)
3. # days = 92 days (PLOP model, Ecologistics, 1988)
4. Subbasin population = data obtained from the municipal offices
5. Delivery = assumed 5% of the total water consumption in urban areas and 1.5% in rural areas that impact on watercourses via sewage disposal systems (Steering Committee, 1994)

7.6 Urban Non-Point Source Algorithm

This algorithm calculates the 92 day summer season *E. coli* load to a watercourse from urban runoff.

URBAN LOAD = LOAD/HA x URBAN AREA

Load/ha = 3.1×10^{10} *E. coli*/ha of runoff was applied to each urban centre (Marsalek, 1978)

Urban area = aerial measurements in hectares were calculated from the Ontario Base Maps

7.7 Wildlife Algorithm

The wildlife algorithm calculates the seasonal *E. coli* load to a watercourse from wildlife present in the watershed. The calculation takes into account four representative, water related animal species.

WILDLIFE LOAD =	CONC/DEF x AVG. EXCRETION x # ANIMALS x DELIVERY x # DAYS

Conc/def. = *E. coli* concentration per 100 g of feces:

i) beaver = 3.6×10^{6} (HRCA, 1992)
ii) muskrat = 3.6×10^{6} (HRCA, 1992)
iii) goose = 7.8×10^{6} (HRCA, 1992)
iv) deer = 1.59×10^{7} (HRCA, 1992)

Average excretion = excreted feces in grams per animal per day

i) beaver = 657 g (Boutin & Birkenholz, 1987)
ii) muskrat = 100 g (HRCA, 1992)
iii) goose = 100 g (HRCA, 1992)
iv) deer = 2800 g (HRCA, 1992)

animals = estimate obtained from the MNR Cambridge (B. Buckland pers. commun.)

delivery = assumed 5% for beaver, muskrat and goose (MTRCA,1991), 0.5% for deer

days = 92 days for the summer season (PLOP model, Ecologistics, 1988)

7.8 BACTERIA TRANSPORT CALCULATIONS

To predict the bacteria load delivered to the beach a bacteria transport model was developed.

7.8.1 CURB Transport Model

The following algorithm calculates the bacteria contribution of each source to the beach taking into account bacteria die-off and travel time from their place of origin to the receiving beach.

$$N = \text{ANTILOG}\ \{\text{LOG}\ N_0 - (kt)\}$$

N = quantity of bacteria delivered to the beach
N_0 = quantity of bacteria delivered to a watercourse
k = bacteria die-off rate per hour (see below)
t = travel time from the source to the beach (see below)

7.8.2 Bacteria Die-off Rate

A variety of different factors such as temperature, availability of nutrients, sunlight, pH, dissolved oxygen, etc., influence the bacteria survival in the aquatic environment. Many studies are involved in the research of bacteria die-off under different laboratory conditions. These studies, however, provide little information on the survival of microorganisms in mixed populations under variable environmental conditions. The effect of inactivation, the effect of natural predators on microbial population and daily changes in the aquatic environment are not yet well understood.

The bacteria die-off rate for the CURB transport model is based on MTRCA in-stream survival studies that reveal the value of 0.35 logs/day.

7.8.3 Travel Times

The travel time determination was one of the important components of the mathematical modeling. The time of travel measures how long it takes the bacteria to reach the beach from its source of input. In order to obtain the necessary data, travel time was measured under both low and high flow conditions. A small amount of Fluorescein sodium dye was well stirred in several litres of water, poured into the stream and the time was recorded. Downstream of this point the dye was detected at as many places as possible and the time recorded again. High flow conditions (measured after significant rain event) depict half the travel time of base flow conditions.

Individual travel times were assigned to pollution sources such as livestock access, barnyard and manure stack runoff and milkhouse wastes, since their location was easy to determine. For other sources such as wildlife and rural septic systems scattered throughout the watershed the travel time was calculated from the middle of the study area.

7.8.4 Dry and Wet Weather Calculations

The CURB model data is presented two ways that characterize dry and wet weather sources and bacteria contribution to the reservoir under these conditions.

The CURB model was developed for the 92 day summer season determined from June 1 to August 31, 1993 (PLOP model, Ecologistics, 1988). This time period was further broken into two parts:

1. Dry weather events (low flow conditions, 72 days)
2. Wet weather events (high flow conditions, 20 days)

7.8.5 Dry Weather Conditions

Low flow or dry weather conditions were considered to be days where no precipitation was recorded. Based on the precipitation data (Ontario Climate Centre) 72 of the 92 day summer season fell under this category.

The following are the contributing pollution sources under dry weather conditions:

1. Cattle access to watercourses
2. Private sewage disposal systems
3. Milkhouse washwater
4. Wildlife

7.8.6 Wet Weather Conditions

High flow or wet weather conditions occurred during 20 of the 92 day summer season when precipitation greater than 3 mm per day occurred. It was estimated that 3 mm of rainfall per day (CVCA, C. Worte, 1993) would cause runoff from the agricultural land in the West Credit River watershed.

Therefore under wet weather conditions the following sources contribute bacteria to the reservoir:

1. Cattle access to watercourses
2. Private sewage disposal systems
3. Milkhouse washwater
4. Wildlife
5. Barnyard runoff
6. Manure stack runoff
7. Urban non-point sources

8.0 MODEL PREDICTIONS

8.1 Dry Weather *E. coli* Load to Watercourses

The bacteria load discharged from the identified sources and delivered to the watercourses was predicted using the CURB algorithms. The summary on the *E. coli* load delivered to the West Credit River during the 72 day dry weather summer season is given in Table 3. The total of 5.91×10^{13} *E.coli* was discharged to watercourses during this time period. Private sewage disposal systems were found to be the primary source of bacteria to the river, followed by cattle access, wildlife and improper disposal of milkhouse washwater.

Table 3: Seasonal dry weather *E. coli* load to watercourses

Source	***E. coli* load**	**% Contribution**	**Priority**
Private sewage disposal systems	$4.27x10^{13}$	72	1
Cattle Access	$1.11x10^{13}$	19	2
Wildlife	$5.23x10^{12}$	9	3
Milkhouse Washwater	$3.33x10^{10}$	< 1	4
Total	$5.91x10^{13}$	100	

According to the model predictions, faulty septic systems contributed the highest percentage of bacteria (72%) to the watercourses during the summer. Livestock access and wildlife delivered 19% and 9% respectively. Bacteria load from improper disposal of milkhouse washwater was of least importance, contributing less than 1% of the total load. Figure 5 graphically illustrates percent contribution of each source to the watercourses.

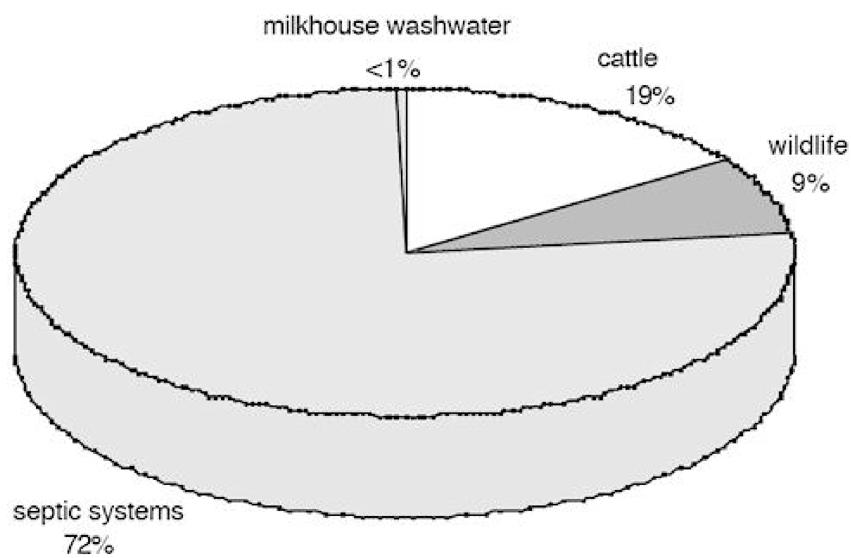


Figure 5: Seasonal dry weather *E. coli* load to watercourses

8.2 Wet Weather *E. coli* Load to Watercourses

During the 20 day wet weather summer season a total load of 2.13×10^{13} *E. coli* was delivered to the watercourses which represents a lower amount than under the dry weather conditions. Table 4 presents the predicted bacteria load discharged from each source, its percent contribution and priority ranking.

Table 4: Seasonal Wet Weather *E. coli* Load to Watercourses

Source	*E. coli* Load	% Contribution	Priority
Private Sewage Disp. Systems	1.19×10^{13}	56	1
Urban Non-point Sources	4.36×10^{12}	20	2
Cattle Access	3.07×10^{12}	14	3
Wildlife	1.45×10^{12}	7	4
Barnyard Runoff	4.96×10^{11}	2	5
Stack Runoff	6.03×10^{10}	<1	6
Milkhouse Washwater	9.24×10^{9}	<1	7
Total	2.13×10^{13}	100	

Figure 6 identifies percent contribution of each source to the watercourses under wet weather conditions. As during dry weather conditions, sewage disposal systems are the major source of bacteria in wet weather discharging 56% of fecal bacteria to watercourses. Runoff from the urban areas delivered 20% and cattle access 14% of the total load. Wildlife accounted for 7% and runoff from barnyards 2% of the total load. Improper disposal of milkhouse washwater and runoff from stacks also contributed bacteria, however the amount represented only less than 1% of the total.

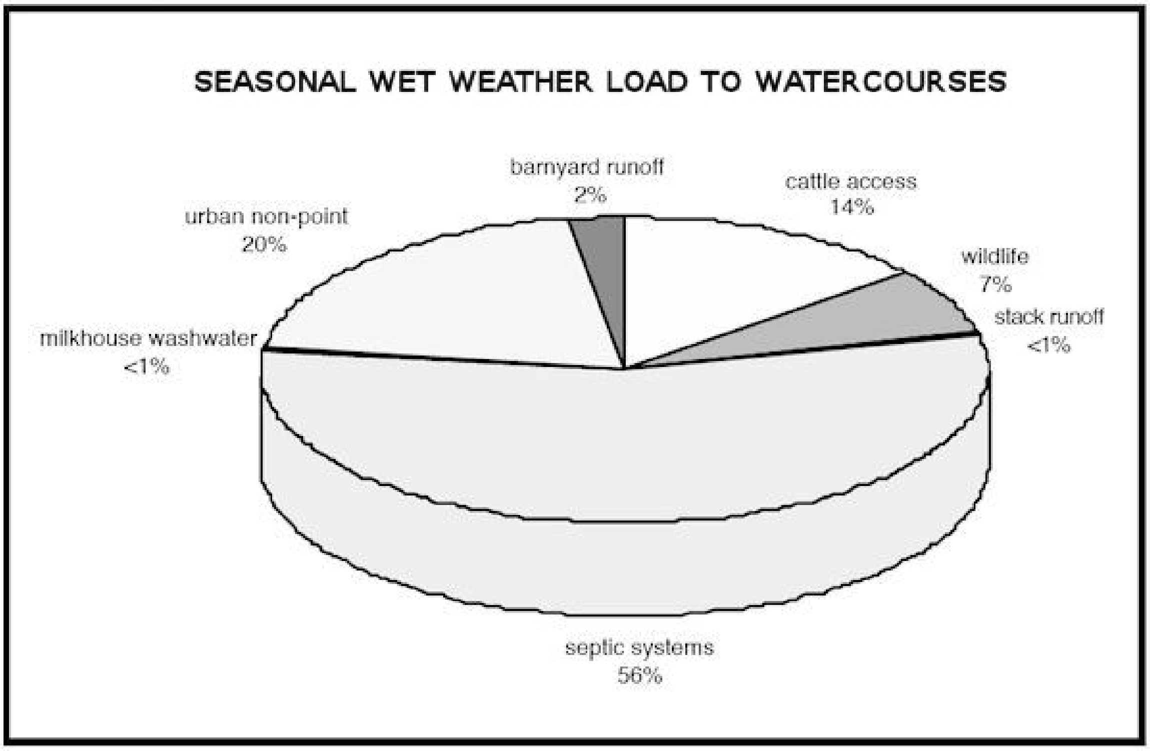


Figure 6: Seasonal wet weather *E. coli* load to watercourses

8.3 *E. coli* Load to the Beach

The CURB model calculates bacteria load delivered to the beach during the 92 day summer season. As was already mentioned above, this time period was divided into two parts representing dry weather (72 days) and wet weather (20 days) conditions.

The CURB transport algorithm calculates the contribution of all bacteria sources to the Belfountain Conservation Area beach, taking into account travel time from the bacteria point of origin, their die-off and disappearance.

8.3.1 Dry Weather *E. coli* Load to the Beach

Evidently, the majority of bacteria are discharged to the watercourses during the 72 day of dry weather conditions.

Table 5 gives an overview on bacteria delivered to the beach from identified pollution sources in the watershed during the dry weather summer season.

Table 5: Seasonal dry weather *E. coli* load to the beach

Source	***E. coli* Load**	**% Contribution**	**Priority**
Private Sewage Disp. Systems	2.49×10^{13}	77	1
Cattle Access	4.63×10^{12}	15	2
Wildlife	2.62×10^{12}	8	3
Milkhouse Washwater	1.18×10^{10}	<1	4
Total	3.22×10^{13}	100	

Based on the model predictions private sewage disposal systems account for 77% of the beach bacteria pollution. Cattle access is the second largest contributor, delivering 15% and wildlife delivers 8% of the total load. Improper disposal of milkhouse washwater from the only dairy operation in the watershed added only less than 1% of the total bacteria. Figure 7 presents graphically percent contribution of individual bacteria sources during the dry weather summer season.

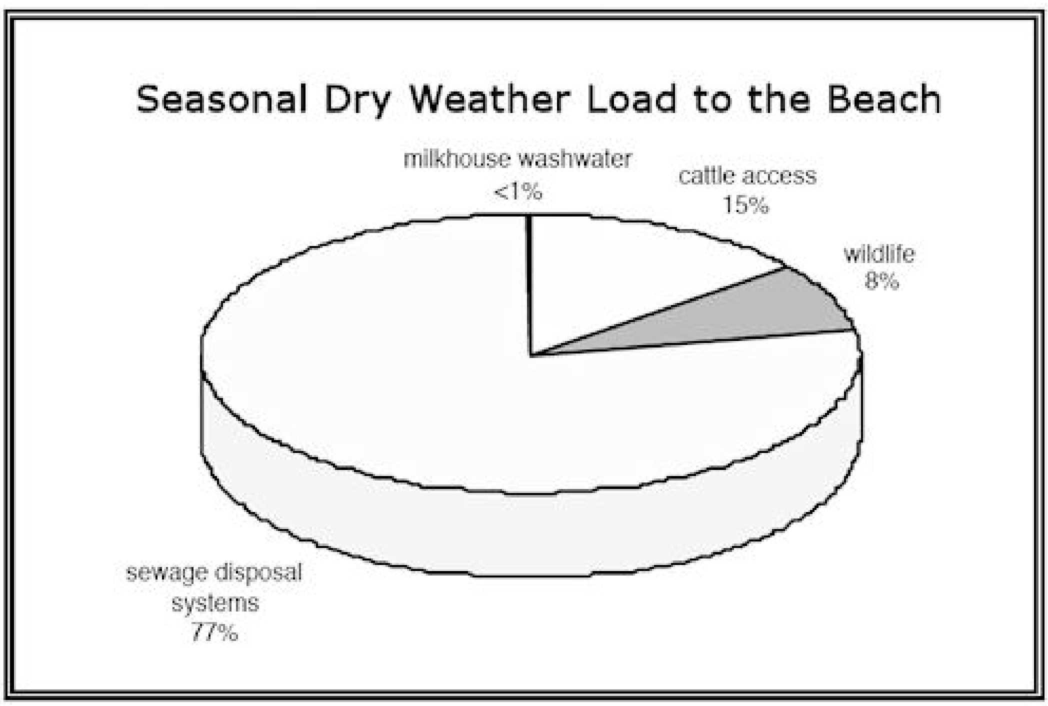


Figure 7: Seasonal dry weather *E . coli* load to the beach

Sewage disposal systems were identified as the number one source, contributing 77% of bacteria reaching the beach. There are three villages serviced by private sewage disposal systems, located on the main branch of the West Credit River, upstream of the reservoir. Belfountain is located just upstream of the swimming beach, Erin Village within 10 hour travel time and Hillsburgh approximately 40 hour travel time from the reservoir. Erin, as the largest built up area in the watershed, is in close proximity to the beach and was found to be contributing about 54% of the total beach bacteria load. Hillsburgh was the second and Belfountain third largest contributor, both delivering 9% bacteria of the total. About 5% was estimated to come from the rural sewage disposal systems in the remainder of the watershed.

Cattle access is the second largest source impacting on the beach and delivering 14% of the total beach load. There were 19 sites identified through the landowner survey with cattle access to watercourses. Most of the farms are located on a tributary with an extensive travel time (29-45 hours) that result in higher bacteria die-off and therefore lesser final impact on the beach.

Wildlife was estimated to deliver 8% of the total beach bacteria load, being the third largest contributor. There is not too much that can be done about wildlife contributions except population control where excess numbers are identified (e.g. Canada geese).

Milkhouse washwater was the least important source of bacteria, contributing less than 1% of the total beach load. The impact from this source is minor since there is only one dairy operation in the watershed located on a small tributary.

8.3.2 Wet Weather *E. coli* Load to the Beach

Over the 20 day wet weather summer period, fewer bacteria were discharged to the river in comparison with the dry weather conditions. However, the bacteria load per day delivered to the beach from identified sources under wet weather conditions is higher due to shorter travel times from their point of origin and higher discharge. The model does not take into account bacteria resuspension from the sediments after rainfall and therefore underestimates wet weather load. Several more contributors come into effect during a rainfall event, when precipitation cause runoff from additional bacteria sources. Seven types of sources were found to deliver bacteria during wet weather (Table 6).

Table 6: Seasonal wet weather *E. coli* load to the beach

Source	*E. coli* load	% Contribution	Priority
Private Sewage Disp. Systems	$8.86x10^{12}$	57	1
Urban Non-Point Sources	$3.29x10^{12}$	21	2
Cattle Access	$1.95x10^{12}$	13	3
Wildlife	$1.03x10^{12}$	7	4
Barnyard Runoff	$3.16x10^{11}$	2	5
Stack Runoff	$4.48x10^{10}$	<1	6
Milkhouse Washwater	$5.51x10^{9}$	<1	7
Total	$1.55x10^{13}$	100	

Similar to the dry weather conditions, private sewage disposal systems were predicted to be the primary contributor, delivering 57% of the total beach bacteria load. As can be seen in comparison of Tables 4 and 6, die-off accounted for a 26% reduction in the bacteria delivered to the watercourses from sewage disposal systems by the time it reached the beach.

Urban non-point sources were recognized as the second largest contributor that added 21% of bacteria delivered to the beach, followed by cattle access with 13% of the total bacteria load to the beach.

Wildlife, barnyard and manure stack runoff and milkhouse washwater are lower priority sources that, combined, accounted for the remaining 9% of the total.

Figure 8 presents the percent contribution of each source to the beach bacteria load during the wet weather.

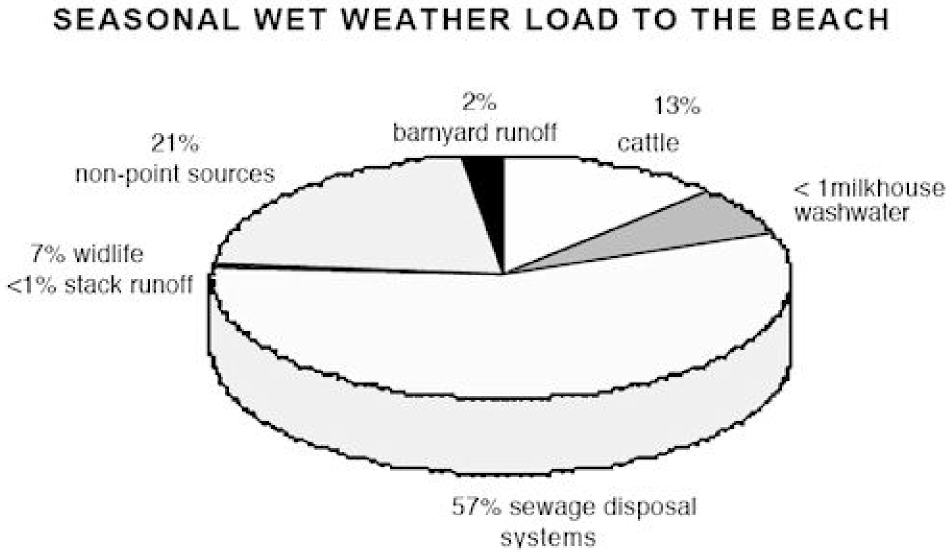


Figure 8: Seasonal wet weather *E. coli* load to the beach

8.3.3 Total Seasonal *E. coli* Load to the Beach

According to the CURB model predictions, the total bacteria load delivered to the beach during the 92 day summer season was $4.77x10^{13}$. A reduction of $3.27x10^{13}$ or 41% of the total bacteria load discharged to the watercourses and delivered to the beach was estimated to be due to natural die-off.

Table 7 gives an overview of bacteria loads delivered to the watercourses and consequently to the beach during the summer season.

Table 7: Comparison of the seasonal *E. coli* load to the watercourses and to the beach.

Source	Watercourse Load	Beach Load
Cattle Access	$1.42x10^{13}$	$6.58x10^{12}$
Septic Systems	$5.46x10^{13}$	$3.37x10^{13}$
Wildlife	$6.68x10^{12}$	$3.65x10^{12}$
Milkhouse Washwater	$4.25x10^{10}$	$1.73x10^{10}$
Stack Runoff	$6.03x10^{10}$	$4.48x10^{10}$
Barnyard Runoff	$4.96x10^{11}$	$3.16x10^{11}$
Urban Non-point Sources	$4.36x10^{12}$	$3.29x10^{12}$
TOTAL	$8.04x10^{13}$	$4.77x10^{13}$

Figure 9 shows graphically the percent contribution of each source to the beach during the entire summer season.

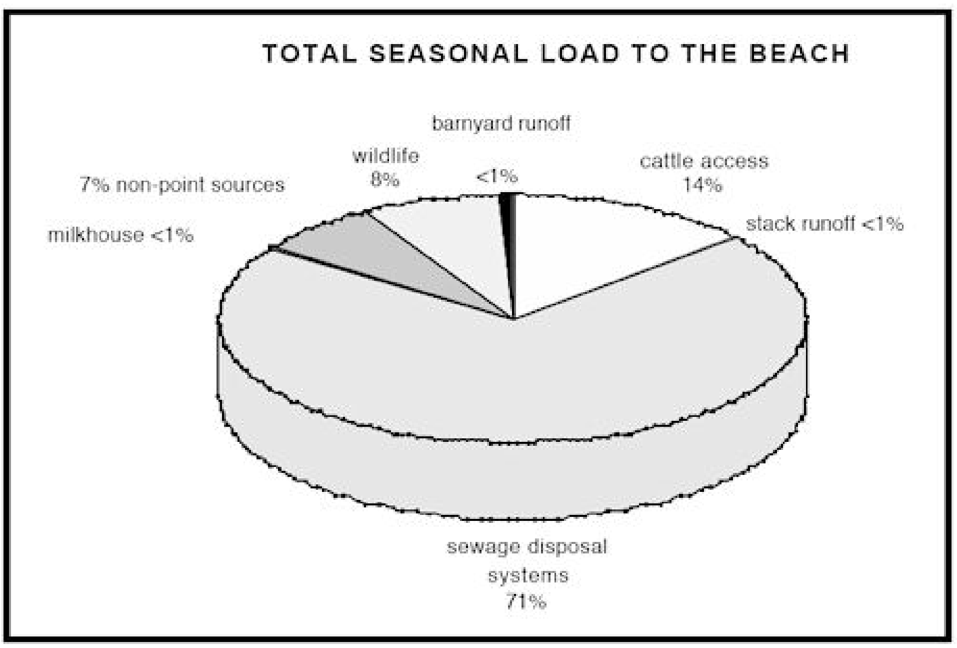


Figure 9: Total seasonal *E. coli* load to the beach

Private sewage disposal systems represent the leading bacteria source, contributing 71% of the total bacteria load delivered to the beach during the summer. The explanation for the sewage disposal systems being the number one pollution source is the location of two urban centres (Erin Village and Belfountain) on the main branch of the West Credit River within a short distance from the beach. From the total bacteria load of $5.46x10^{13}$ delivered to watercourses by private sewage disposal systems, 38% of bacteria died-off during the transport to the beach.

The second most significant source is cattle access to watercourses that adds 14% or $6.58x10^{12}$ of the total bacteria to the beach. Most of these farms and sites where cattle have access to a watercourse are located on a tributary, a long distance from the beach. A large wetland below the sources help to filter out excessive bacteria and nutrients. Therefore the bacteria load at the beach represents a reduction of 54% of the total initial load.

Wildlife contributed 8% or $3.65x10^{12}$ bacteria to the beach during the summer and had a priority rating of three. Deer, muskrat, beaver and goose populations were taken into account for the CURB model. As was mentioned previously, there is not too much that can be done about wildlife, except population management in certain areas.

Urban non-point sources or stormwater runoff from the built up areas contributed 7% or $3.29x10^{12}$ bacteria to the beach, representing the fourth most important source. Stormwater from all three villages is discharged through storm sewers or ditches directly to the river without any prior treatment. A reduction of 25% of the initial input was documented.

Three remaining agricultural sources were found to be contributing a significantly lower amount of bacteria to both watercourses and the beach. Barnyard runoff, manure stack runoff and milkhouse washwater contributed a combined 1% or $3.78x10^{11}$ of the total bacteria load to the beach.

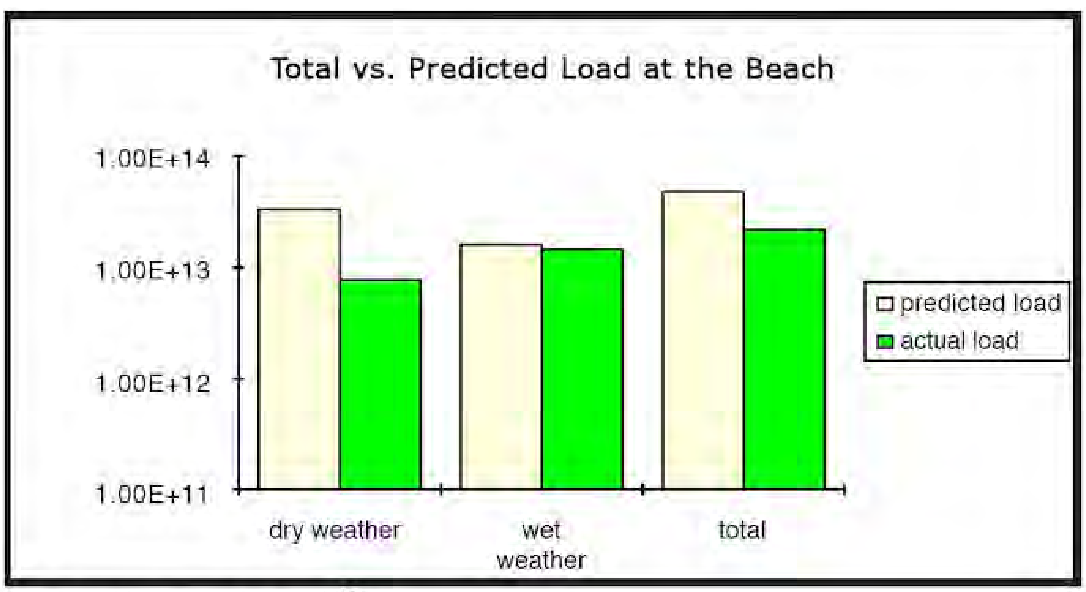
Other agricultural sources such as improper manure spreading and manure spills, that might impact the water quality, were not identified.

9.0 CURB MODEL VERIFICATION

A comparison with the actual water quality data was made in order to verify the results calculated by using the CURB model algorithms.

The watershed area was broken down into four parts and the actual bacteria concentration was calculated for each station that addressed the upstream sources of each area. Geometric mean *E. coli* concentration of the station was multiplied by the average discharge to obtain the actual bacteria load for each area. These results were compared to the actual beach load, calculated the same way, and expressed as a percent contribution of the total load. Predicted bacteria loads for the same stations were calculated by using the CURB algorithms. The predicted load reflected the sum of sources identified in the upstream part of the section. This load was compared to the predicted total beach load and its percent contribution to the beach was calculated. The prediction was close to the actual loads calculated.

Figure 10 shows the seasonal comparison of the beach bacteria loads predicted by the mathematical model and actual loads measured at the beach.



$1.00E+01 = 1.00x10^{10}$

Figure 10: Total versus predicted seasonal *E.coli* load at the beach (1993)

Figures 11 and 12 compare the concentration of the individual samples collected at the beach during the summer season to the predicted range. The CURB model predicts the dry weather *E. coli* (EC) concentration to be between 431-725 EC/100 mL. The prediction is higher than the actual geometric mean of 132 EC/100 mL probably due to model limitations (See 9.1) or due to overestimates of the pollution sources.

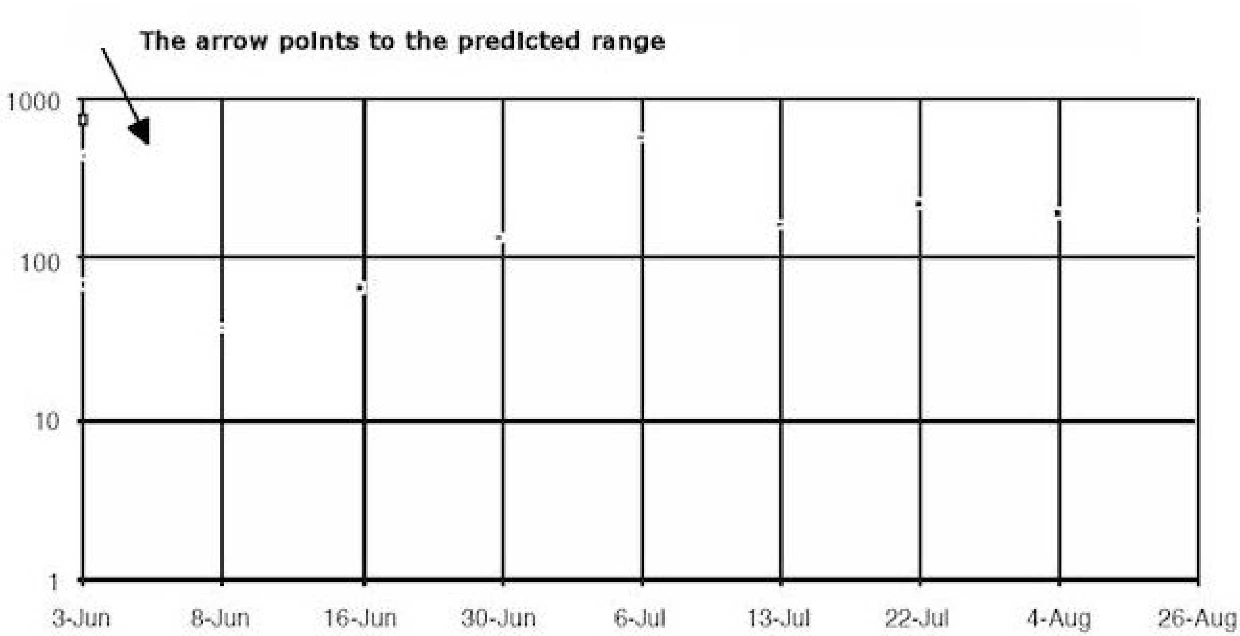


Figure 11: Predicted versus actual water quality data at the beach under dry weather conditions

Figure 12 compares predicted and actual *E. coli* concentrations under the wet events. The model predicts the wet weather bacteria concentrations to be within the 528-862 EC/100 mL range. The measured geometric mean of 636 EC/100 mL falls within the prediction.

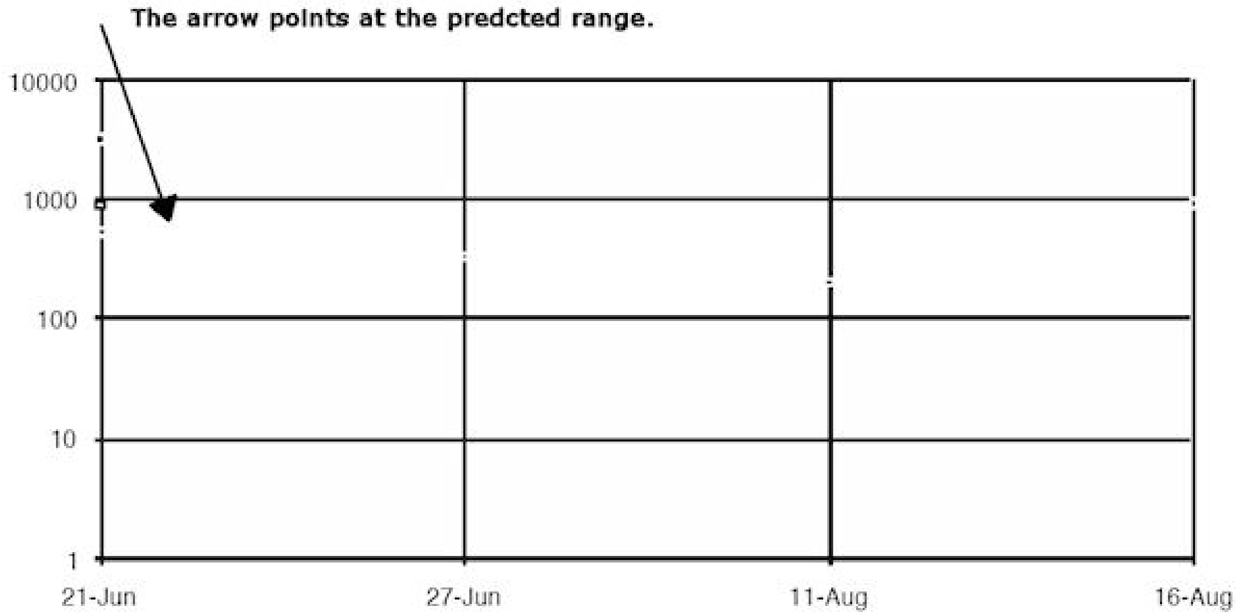


Figure 12: Predicted versus actual water quality data at the beach under wet weather conditions

9.1 Model Limitations

The CURB model is a mathematical model with limited accuracy. The following is a list of potential limitations that may result in some discrepancies.

1. The transport model does not account for bacteria sedimentation during the dry events and their resuspension after rainfall.

2. Some of the algorithm components values had to be estimated, such as:
   i. Delivery rate for the private sewage disposal systems.
   ii. Concentration of wildlife populations and the delivery rate.

3. Only some wildlife species were included in the model based on an estimate.

4. Travel time of certain river reaches was estimated due to technical difficulties of dye testing.

5. Wildlife and rural sewage disposal system algorithms were simply calculated as point sources in the middle of the watershed.

6. This model takes into account only the summer swimming season (June through August) due to the availability of the field data and the period of beach closure, even though bacteria enter the river and beach year round.

10.0 REMEDIAL MEASURE COSTS

The remedial measure costs were calculated for projects identified in the watershed and that can be addressed through the CURB program. Table 8 lists costs calculations for different items funded by the CURB program.

Table 8: Approximate remedial project costs.

Remedial Project	Cost
Livestock Access Restriction	
Fencing	$10/m
Alternate Watering Device	$500
Mid-level Crossing	$5,000
Private Sewage Disp. Systems	
Septic Tank + Tile Bed	$5,000
Manure Storage	$25,000-35,000
Runoff Containments	$20,000-25,000
Milkhouse Washwater Disposal Systems	
Treatment Trench System	$10,000

The total estimated cost for the West Credit River watershed is $1,025,000 and would result in 85% bacteria reduction at the Belfountain Conservation Area beach if all projects are completed. Table 9 gives an overview and break down of the watershed costs for remedial projects addressed through the CURB Program.

Table 9: Watershed Remedial Project Costs

Remedial Project	# Projects	Capital Costs	Bacteria Reduction
Livestock Access Restriction	19	$56,800	14%
Private Sewage Disp. Systems	89	$443,750	71%
Manure Storage	12	$340,000	<1%
Barnyard Runoff Containment	7	$175,000	<1%
Milkhouse Washwater Disposal System	1	$10,000	<1%
Total	128	$1,025,550	85%

Private Sewage Disposal Systems

The total cost for replacing or upgrading sewage disposal systems in the watershed was estimated to be $443,750. The estimate is based on an approximate cost of $5,000 per sewage disposal system (M. Smith, Wellington Health Department).

Cattle Access

A total watershed cost was calculated for cattle access restriction to watercourses. The price for the page wire fence was estimated to be $10 per metre (MVCA,1990). A cost of $500 for the nose pump (MTRCA, 1990) was added to sites that required alternate watering source. Furthermore the price of $5,000 was estimated for the mid-level crossing. Cattle access restriction proved to be the second least costly remedial measure.

Manure Stack Containment

Manure stack containments were proved to be the second most costly remedial measure estimated at $340,000. The cost for a solid covered manure storage ranges from $25,000-$35,000 (SCRA, 1990) according to a size of operation.

Barnyard Runoff Containments

Runoff containments ranked as a third most costly method for reducing bacteria load to the beach. A total estimate of $175,000 is based on $20,000 to $25,000 per open concrete runoff tank in the watershed (MTRCA, 1990).

Milkhouse Washwater Disposal Systems

A proper disposal of milkhouse washwater was found to be the least costly remedial method since there is only one dairy farm in the watershed. A cost of $10,000 was estimated for the sediment tank treatment trench system.

Urban Non-Point Sources

The cost for the urban non-point sources was not calculated because the remedial measures can not be addressed and implemented through the CURB program.

10.1 Remedial Measure Cost-effectiveness

Private Sewage Disposal Systems

Private sewage disposal systems were found to be the most efficient and cost effective remedial measure for improving water quality in the Belfountain Conservation Area reservoir. If all proposed projects were completed, a 71% bacteria reduction at the beach at a cost of $443,750 would occur. This would lower the dry weather geometric mean from 132 EC/100 mL to 39 EC/100 mL and wet weather geometric mean to from 636 EC/100 mL to 187 EC/100 mL.

CURB may cover 50% of each project cost with a grant ceiling of $2,000 for sewage disposal system upgrading or replacement.

Cattle Access

Livestock access restriction to watercourses was recognized as a second most efficient and cost effective measure to the beach water quality improvement. A total of $56,000 spent on the proposed projects would result in about 14%

bacteria reduction at the beach. In terms of bacteria concentrations, the *E. coli* geomean at the beach would decrease to 114 EC/100 mL under the dry weather conditions and to 547 EC/100 mL under the wet weather conditions. The estimated total cost includes fencing cattle out of the watercourses, alternate water supply, mid-level crossings where necessary and bank re-vegetation.

CURB grants may cover 75% of each project cost with a ceiling of $10,000.

Barnyard Runoff / Manure Stack Containments

Barnyard runoff and manure stack containments ranked as the second and the third most efficient and cost effective remedial measure requiring $340,000 and $175,000 for the projects implementation. The CURB program funds different types of manure storages, runoff containments and eavestroughs and surface diversions that would direct precipitation runoff away from contaminated barnyards and stacks. If suggested projects are completed, the beach bacteria concentration would be lowered by less than 1%, without significantly improving water quality.

The CURB program covers 50% of the manure storage or runoff tank costs with a ceiling of $12,000.

Milkhouse Washwater Disposal Systems

Milkhouse washwater disposal was found to be the least costly and cost effective method to improving beach water quality. This project has an estimated cost of $10,000 for the only dairy farm in the watershed. This would decrease the bacteria concentration at the beach insignificantly by less than 1%.

A grant rate of 50% and a grant ceiling of $5,000 is offered for milkhouse washwater disposal systems.

Urban Non-Point Sources

Urban stormwater was detected as a quite important wet event source contributing 7% of the total bacteria load to the beach. The impact of stormwater should be funded through alternate programs since it does not qualify under the CURB Program.

11.0 IMPLEMENTATION STRATEGY

The Credit Valley Conservation Authority is prepared to start undertaking the first year of the CURB program implementation phase. The CVCA will work as THE lead agency with technical and financial support of the MOEE. The CURB Review Committee comprised of the MOEE, CVCA, the Ministry of Health, the Ontario Ministry of Agriculture and Food and the Ontario Soil and Crop Improvement Association representatives will review and evaluate proposed projects.

11.1 Private Sewage Disposal Systems

In the villages and rural areas of the West Credit River watershed, sewage and sanitary waste disposal is collected, treated and disposed of on site through the use of private sewage disposal systems. A correctly designed, constructed and maintained sewage disposal system will function effectively and safely, however a system not fulfilling these requirements may endanger health and the environment. According to the CURB model, private sewage disposal system failures were identified as a major contributor of bacteria to watercourses and the Belfountain beach.

A survey undertaken by the CVCA in 1992 identifies that approximately 27% of sewage disposal systems are in the Village of Erin are substandard, experiencing problems such as back-ups and ponding, or are not regularly or have never been maintained. These problem sewage disposal systems could not be precisely located due to anonymity of the survey. The majority of bacteria that affect the beach comes from this source.

If there is a necessity of further investigation on systems that are contributing to pollution, the Health Department should be the lead agency in undertaking this task. If a problem is detected there is a regulatory follow up that requires improvement of the system up to the standard. However, under the CURB program no enforcement can be performed and the homeowners would only be encouraged to upgrade their sewage disposal systems.

If a communal system is to be considered for part of the Village of Erin a thorough investigation of existing sewage disposal systems should be conducted with cooperation of involved agencies.

The CVCA should work jointly with the Peel and Wellington Health Departments to increase awareness on malfunctioning sewage disposal systems and implementing remedial measures. Newsletters and fact sheets will be distributed to all watershed residents comprising information on public health and environmental hazard that results in improper systems. The homeowners will be encouraged to upgrade their sewage systems while utilizing CURB grants.

11.2 Livestock Access

Livestock access to watercourses has been identified as a second major contributor of bacteria to watercourses and to the beach. Excessive levels of bacteria, nutrients and sediments are delivered to watercourses through cattle access. Various pathogenic bacteria, viruses and parasites comprised in feces could negatively influence downstream users of water. Extreme nutrient loading in watercourses causes algae growth, and subsequent eutrophication.

Restricting livestock out of the watercourses is the second most cost effective mean to reduce bacterial and nutrient levels in watercourses and at the beach.

A great importance of the educational process will be the need to make farmers aware of the impact that cattle access causes to watercourses. As part of the extension services, fact sheets and newsletters that provide information on fencing and alternate watering devices will be distributed to landowners. Alternative solutions will be discussed on an individual basis with interested farmers. The CURB grants should also motivate farmers to recognize problems and come forward.

11.3 Barnyard and Manure Stack Runoff

In comparison to the sources mentioned above barnyard and manure stack runoff had a low priority ranking in bacteria contribution to the beach. Nevertheless the impact on local watercourses or certain river reaches would be much more significant.

Contaminated water from manure stacks, uncovered manure storages and barnyards is carried with precipitation via surface runoff towards watercourses. Bacteria and nutrients from livestock manure are delivered to watercourses and the downstream swimming beach causing water be unsafe for livestock consumption and recreational purposes.

Many farms in the watershed are of a smaller scale. Majority of operations are hobby farms with lower number of cattle or horses that do not have any type of barnyard at all. Cattle or horses stay at pastures that surround barns and some farmers keep cattle at pastures year round. There would certainly be an impact from runoff of these pastures, however, the CURB model did not take this into account.

It will be necessary to promote correct manure management practices to landowners through shows, open houses or door to door advertising. Factsheets that describe different options of manure containment will be made available to farmers. Clean water diversion projects such as eavestroughs on farm buildings, earthen berms and diversion ditches will be promoted to keep clean water away from contaminated areas.

Grants offered by the CURB program will encourage landowners to address existing problems.

11.4 Milkhouse Washwater Disposal Systems

Milkhouse waste management is an important part of each dairy operation and planning of proper containment and disposal of milkhouse wastes plays a very important role. Commonly in the past the wastewater was directly discharged to watercourses. This wastewater contains excessive amount of bacteria and nutrients that negatively impact water quality and cause health risk to potential water users. An average dairy farm discharges about 30 kg of phosphorus in milkhouse wastewater per year in addition to other chemicals that originate in detergents used for flushing pipelines.

The milkhouse wastes from a dairy operation could be added to a liquid manure or runoff storage and be spread on a land or be contained and treated in a septic tank/treatment trench system. Research shows that in order to extend a life span of the system the first flush from the line that contains some milk should be fed to calves. This prevents milk solids from entering the trenches and prevents their clogging. Conservation sinks that ensure lower water use could be also used.

Although there is only one dairy farm in the studied watershed far upstream of the beach, this local water quality problem should be addressed as well.

Financial incentive offered by the CURB program together with technical advice would allow the landowner fix existing problems.

12.0 CURB RECOMMENDATIONS

The following are the recommendations of the Credit Valley Conservation Authority CURB Plan:

1. The CVCA in concept with appropriate agencies should address bacteria sources contributing to the Belfountain Conservation Area beach water quality degradation that were identified through the study.

2. The CVCA should be involved as the lead agency in the MOEE's CURB Program to implement remedial measures aimed at water quality improvement. The program will be carried out with technical assistance of the Steering Committee comprised of the Ontario Ministry of Environment and Energy, the Ministry of Health, the Ontario Ministry of Agriculture and Food, the Ontario Soil and Crop Improvement Association and the CVCA representatives.

3. The Wellington and Peel Health Departments should work cooperatively with the CVCA to further investigate substandard or malfunctioning private sewage systems.

4. The residents should be better educated on functioning and maintenance of sewage disposal systems and also encouraged to repair or upgrade inappropriate systems. The residents should be encouraged to better maintain their septic systems, e.g. pump them regularly every 1-3 years.

5. The Health Units in cooperation with the CVCA should further investigate sewage systems impacting on watercourses within the watershed, especially in the Village of Erin, eg. dye testing, further surveys. Due to the greatest impact of the Village of Erin of all identified sources, upgraded or alternative sewage treatment methods should be properly researched for the Village of Erin when problem areas are identified.

6. Farmers should be encouraged to adopt recommended conservation agricultural practices and participate in the CURB program implementation phase.

7. The CVCA should continue to carry out an extensive educational program in the watershed through newsletters, press releases, an Open House, public broadcasting, etc., to inform the residents on pollution sources of the West Credit River and Belfountain reservoir, and the remedial measures that are offered and should be undertaken.

8. Water quality monitoring should continue to assess long term trends and effectiveness of implementation projects.

9. More groundwater studies should be carried out to confirm potential septic system leakage, new by-law controls of appropriate designs and alternatives.

10. Subwatershed study should be initiated to holistically review interrelated resource issues.

11. Protection or creation of wetlands as hydrologically important areas that significantly contribute to water purification should be encouraged.

12. Stormwater management retrofitting to prevent or reduce impacts should be implemented.

REFERENCES

Ecologistics Limited, 1988. PLOP-A Planning Tool to Evaluate the Pollution Potential of Livestock Operations in Southern Ontario. Waterloo, Ontario.

Buckland B. 1994. Ontario Ministry of Natural Resources. Personal Communication. Cambridge, Ontario.

Brandes M. Characteristics of Effluents from Gray and Black Water Septic Tanks. Journal WPCF, November 1978: 2547-2559.

Crane S.R., Moore J.A., Grismer M.E., Miner J.R. Bacterial Pollution from Agricultural Sources: A Review. American Society of Agricultural Engineers, 1983: 858-873.

Evans M.R., Smith M.P.W. Treatment of Farm Animal Waste. Journal of Applied Bacteriology Symposium Supplement 1986: 27-41.

Hudson J.J., Roff J.C. 1992.Bacterial Productivity in Forested and Open Streams in Southern Ontario. Journal of Fisheries and Aquatic Science. Vol.49: 2412-2421.

Kress M., Gifford G.F. 1984. Fecal Coliform Release from Cattle Fecal Deposits. Water Resources Bulletin, Vol 20, No 1: 61-65.

Linton A.H., Hinton M.H. 1988. Enterobacteriaceae Associated with Animals in Health and Disease. Journal of Applied Bacteriology Symposium Supplement, 71-85.

Mar P. 1991. Clean Up Rural Beaches Plan for the East Humber River, Centreville Creek, and Bruce Creek Watersheds. Downsview, Ontario.

Ministry of the Environment and Energy. 1984. Water Management, Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.

Quershi A.A. 1979. Microbiological Studies on the Quality of Urban Stormwater Runoff in Southern Ontario. Water Research, Vol 13: 977
985.

APPENDIX A:

EQUIVALENT ANIMAL UNITS (EAU)

Animal Type	Weight (kg)	EAU EC	EAU Phosphorus
Beef Cow		1.04	1.04
Slaughter Steer	455	1.00	1.00
Yearling Beef	365	0.71	0.78
Beef Calf	180	0.480	0.53
Dairy Cow		1.62	1.50
Dairy Heifer	318	0.71	0.75
Dairy Calf	136	0.36	0.46
Sheep	45	0.02	0.17
Turkey	4.5		0.03
Chicken/Duck	1.8		0.02
Horse	455	0.013	1.20

From PLOP Model, Ecologistics, 1988

APPENDIX B:

CURB MODEL CALCULATIONS AND REMEDIAL MEASURE COSTS

CATTLE ACCESS

Farm #	Bac. Load Dry	Bac. Load Wet	Cost
1	9.12×10^{10}	1.79×10^{11}	$2,800
2	7.32×10^{9}	4.76×10^{9}	$2,100
3	1.37×10^{11}	6.16×10^{10}	$2,500
4	1.65×10^{11}	1.19×10^{11}	$6,100
5	5.13×10^{8}	2.72×10^{8}	$2,100
6	3.16×10^{9}	1.68×10^{9}	$1,000
7	6.88×10^{8}	2.10×10^{8}	$2,500
8	7.53×10^{10}	$4,20 \times 10^{10}$	$2,500
9	1.13×10^{11}	6.26×10^{10}	$4,500
10	4.52×10^{10}	2.51×10^{10}	$2,100
11	3.28×10^{11}	1.95×10^{11}	$1,500
12	2.18×10^{11}	1.27×10^{11}	$3,000
13	1.74×10^{9}	7.37×10^{8}	$1,500
14	5.96×10^{11}	2.78×10^{11}	$8,000
15	1.88×10^{11}	6.60×10^{10}	$1,500
16	9.41×10^{8}	3.30×10^{8}	$2,500
17	5.45×10^{11}	1.95×10^{11}	$8,000
18	1.45×10^{12}	5.19×10^{11}	
19	5.70×10^{11}	1.63×10^{11}	$2,600
Total	4.63×10^{12}	1.95×10^{12}	$56,800

BARNYARD RUNOFF

Farm #	Bac. Load Dry	Bac. Load Wet	Cost
3		1.76×10^{6}	$25,000
4		1.68×10^{4}	$25,000
8		4.44×10^{10}	$25,000
6		1.39×10^{10}	$25,000
20		1.25×10^{11}	$25,000
13		3.76×10^{10}	$25,000
18		2.76×10^{10}	$25,000
Total		3.16×10^{11}	$175,000

MANURE STACK RUNOFF

Farm #	Bac. Load Dry	Bac. Load Wet	Cost
1		$2.42x10^9$	$35,000
2		$4.88x10^8$	$25,000
3		$2.73x10^9$	
4		$2.91x10^9$	$35,000
5		$1.39x10^9$	$25,000
6		$1.39x10^9$	$25,000
7		$2.22x10^9$	
8		$2.22x 10^9$	$25,000
9		$2.22x 10^9$	$25,000
10		$1.78x10^9$	$25,000
13		$3.14x10^9$	
14		$2.64x10^9$	$35,000
15		$2.81x10^9$	
16		$2.11x10^9$	$25,000
17		$3.45x10^9$	
18		$3.45x10^9$	
19		$4.32x10^9$	$35,000
20		$3.14x10^9$	$25,000
Total		$4.48x10^{10}$	$340,000

PRIVATE SEPTIC SYSTEMS

	Bac. Load Dry	Bac. Load Wet	Cost
Hillsburgh	$2.99x10^{12}$	$1.65x10^{12}$	$96,000
Erin	$1.74x10^{13}$	$5.76x10^{12}$	$229,000
Belfountain	$2.79x10^{12}$	$7.8x10^{11}$	$21,000
Rural	$1.71x10^{12}$	$6.73x10^{11}$	$96,000
Total	$2.49x10^{13}$	$8.86x10^{12}$	$435,000

MILKHOUSE WASHWATER DISPOSAL SYSTEMS

Farm #	Bac. Load Dry	Bac. Load Wet	Cost
21	$1.18x\ 10^{10}$	$5.5x\ 10^{9}$	$10,000

WILDLIFE

	Bac. Load Dry	Bac. Load Wet
Total	$2.62x\ 10^{12}$	$1.03x\ 10^{12}$

URBAN NON-POINT SOURCES

	Bac. Load Dry	Bac. Load Wet
Hillsburgh		$6.29x\ 10^{11}$
Erin		$2.35x10^{12}$
Belfountain		$3.09x10^{11}$
Total		$3.29x10^{12}$