MAIN MENU

TECHNICAL DOCUMENT

ENVIRONMENTAL PLANNING FOR THE CREDIT RIVER HEADWATERS SUBWATERSHED NO. 19

Prepared by:

Aquafor Beech Limited

Terraqua Investigations Ltd.

Beak International Incorporated

Geomatics International Inc.

Triton Engineering Services Limited

Walker, Nott, Dragicevic Associates Limited

January 1997
Ref No. 6516.30

FOREWORD

This document is one of four that has been prepared as part of the study. This document (the TECHNICAL DOCUMENT) describes in detail the findings and recommendations of the study.

The other three documents include a(n):

- EXECUTIVE SUMMARY which provides highlights from the study (four pages);
- SUMMARY REPORT which provides a brief overview of the key findings and recommendations; and
- TECHNICAL APPENDIX which in turn contains six separate documents detailing specific field and/or technical components of the study (140 pages approximately).

We would like to extend our appreciation to all who participated in the study, including:

- staff from Amaranth Township, Town of Caledon, East Garafraxa Township, Mono Township, Town of Orangeville, Region of Peel, the Credit Valley Conservation, Ontario Ministry of Environment and Energy, Ministry of Municipal Affairs, Ministry of Agriculture and Food, and Ministry of Natural Resources;
- members from the Public Advisory Group;
- local residents; and
- representatives from local interest groups.

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1.1
	1.1 General	1.1
	1.2 Background	1.2
	1.3 Study Rationale	1.3
	1.4 Study Goal and Objectives	1.3
	1.4.1 Study Goal	1.3
	1.4.2 Study Objectives	1.4
	1.5 Report Outline	1.5
	1.6 Terminology	1.6
2.0	SUBWATERSHED NO. 19	2.1
	2.1 General	2.1
	2.2 Existing and Approved Land Uses	2.1
	2.3 Physiography	2.2
	2.4 Surface Water Drainage	2.3
3.0	EXISTING SUBWATERSHED CONDITIONS	3.1
	3.1 General	3.1
	3.2 Natural Environmental Resources	3.1
	3.3 Water Resource Features	3.2
	3.3.1 Hydrology	3.2
	3.3.2 Regional Climate and Streamflow Characteristics	3.3
	3.3.3 Water Budget	3.5
	3.3.4 Flood Flows	3.5
	3.3.5 Flood Risk	3.7
	3.4 Hydrogeology	3.7
	3.4.1 Overview	3.7
	3.4.2 Objectives	3.9
	3.4.3 Background	3.10
	3.4.4 Field Methods	3.10
	3.4.5 Geology and Hydrostratigraphy	3.10
	3.4.6 Baseflow and Discharge	3.13
	3.4.7 Recharge Areas, Discharge Areas and Groundwater Flow	3.17
	3.4.8 Aquifer Systems and Groundwater Supply	3.22
	3.4.9 Summary	3.25
	3.5 Surface Water Quality	3.25
	3.5.1 General	3.25
	3.5.2 Key Water Quality Parameters	3.28
	3.5.3 Historical Water Quality Data Review	3.29

Page

3.5.4 Water Quality Monitoring Program 3.36
3.5.5 Water Quality Modelling 3.37
3.5.6 Summary 3.38
3.6 Fluvial Geomorphology 3.39
3.6.1 Overview 3.39
3.6.2 Geomorphic Principles 3.40
3.6.3 The Study Area 3.41
3.6.4 Study Methodology 3.42
3.6.5 Results 3.42
3.6.6 Baseline Geomorphic State 3.43
3.6.7 Sensitivity to Change 3.46
3.6.8 QUALHYMO Model Analysis of Instream Erosion Potential 3.47
3.6.9 Summary 3.48
3.7 Terrestrial Features 3.49
3.7.1 Introduction 3.49
3.7.2 Study Objectives 3.50
3.7.3 Study Methods 3.50
3.7.4 Summary 3.55
3.8 Aquatic Features 3.56
3.8.1 Introduction 3.56
3.8.2 Study Objectives 3.58
3.8.3 Study Methods 3.58
3.8.4 Key Findings 3.60
3.8.5 Summary 3.63
3.9 Natural System Linkages 3.63
3.10 Summary 3.66

4.0 STUDY GOALS AND OBJECTIVES 4.1
4.1 General 4.1
4.2 First Public Open House 4.4

5.0 ALTERNATIVE BEST MANAGEMENT PRACTICES 5.1
5.1 General 5.1
5.2 General Types of Best Management Practices 5.1
5.2.1 Environmental Protection or Prevention 5.1
5.2.2 Environmental Control 5.2
5.2.3 Regulatory Control 5.2
5.2.4 Habitat Protection, Restoration or Enhancement 5.2
5.3 Urban Best Management Practices 5.3
5.3.1 Water Quality/Quantity Control Facilities 5.3
5.3.2 Infiltration Facilities 5.5

Page

5.3.3 Site Planning 5.6
5.3.4 Aquatic Habitat Restoration 5.6
5.3.5 Terrestrial Habitat Restoration 5.7
5.3.6 Wetland Creation 5.8
5.3.7 Municipal Source Control Practices 5.9
5.3.8 Public Education 5.9
5.3.9 Reforestation 5.10
5.3.10 Erosion and Sediment Control During Construction 5.10
5.3.11 Natural Channel Design 5.11
5.3.12 Urban Retrofitting 5.13
5.3.13 Buffer Zones 5.13
5.3.14 Groundwater Recharge and Baseflow Protection 5.14
5.4 Rural Best Management Practices 5.15
5.4.1 Quality/Quantity Control Facilities 5.15
5.4.2 Site Planning 5.16
5.4.3 Source Controls 5.17
5.4.4 Buffers 5.17
5.4.5 Reforestation 5.17
5.4.6 Natural Channel Design 5.18
5.4.7 Wetland Creation 5.18
5.4.8 Public Education 5.18
5.4.9 Terrestrial Habitat Enhancement 5.18
5.4.10 Groundwater Recharge and Baseflow Protection 5.18

6.0 EVALUATION OF ALTERNATIVE ECOLOGIC LEVELS 6.1
6.1 Background 6.1
6.2 Ecologic Alternative No. 1 - Maintain Existing Ecologic Conditions 6.3
6.2.1 Ecologic Goal 6.3
6.2.2 Ecologic Objective 6.3
6.2.3 Ecologic Constraints 6.4
6.2.4 Key Protective Measures 6.4
6.2.5 Summary 6.6
6.3 Ecologic Alternative No. 2 - Restoration/Enhancement of Key Ecologic Conditions 6.7
6.3.1 Ecologic Goal 6.7
6.3.2 Ecologic Objective 6.8
6.3.3 Key Ecologic Constraints 6.10
6.3.4 Key Enhancement/Restoration Measures 6.10
6.3.5 Summary 6.14

		Page
6.4	Consultation Process	6.16
6.4.1	General	6.16
6.4.2	Second Public Open House	6.16
6.4.3	Evaluation Criteria and Review of Alternative Ecologic Levels	6.18
6.5	Selection of the Preferred Ecologic Level	6.20
7.0	THE RECOMMENDED PLAN	7.1
7.1	Background	7.1
7.2	Surface Water Management Plan	7.4
7.2.1	Flood Control Management	7.4
7.2.2	Stream Corridor Management	7.6
7.2.2.1	Natural Channel Stabilization Recommendations	7.8
7.2.2.2	Existing Inline Pond Retrofits, Bypassing and/or Removal Recommendations	7.11
7.2.3	Surface Water Quality	7.14
7.3	Groundwater Management Strategy	7.15
7.3.1	Groundwater Recharge	7.16
7.3.2	Groundwater Withdrawal	7.18
7.3.3	Contaminant Susceptibility	7.19
7.4	Greenlands Plan	7.20
7.4.1	Stream and Valley Corridor System	7.20
7.4.2	Terrestrial System	7.24
7.4.3	Recreational Trail System	7.35
7.5	Tributary Factsheets	7.35
7.5.1	Environmental Resources	7.36
7.5.2	Environmental Protection Targets	7.37
7.5.3	Key Best Management Practices	7.37
7.5.4	Future Study Requirements	7.37
8.0	IMPLEMENTATION	8.1
8.1	General	8.1
8.2	Subwatershed Plan Administration	8.2
8.3	Considerations for Proposed Measures	8.3
8.3.1	General	8.3
8.3.2	Surface Water Implementation Strategy	8.6
8.3.2.1	Flood Control	8.6
8.3.2.2	Stream Stability/Erosion Control	8.8
8.3.3	Groundwater Implementation Strategy	8.10
8.3.4	Greenlands Implementation Strategy	8.12

Page

8.4 Land Use Planning Considerations 8.17
8.4.1 General 8.17
8.4.1.1 Official Plan 8.18
8.4.1.2 Transitional Measures 8.21
8.4.2 Official Plan Considerations 8.22
8.4.3 Official Plan Policy Framework 8.25
8.4.4 Implementation Mechanisms 8.29
8.5 Future Studies/Initiatives 8.35
8.5.1 General 8.35
8.5.2 Environmental Management Plans 8.37
8.5.2.1 Surface Water Resources 8.37
8.5.2.2 Groundwater Resources 8.39
8.5.2.3 Terrestrial Resources 8.41
8.5.2.4 Aquatic Resources 8.43
8.5.2.5 Stream and Valley Morphology Study 8.43
8.5.2.6 Headwater Tributary Assessment 8.45
8.5.2.7 Preparation of an Environmental Management Plan 8.45
8.5.3 Stormwater Management Implementation Report 8.46
8.5.4 General Studies 8.46
8.5.5 Groundwater Management Strategy 8.47
8.6 Education/Stewardship 8.49
8.7 Environmental Monitoring 8.53
8.7.1 General 8.53
8.7.2 Surface Water Quantity 8.55
8.7.3 Groundwater 8.56
8.7.4 Surface Water Quality 8.57
8.7.5 Fluvial Geomorphology 8.58
8.7.6 Terrestrial Resources 8.59
8.7.7 Aquatic Resources 8.62

9.0 CONCLUSIONS AND RECOMMENDATIONS 9.1
9.1 Conclusions 9.1
9.2 Recommendations 9.4

APPENDIX A: Technical Index

LIST OF TABLES

Table No.

3.1: Climate and Precipitation Characteristics
3.2: Existing Stormwater Management Facilities - Subwatershed No. 19 Study
3.3: Peak Flow Rates at Various Locations within Subwatershed No. 19
3.4: Flood Damage Centres
3.4.1: Summary of Spot Flow Measurement Sites, Techniques and Flows
3.4.2: Groundwater Balance
3.4.3: Estimated Well Capacities and 1993 Water Consumption for the Town of Orangeville Municipal Wells
3.5: Orangeville Sewage Treatment Plant Effluent Summary
3.6: Water Quality Sampling Results of Urban Drainage
3.7: Annual Pollutant Concentration and Loadings Summary
3.8: Results of the Phase 1 Survey
3.9: Rosgen (1993) Classification of Stream Types for the Study Sites
3.10: Plan and Profile Characteristics
3.11: Hydraulic, Substrate and Sediment Characteristics
3.12: Comparison of Observed and Simulated Flow Volumes by Season for 1990
3.13: Comparison of Hydrologic Budget Components for Urban and Non-Urban Land Use Types
3.14: Baseflow Component by Sub-Basin
3.15: Biotic Index Values for Stations Located in the Credit River Subwatershed No. 19
3.16: Framework for Characterizing Environmental Quality in Subwatershed No. 19
3.17: Biophysical Performance Standards for Aquatic Ecosystem Objectives - Subwatershed No. 19
3.18: Summary of IBI Results, Credit River Subwatershed 19, July-August 1994

5.1: Listing of Alternative BMPs
5.4.1: Rural BMPs

6.1 Maintain Existing Ecologic Conditions
6.2: Restoration and Enhancement of Key Ecologic Constraints
6.3: Proposed Measures and Associated Benefiting Environmental Resources

7.1: Recommended Subwatershed 19 Management Plan
7.2: Summary of Recommendations for Flood Damage Centres
7.3: Average Annual Recharge
7.4.1: Characteristics of the Existing versus Rehabilitation Terrestrial System
7.4.2: Representative Communities
7.4.3: Edge Plants

Table No.

7.4.4: Shade Tolerant (Interior Forest) Plants
7.4.5: Representative Wildlife

8.1A: Implementation Considerations for Stream Restoration
8.1B: Implementation Considerations for Developing an Urban Forestry Program
8.1C: Implementation Considerations for Agriculture Stewardship Fencing and Buffers
8.1D: Implementation Considerations for Naturalization of Significant Natural Features
8.1E: Implementation Considerations for Naturalization Plans for Valleyland Corridors
8.1F: Implementation Considerations for Naturalization of Upland Vegetated Corridors and Key Tableland Woodlots
8.1G: Implementation Considerations for Retrofitting of Existing Stormwater Management Facilities and Ponds
8.1H: Implementation Considerations for Development of a Groundwater Management Plan
8.1I: Implementation Considerations for Development of a Recreational Trail System
8.1J: Implementation Considerations for Replacement of Wells 5/5A
8.1K: Implementation Considerations for Melville Pond Dam
8.1L: Implementation Considerations for Flood Control
8.2: Official Plan Policy Framework

LIST OF FIGURES

Figure No.

1.1: Credit River Watersheds
1.2: Credit River Subwatershed 19

2.1: Credit River Subwatershed 19 Study - Existing Land Use
2.2: Credit 19 Subwatershed - 3-D View

3.1: Credit River Subwatershed 19 - Environmental Monitoring Sites
3.2: Generalized Flow Patterns
3.3: Credit River Subwatershed 19 Mean Monthly Flow Characteristics
3.4: Credit River Subwatershed 19 - Water Resources
3.5: Generalized Groundwater Flow and the Influence of Geology to Groundwater Flow
3.6: Stream Bed Piezometers and Spot Flow Measurements
3.7: Credit River Subwatershed 19 Study - Quaternary Geology
3.7a: Bedrock Topography

Figure No.

3.7b: Hydrostratiographic Cross-Section and Hydrostratiographic Cross-Section
3.8: Credit River Subwatershed 19 - Areas of Research and Discharge Groundwater
3.9: Water Table Contours and Groundwater Flow Direction
3.9a: Major Groundwater Withdrawal
3.11: Time Scales of Storm Runoff Water Quality Problems
3.12: Space Scales of Storm Runoff Water Quality Problems
3.13: Water Quality Trends for Suspended Solids, Fecal Coliform and Copper
3.14: Water Quality Trends for Total Phosphorus, Nitrites and Nitrates and TKN
3.15: Pollutant Loadings Summary
3.16: Conceptualized Morphological Response
3.17: Credit River Subwatershed 19 - Survey Site Location Map
3.18: Bank Stratigraphy
3.19: Credit River Tributary Site 4, Orangeville, Ontario
3.20: Credit River Subwatershed 19, 1990 Discharge
3.21: Credit River Subwatershed 19 - Terrestrial Resources
3.22: Credit River Subwatershed Study - Existing Aquatic Communities

6.1: Alternative No. 1 - Maintain Existing Ecologic Conditions
6.2: Alternative No. 2 - Restoration/Enhancement of Key Ecologic Constraints
6.5: Aerial View of the Credit Oxbow and Caledon Tributaries in the Late 1940s
6.6: Aerial View of the Credit Oxbow and Caledon Tributaries in 1989

7.1: Credit River Subwatershed No. 19 Recommended Plan
7.2: Credit River Subwatershed No. 19 Proposed Trail System

8.1: Proposed Approval Process

1.0 INTRODUCTION

1.1 General

In early 1992, the Credit Valley Conservation Authority, in concert with all member municipalities and the Ministry of Natural Resources (MNR) and Environment and Energy (MOEE) completed a Watershed Management Strategy. The two phased study evaluated the present and future state of the Watershed of the Credit River with respect to its overall health (e.g., flooding, erosion, baseflows, surface and groundwater quantity and quality and the natural environment). The results of the study suggested that many areas within the Credit River Watershed presently support a healthy ecosystem. However, the results also showed that, if not properly managed, further development within the watershed may result in a significantly degraded environment.

The watershed study recommended that the entire Credit River Watershed be subdivided into 20 subwatersheds (see Figure 1.1) based on natural riverine boundaries, and that Subwatershed Plans be prepared in order to properly manage the overall health of the watershed. Subwatershed No. 19 is one of the 20 subwatersheds.

The process of Subwatershed Planning has evolved over the last 15 years. The typical Subwatershed Plan of the early 1980s, which was commonly termed Master Drainage Plan, was primarily concerned with two issues; flooding and erosion. In the latter part of the 1980s the plan evolved and typically dealt with the above issues as well as water quality and occasionally aquatic resources.

Presently, Subwatershed Plans deal with a number of issues including:

- the water budget (i.e., groundwater, baseflow and peak flows);
- terrestrial and aquatic habitat;
- woodlands, including woodlots and forests;
- wetlands;
- stream morphology;
- Areas of Natural and Scientific Interest;

- Environmentally Sensitive Areas;
- aesthetics; and
- recreation.

Furthermore, the plans are ecosystem based, with the potential interaction between each of the natural environmental resources being strongly considered.

Integration of the Land Use Planning Process with Environmental Planning has also evolved over the last 15 years. Whereas the common practice in the early to mid eighties involved the development of Official, Secondary and Draft Plans with nominal consideration of environmental consequences; present practice considers the two planning processes in unison. The Subwatershed Plan integrates the functions of Environmental Planning and the Land Use Planning process. Although the Subwatershed Plan does not set out ideal land uses, it does make valuable contributions to the land use decision making process by defining development opportunities and constraints with respect to the protection, enhancement & restoration of the natural environment resources under present land use conditions and as land use changes occur. Information derived from the Subwatershed Plan will be incorporated into planning documents as the basis of environmentally conscious land use designations and development policies.

1.2 Background

Subwatershed No. 19 is located at the headwaters of the Credit River and encompasses parts of the following five municipalities (Figure 1.2):

- Township of Amaranth;
- Town of Caledon;
- Township of East Garafraxa;
- Township of Mono; and
- Town of Orangeville.

Subwatershed No. 19 drains an area of approximately 62 km^2. The upper part of the watershed includes Monora Creek and two unnamed tributaries (one of which will be

subsequently referred to as the Eastern tributary) which drain to Island Lake. Flows from Island Lake, as well as the Mill Creek tributary, are conveyed southerly via the Credit River. Toward the southern limit of the study area, flows from three unnamed tributaries located within the Town of Caledon also discharge to the Credit. The downstream limit of the study area is Melville Pond. The dominant land use is rural, with approximately 50 percent of the lands being used for agricultural purposes. Urban land uses account for approximately 25 percent of the land. The remaining land uses included conservation lands, forested lands and Environmentally Significant Areas.

1.3 Study Rationale

Development of a long-term management strategy is necessary in order to protect, enhance or restore environmental quality in light of current and future demands on the resources. At the present time there is no mechanism for evaluating the cumulative effects of land uses on water resources and environmental quality on a subwatershed basis. Nor are there any criteria for prioritizing among water uses. This situation largely exists because responsibility for land use and water resource planning falls within the mandate of on the order of 20 public authorities, each with varying levels of interest and differing management objectives.

Completion of the Subwatershed Plans will provide an environmentally sound framework within which those involved in planning and decision-making can evaluate the consequences of current and future development scenarios in the context of the entire subwatershed, and indeed the entire watershed.

1.4 Study Goal and Objectives

1.4.1 Study Goal

The study goal has been defined as: "develop a plan for the protection, enhancement and restoration of the natural environmental resources under present conditions and as land use changes occur".

1.4.2 Study Objectives

The study objectives relate to the four phases of the study and may be defined as:

Phase I: Establish Existing Environmental Conditions

- carry out the appropriate field and technical studies in order to define existing environmental conditions;
- identify existing and approved land uses;
- establish environmental goals and objectives; and
- identify form, function and linkages between the natural systems.

Phase II: Development of Alternative Ecologic Levels of Protection/Enhancement

Phase III: Select Recommended Plan

- identify measures (Best Management Practices) that, when implemented, will protect, enhance or restore the natural environmental resources;
- select, based on the environmental goals and objectives, as well as existing/potential environmental conditions, two alternative levels of Ecologic Protection or Enhancement; and
- select a Recommended Subwatershed No. 19 Plan based on social, economic and environmental considerations.

Phase IV: Implementation

- develop an Implementation Plan;
- develop Terms of Reference for Future studies at the Secondary and Draft Plan stages; and
- establish environmental policies to be integrated into the Official Plan and other planning documents.
- define an environmental monitoring plan to ensure that the environmental targets are achieved.

1.5 Report Outline

The report is divided into nine chapters. Outlined below is an overview within each chapter together with a brief explanation as to how the chapters relate to each other.

Chapter 1 - Introduction

This chapter describes the study goals and objectives as well as providing terminology for key words or descriptors.

Chapter 2 - Subwatershed No. 19

A brief overview as to the characteristics of Subwatershed No. 19 is provided as are the present land uses within the area.

Chapter 3 - Existing Subwatershed Conditions

A description of the technical and field studies that were carried out in order to define existing environmental conditions is provided. Also provided, for each natural environmental resource is a summary with respect to:

- component (e.g. aquatic resources) program that was completed;
- objectives of the component program; and
- key findings and implications.

A qualitative overview as to how the environmental features are inter-related is provided.

Chapter 4 - Environmental Goals and Objectives

The approach to development of environmental goals and objectives is provided as are the goals and objectives. Also provided in this chapter is a summary of the input from the first public meeting.

Chapter 5 - Alternative Best Management Practices

Alternative measures (or Best Management Practices) for protecting, enhancing or restoring the natural environmental resources are provided.

Chapter 6 - Evaluation of Alternative Ecologic Levels

The selection and evaluation of Alternative Ecologic Levels is presented. The alternative ecologic levels were selected based on existing and potential environment conditions and the goals and objectives as developed for the subwatershed. Selection of the preferred ecologic level, subsequently referred to as the Recommended Plan, is presented.

Chapter 7 - The Recommended Plan

A description of the Recommended Plan, together with the associated measures necessary to meet the goals and measures of the plan, is presented.

Chapter 8 - Implementation

The activities which must be undertaken if the Recommended Plan is to be successfully implemented are described.

Chapter 9 - Conclusions and Recommendations

A summary of the report findings is presented.

1.6 Terminology

Several key words or phases will be used throughout the text. Definitions are provided below:

Subwatershed: A subwatershed encompasses all lands (surficial and subsurface) as well as the ditches, tributaries and main

branches which drain to a common point. In this case, the subwatershed is Subwatershed No. 19 which is comprised of 62 km^2 of land, and a series of tributaries which drain to the headwaters of the Credit River.

Subcatchment: A subcatchment includes the lands (surficial and subsurface) that drain to a tributary, such as Mill or Monora Creek.

Natural environmental resource: The term natural environmental resource will be used to describe various environmental or water related attributes which presently (or potentially) exist within Subwatershed No. 19. These include:

- aquatic resources;
- terrestrial resources;
- water resources; including water quality and groundwater;
- floodplain characteristics including flooding;
- erosion-stream morphology;
- aesthetics; and
- recreation.

Ecosystem Approach: Two definitions have been provided to describe the ecosystem approach. The first is based on a technical definition while the second (which is based on the Crombie Commission) has been used to describe the ecosystem to the non-technical audience.

First Definition (Technical) - The ecosystem is defined as a community of living coexisting organisms (including man) and the non-living physical and chemical

environment in which that community lives. Thus, there is a constant interaction and interdependence between the living and non-living components of the ecosystem. The dynamics of the environment allow for variations in key factors. Indeed, one attribute of an ecosystem is that it is constantly changing.

The concept of an ecosystem can be applied at any level of scale - a wetland, a tributary, or the entire watershed. This ecosystem approach is particularly applicable to land and water management studies because it integrates physical, chemical and biological information, so all of the factors are considered at each scale, in assessing overall environmental quality.

Second Definition (Non-Technical) - In more straightforward terms, an ecosystem approach considers the following:

- everything is connected to everything else;
- human beings are part of nature and not separate from it;
- human beings are responsible for their actions and associated impacts; and
- economic health and environmental health are mutually inclusive.

Best Management Practice: A Best Management Practice is a measure (active or passive) that when implemented, will assist in protecting, enhancing, or restoring the environmental features. Best Management Practices may be active measures; e.g., the construction of a stormwater management facility to control peak flows and reduce pollutant loadings from an

urban area. Alternatively, they may be passive; e.g., implementation of a top-soil bylaw to minimize erosion during construction or a buffer strip to protect the integrity of the streams.

Terrestrial: Terrestrial resources include: landforms, such as moraines, kettle lakes, escarpments, glacial lake shorelines; natural vegetation features such as woodlands, savannas, prairies, meadows, valley/riparian lands, hedgerows, plantations, wetlands; and, wildlife, including mammals, birds, reptiles and amphibians.

Natural System Linkages: Natural linkages refer to the inter-relationships between environmental features. These inter-relationships can be described in terms of attribute, function, and linkage.

An **attribute** is a physical characteristic, structure or uniqueness of a natural feature, for example woodlands are areas of natural forest cover that include mature trees, an understorey of shrubs and a ground cover of forbs and grasses that may include rare Carolinian species.

A **function** describes a process or an activity that an area serves within the context of the landscape, for example woodlands provide habitat for wildlife, shade streams to moderate temperatures and slow the rate of runoff into streams.

A **linkage** is a pathway, connection or relationship that an area shares with other areas that is part of a larger complex, for example a woodland may provide a wildlife corridor between two larger natural areas which together, serve to sustain a white tail deer population. Another

example of a linkage includes the flow path of water infiltrating into the ground and resurfacing at a discharge location, thereby providing baseflow for aquatic resources.

Ecologic Level: An ecologic level is defined as an ecological condition or state of health where the functions and linkages of the natural components of an ecosystem are in balance with the human components of the ecosystem. In other words, any trends toward progressive deterioration or degradation of the natural environment will be halted, reversed or redirected to achieve an equilibrium with the human environment. This state of balance or equilibrium may be maintained at different levels based on the value that the local community places on natural ecosystem components.

Fluvial Geomorphology: the study of physical features of the earths surface which describe the features of a watercourse. There are many features of a stream channel such as width, depth, velocity, discharge, slope, channel materials, sediment load, and sediment size which form the morphology of watercourses. In a natural watercourse these features are dynamic, yet operate within a given equilibrium. A change in any one of these features could alter the watercourse and result in accelerated channel erosion or sedimentation.

2.0 SUBWATERSHED NO. 19

2.1 General

This chapter will present existing and approved land uses within the subwatershed (Chapter seven will discuss potential land use changes). Also presented, is an overview of the physiography of the subwatershed as well as a general description of each tributary within the subwatershed.

2.2 Existing and Approved Land Uses

The land uses, in general, are divided into various designations of urban & rural land use types. Urban land uses were defined by:

- reviewing the most recent Official Plans for each municipality;
- reviewing the status of approximately 40 individual applications which have been presented to the five municipalities in recent years (see Appendix); and
- meeting with the individual municipalities/agencies to define approved developments.

For the purpose of this study, approved urban land uses included either land that is currently developed or planned within the municipalities Official Plan or individual applications that have received draft approval at the date of preparation of this report.

Rural land uses were established based on mapping (1982) as prepared by Ontario Ministry of Agriculture and Food.

Figure 2.1 illustrates the existing and approved land uses within the Subwatershed No. 19. Within the urban areas, the following designations were used:

- residential;
- estate residential/rural residential;
- commercial;

- industrial;
- commercial/industrial;
- open space/recreational;
- hazard lands/environmental resource/environmental protection;
- institutional; and
- extractive industrial/pits and quarries.

Within the rural areas, the following designations were used:

- wildlands, which includes woodlands, wetlands, idle agricultural lands;
- intensive agriculture, which includes mixed grain and hay;
- less intensive agriculture, which includes mixed hay and grain; and
- pasture, which includes pasture and fallow lands.

2.3 Physiography

Subwatershed No. 19 comprises a surface drainage area of approximately 62 km^2. Seven major tributaries drain to the main branch of the Credit River within the subwatershed. The topography varies from 525 mASL in the western portion of the subwatershed to 405 mASL where the Credit River exits the subwatershed at Melville (Figure 2.2).

The most dominant feature in the subwatershed is the Orangeville Moraine, and although this moraine is split in the subwatershed, it still occupies the majority of the western, southern and southeastern portion of the subwatershed. The overburden related to the Orangeville Moraine consists of extensive deposits of permeable sand and gravel, sometimes capped by less permeable sandy silt or silty clay tills. In the northeastern and eastern portions of the subwatershed, the Singhampton Moraine overlays the Orangeville Moraine. Both moraines commonly exhibit hummocky terrain. The central portion of the subwatershed, including the Credit River floodplain and Island Lake, mainly consists of sand and gravel from glacial streams. This area overlays a significant bedrock valley which extends through the subwatershed from the Nottawasaga Valley, directly north of the reservoir, and generally follows the river to, and beyond Melville. The underlying bedrock consists of fractured dolostone. The prevalence of sand and gravel in the

subwatershed gives rise to numerous past and existing aggregate operations.

Numerous wetlands occur in the lower, flatter areas associated with the Credit River and in the less permeable bog deposits at high elevations within the subwatershed.

A significant amount of precipitation recharges the permeable surficial sediments and soils within the subwatershed. The groundwater divide extends to the west beyond the surface water divide and it is estimated an additional 6.0 km^2 area is available for recharge to the groundwater flow system within the subwatershed.

The hydrogeological setting allows for large quantities of high quality groundwater baseflow to enter the tributaries and main branch of the Credit River.

2.4 Surface Water Drainage

Subwatershed No. 19 (see Figure 1.2) is located in the headwaters of the Credit River watershed. Surface water drainage in this subwatershed is characterized by two areas.

The first area consists of three smaller drainage systems which flow into Island Lake. Monora Creek is the largest of these areas and discharges to the west end of the reservoir. The Monora Creek drainage system has three major tributaries referred to in this study as the North, Middle and South Monora Creek tributaries. Traditionally a rural and forested area, it is presently being developed with urban land uses. Baseflow consists of large quantities of groundwater originating from many springs. To the far north east side of the watershed two smaller drainage systems flow into Island Lake. The upper tributary is referred to in this study as the Eastern Tributary and the lower tributary is unnamed. Both drainage systems have very little base flow and both have rural land uses.

The second major drainage area in Subwatershed No. 19 originates at the discharge from Island Lake. This is the beginning of the Credit River. Shortly downstream of the reservoir urban drainage from the Town of Orangeville flows into the Credit River just west and north of the intersection of Highways 9 and 10. Downstream from this point, Mill Creek flows into the Credit River. The headwaters of Mill Creek are characterized by

rural land uses with good baseflow from groundwater sources. As Mill Creek flows towards the Credit River, it receives urban storm water runoff from the Town of Orangeville and becomes more channelized as it flows behind residential and commercial land uses. As the Credit River flows southerly, it receives flow from the Orangeville Sewage Treatment Plant (STP). At its point of discharge the STP accounts for approximately 50 percent of the baseflow within the Credit River.

The upper reach of the Credit River is very slow moving and wide and flows through the Melville Marsh ESA (also known as Orangeville Marsh) to its first crossing under Highway 10. At Highway 10 the Credit River is flowing in a easterly direction. It then turns south and then west crossing under Highway 10 again. The first and second crossings are referred to as the north and south crossings, respectively, in this study. In the meander east of Highway 10 the Credit River receives flow from three streams, referred to in this study as the Caledon tributaries. Each Caledon tributary has good quantities of baseflow originating from groundwater sources. From here the river meanders to Melville Pond where flow is regulated by a small dam.

3.0 EXISTING SUBWATERSHED CONDITIONS

3.1 General

The following sections provide an overview of the current state of the natural environmental resources of Subwatershed No. 19. In order to identify the current state of natural environmental resources, several baseline studies were undertaken. The objectives of these studies were:

- to establish the current condition of natural environmental resources;
- to identify the direction of past trends, i.e., deteriorating, stable or recovering; and
- to set up computer models and other analytical tools for use in impact assessment.

Defining the current state of the environment, as well as the interrelationships between each resource is necessary in order to realistically define environmental goals, objectives and targets for the protection, restoration and enhancement of the natural environmental resources.

The environmental monitoring stations used throughout this study and referenced in the following sections are presented in Figure 3.1.

3.2 Natural Environmental Resources

For the purposes of this study, the term natural environmental resources has been used to describe various environmental or water related attributes which presently exist within Subwatershed No. 19. These include:

- water resource features, including the quantity and quality of water in watercourses and groundwater;
- floodplain features, including flooding;
- aquatic features, including aquatic habitats of watercourses, and aquatic communities;
- stream morphologic features, including channel stability and erosion;
- terrestrial features, including landform, vegetation, wetlands and wildlife;
- recreational features, including public lands and trail systems; and

- aesthetics.

The protection, restoration or enhancement of these diverse resources is a major objective of the Credit Valley Conservation Authority (CVC), the member municipalities, the Ontario Ministry of Natural Resources (OMNR), and Ministry of the Environment and Energy (MOEE).

In the following sections, an overview of the resources is provided. The overview provides a general description of and the importance of each resource, followed by discussion of the existing baseline conditions within the subwatershed. These overviews have been compiled from literature sources, field investigations, computer simulation modelling and personal communications. For some sections, further discussion and details are provided in a separate set of Technical Appendices.

It is important to recognize that the natural environmental resources are highly inter-related because of their ecological functions and environmental pathways or linkages. For example, vegetated floodplain features provide for the conveyance of spring melt waters thereby reducing flood risks and channel erosion forces, provide habitat for many plants and animals and shade watercourses maintaining cool water for fish. Although they are discussed separately in the following sections, they should be regarded as separate layers on a map that, together, present a mosaic of environmental features with different sensitivities to human activities. A summary of baseline conditions and the linkages between the various features is provided at the end of this chapter.

3.3 Water Resource Features

3.3.1 Hydrology

The hydrologic cycle (Figure 3.2) describes the endless movement of water from land to the lakes and oceans, and to the atmosphere through evaporation and transpiration, and return by precipitation. The hydrologic characteristics of a subwatershed influence the nature of flooding, stream morphology and channel erosion, sediment transport, pollutant loadings, fish and wildlife resources/habitat, recreational opportunities, and aesthetics. Land use alteration, such as those associated with agricultural and/or urban expansion, result in changes to the hydrologic cycle which may or may not impact environmental features. Water resources planning and management must account for these changes.

Key components of the hydrologic cycle which have been addressed in this study are as follows:

- regional climate and streamflow characteristics;
- flood flows;
- groundwater resources; and
- overall water budget.

To identify the baseline conditions and environmental limitations of these components, the following tasks were undertaken:

- review of background reports and historical streamflow data;
- implementation of a streamflow monitoring program;
- extension and updating of an existing hydrologic model for the study area (INTERHYMO); and
- development of a continuous hydrologic model for the study area (QUALHYMO).

3.3.2 Regional Climate and Streamflow Characteristics

A summary of climatological data typical of the local region is provided in Table 3.1. The mean annual precipitation in the Greater Toronto Area (GTA) is 762 millimetres (mm), which varies from a mean monthly low in February of 46 mm to a mean monthly high in August of 77 mm.

Snowfall in the region area has historically occurred as early as October, however, significant snow pack accumulation typically does not result until late December when mean daily temperatures are below freezing. Mean annual snowfall is approximately 131 centimetres (cm). In the spring, the snowmelt tends to begin by mid-March with the majority of the accumulated snow pack depleting between April 1 and May 1.

Mean daily temperatures vary from a low of -7EC in January to a high of 21EC in July. The predominant winds are from the northwest and the mean annual wind speed is 15.4 kilometres per hour. Mean annual lake evaporation has been estimated to be approximately 581 mm.

Information on streamflow in the Credit River is available for one location (Melville Pond

outlet which is the downstream limit of the study area) from the Water Survey of Canada.

A summary of maximum, mean, and minimum recorded monthly flows at this location is provided in Figure 3.3. The results, as illustrated in Figure 3.3 and the accompanying table, reflect the existing physiographic, terrestrial and land use conditions within the watershed, i.e.:

- the permeable soils, together with the strong surface/groundwater interactions which result in:

  - significant baseflows during the dry and warm summer months; and
  - moderate peak flows.

- terrestrial features, including woodlots in high recharge areas, which replenish groundwater sources and instream wetlands which moderate flow changes;

- Island Lake which significantly attenuates peak flows, and augments low flows from approximately 14 percent of the study area;

- the Orangeville Sewage Treatment Plant which provides a continuous flow of 115 litres per second.; and

- peakflows which occur in the spring season indicating an area for which predominant land use is rural.

3.3.3 Water Budget

A simplified representation of the components of the hydrologic cycle may be expressed as:

$$P = Q_R + ET + G_R + G_L \text{ " } {}^{a}S$$

in which P is precipitation, Q_R is overland flow, ET describes evapotranspiration losses, G_R and G_L represents the subsurface (groundwater) contribution to surface flow and deep groundwater losses respectively, and ^{a}S is the change in the amount of moisture stored in the ground or ponded on the surface.

The character and composition of the land surface exerts a profound affect on runoff processes and the relative importance of each of the components of the hydrologic budget. Changes in land use may alter this balance and fundamentally change the character of the hydrologic regime. Consequently, determination of the amount of water assigned to each component of the hydrologic budget, on an annual basis, under existing land use conditions provides a basis for evaluation of the potential impacts of urbanization of the watershed. It also provides a bases for evaluation of alternatives for the management of surface and groundwater flow systems.

The hydrologic model QUALHYMO was used to determine the amount of water attributed to each component under existing land use conditions. Results from the analyses indicate that overland flow constitutes, on average, 10% of the total volume of precipitation occurring over the basin. Subsurface flow represents 50% of annual precipitation. Losses through evapotranspiration and baseflow make up the balance of approximately 40% and 10%, respectively.

3.3.4 Flood Flows

A hydrologic analysis was undertaken for Subwatershed No. 19 with the following primary objectives:

- to establish a model suitable for simulating the hydrologic response to rainfall events;
- to estimate peak flows associated with existing land uses;
- to provide input to the hydraulic model which, in turn, will estimate flood levels; and
- to provide a tool for evaluation of water management alternatives.

The first three objectives will be addressed in this section.

The hydrologic response of Subwatershed No. 19 was modelled using the GAWSER watershed model. This model was based upon the initial model developed for the Phase I Credit River Water Management Strategy. The portion of the model for Subwatershed No. 19 was discretized further to provide design flow at specific points of interest.

The drainage areas within Subwatershed No. 19 are illustrated on Figure 3.4. Design flows were developed by the model for each drainage area illustrated, routed and added along the

network of tributaries for Subwatershed No. 19.

A number of stormwater management facilities are located within urbanized portions of the subwatershed. These facilities were constructed to control peak flow rates from urban development to pre-development levels to avoid impacts to receiving streams due to the land development. Most facilities were implemented to control flooding impacts. Stormwater management facilities control flows from relatively recent development and were not installed in the older developed areas. A summary of stormwater management and storage facilities is provided in Table 3.2.

Island Lake provides significant control of flows on the Credit River. This facility was constructed primarily to augment low flows in the Credit River during summer months and also provides some storage for flood events. The major stormwater management facilities, including Island Lake, were incorporated into the hydrology model reflecting their influence in controlling flow rates in the stream network.

Streamflow data within the subwatershed provided flowrates for use in calibrating the hydrologic model. A permanent "Water Survey of Canada" Streamgauge is located near the outlet of the watershed with 22 years of flow data. Two continuous streamgauges and four staff gauges (providing peak water levels) were installed in the subwatershed to provide additional flow data. The location of the gauging stations are illustrated on Figure 3.1. The calibration of the hydrologic model provides adjustment to increase the accuracy of the model in predicting the runoff characteristics of the subwatershed. Information outlining the calibration of the model is provided in the Appendix.

Design peak flowrates, which were generated at the points of interest throughout the subwatershed, are summarized in Table 3.3. These flowrates reflect existing development conditions. Future development and stormwater management scenarios will be developed in subsequent phases of this study.

3.3.5 Flood Risk

Floodline mapping has been developed for the major portions of the stream network in Subwatershed No. 19 in previous studies. The portions where floodline mapping is available is illustrated on Figure 3.4.

The floodline mapping indicates that there are seven areas within current development

areas that are subject to the flooding under the regulatory storm event (i.e., flood damage centres). These flood damage centres are illustrated on Figure 3.4. The number of buildings subject to flooding under regulatory storm conditions (Hurricane Hazel) are listed in Table 3.4.

3.4 Hydrogeology

The following section presents a summary of the overall hydrogeological component of the study with emphasis on the objectives, methodology and general interpretation of the findings relevant to the objectives of the study. A detailed description and documentation of data collected for the hydrogeologic investigation is presented in the Technical Appendix.

3.4.1 Overview

Hydrogeology is the study of the movement of water through the ground and the interaction of this groundwater with surface water. In order to better answer the objectives of the Subwatershed No. 19 study as outlined in Chapter 1 a sound understanding of the hydrogeologic conditions in the subwatershed is required. It is important to understand the inter-relationship between the hydrogeologic conditions and the subwatershed ecosystem in order to assess and develop targets and controls for potential land use changes.

It is important to understand how hydrogeologic conditions influence the water movement and the hydrologic cycle. Figure 3.5 (a) shows a schematic of groundwater flow. Water from precipitation percolates or infiltrates into the ground until it reaches the water table. Areas where water moves away from the water table are known as recharge areas. These areas are generally in areas of topographically high relief. Areas where groundwater moves towards the water table are known as discharge areas. These generally occur in areas of topographically low relief, such as stream valleys. Groundwater ultimately reaches the streams by discharging either from the streambank seepage or from the streambed. Groundwater that discharges to streams is the water that maintains the baseflow of the stream. Wetlands are often fed by groundwater discharge.

There are different types and rates of recharge and discharge. As shown in Figure 3.5 (a) recharge and discharge can be local or regional. Water percolating into the ground at a specific location may discharge to a small stream a short distance away (i.e. Location 1 Figure 3.5 (a)). This is local recharge and local discharge. Some water may recharge a

certain area and discharge to a larger river basin a long way from the source of recharge. This is known as regional recharge and regional discharge. (ie. Location 3, Figure 3.5 (a)).

If this groundwater travels through a permeable sand and gravel it may travel several metres to several hundred metres in a year. Groundwater travelling through clay may move on the order of centimetres in a year. Depending on the geologic material and distance of travel, water infiltrating to the water table could discharge to surface water several months later or thousands of years later.

Permeable geologic materials through which groundwater moves are known as aquifers. Aquifers are "water bearing" formations meaning that water can be easily extracted from these units. The less permeable units are known as aquitards, and although water can move through these units, it moves slowly and it is difficult to extract water from these units. How these aquifers are connected within a hydrogeologic setting is what controls much of the movement of groundwater.

Figure 3.5 (b) shows the complexity of groundwater flow related to variable geologic conditions. In some areas groundwater movement is mainly confined to a local flow system such as Location A in Figure 3.5 (b) as the underlying geologic units have a low permeability. Where the low permeability units are absent then groundwater flow may be to the deeper regional flow (ie. Location B, Figure 3.5 (b)).

These geologic conditions also affect the impact of groundwater extraction from pumping wells as noted by the different locations of three pumping wells in Figure 3.5 (b). The deeper well (Well 1) will have limited impact on the shallow groundwater zone and the surface water. Well No. 2 may impact the shallow zone if pumped at a high enough rate and over a period of time. Well No. 3 could have a significant impact on the baseflow and wetlands associated with the overlying stream valley, even at low pumping rates. These potential impacts are generally time-dependent, with more localized effects occurring in a shorter time period. These figures demonstrate the importance of understanding the geologic and hydrogeologic conditions within the watershed ecosystem.

3.4.2 Objectives

The overall objectives of the hydrogeological component of the subwatershed study are:

- identify the geological and hydrogeological setting for the subwatershed;
- identify the linkages between watershed hydrogeology and hydrology;

- identify potential sources of water supply;
- develop various guidelines for protection ; and
- develop a monitoring program.

For the Phase 1 component of this study, specific objectives include:

- determine the watershed variables which will affect the groundwater/surface water interaction;
- delineate groundwater discharge areas;
- delineate groundwater recharge areas;
- determine areas of potential groundwater supply sources;
- quantify groundwater discharge to the subwatershed;
- assess groundwater impacts as a result of existing development; and
- assess the susceptibility of the aquifer to contamination and the need for well head protection and aquifer management plan.

3.4.3 Background

A background review, assessment and selected compilation of existing data included:

- published government maps and reports (i.e. geological, hydrogeological, water surveys, etc.);
- reports of previous hydrogeological studies carried out within the subwatershed;
- MOEE water well records;
- published scientific and technical papers; and
- Town of Orangeville records for water usage, water levels and precipitation.

3.4.4 Field Methods

Various field components were implemented to meet the objectives. These components included:

- installation of streambed piezometers to assess groundwater discharge characteristics and for long term water level monitoring;
- installation of monitoring wells to determine overburden and bedrock flow system characteristics in a significant discharge area;
- detailed stream flow measurements to assess baseflow quantities; and

- stream and streambed temperature measurements to semi-quantify groundwater discharge.

Monitoring locations can be found on Figure 3.6.

3.4.5 Geology and Hydrostratigraphy

The most significant geological feature within the subwatershed is the Orangeville Moraine. This hummocky to generally flat feature extends from an area, southwest of Orangeville and splits into two arms at Caledon Lake as it enters the subwatershed. This feature is mainly represented as ice contact stratified drift on the Quaternary Geology map (Figure 3.7). The moraine consists mainly of sand and gravel with minor amounts of silt or till. This moraine was the first feature formed when the Wisconsinan glacier, which covered all of Ontario, split and the ice fronts receded towards Lake Ontario, Georgian Bay and Lake Simcoe. Meltwaters from the glacier, laden with sand and gravel, flowed between the receding edges or "lobes" of the glacier and formed the Orangeville Moraine. The till units within the subwatershed are all of a sandy silt nature and may contain small amounts of clay. These tills include the Tavistock Till in the central area, the Port Stanley Till in the southeast and the Newmarket Till in the northeast. These till units have been mapped as either overlaying or being interlayered with the Orangeville Moraine and formed coincidentally with the Orangeville Moraine or during a local re-advancement of the ice.

As the ice melted during glacial retreat large quantities of melt water flowed through a major spillway, situated in the subwatershed from an area around Melville, north to the Nottawasaga Valley, southwest from Caledon Lake to Hillsburgh and south through the Credit River valley. The initial, higher volume meltwaters deposited the more coarse glaciofluvial outwash gravels. The outwash sands were deposited as the meltwater volumes decreased, and eventually fine grained sands, silts and clays were deposited as glaciolacustrine or local pond sediments. More recent silt, sands and gravels (alluvium) has been deposited along the Credit River and its tributaries. Bog deposits are present within the subwatershed, most notably the Rosehill swamp in the southeast and the Anglers and Hunters wetland in the northwest. The thickness of the overburden described above varies from approximately 90 metres in the northeastern portion of the subwatershed to zero at the bedrock outcrops at the foot of the Melville Hill.

The underlying bedrock throughout the majority of the subwatershed consists of the white

to light grey, fine grained porous dolostone of the Amabel Formation. Underlying this formation are the interbedded shales and sandstone of the Cabot Head Formation, the dolomite of the Manitoulin Formation, the Whirlpool sandstone and the Queenston shale. The bedrock topography varies from greater than 450 metres amsl in the western portion of the subwatershed to a low of 330 metres amsl in the north eastern end of the reservoir Figure 3.7a). A significant bedrock valley runs through the subwatershed with one section trending from the intersection of Highway's #9 and #10, around Purple Hill, under the reservoir and then forms the Nottawasaga Valley. The second section trends from the intersection of Highway's #9 and #10 running south east and south following the Credit River Valley. Outcrops along the westerly side of the southerly trending bedrock valley occur at the foot of Melville Hill. The bedrock topography slopes from the west and east portions of the subwatershed to the bedrock valley.

Geological cross sections presenting overburden characteristics and bedrock topography through the eastern and western portion of the subwatershed are shown in Figure 3.7 (b). These cross-sections show the thickness and extensive nature of the sands and gravels. This overburden characteristic has led to fourteen extraction operations within subwatershed, primarily in the ice-contact stratified drift in the western portion. As mapped by the Ontario Division of Mines, the greatest probability for economic extraction is in the outwash sands and gravels adjacent to the reservoir.

Hydrostratigraphy is a term used to describe geological units and their functions in the hydrogeological system. For example, areas or layers of sand and gravel would be aquifers whereas layers of silt and clay would be aquitards. For purposes of discussion and presentation, geological units consisting of sands and gravels will be considered permeable, units consisting of sands and silts or an interlayering of sands silts and minor amounts of clay will be considered semi-permeable, and units consisting of clay will be considered relatively impermeable.

The more permeable units will provide a more efficient hydraulic pathway for (1) recharge, such as in the western portion of the subwatershed, (2) discharge, such as North and South tributaries of Monora Creek and (3) for flow from the recharge areas to the discharge areas. The semi-permeable units may not have the ability to produce substantial quantities of groundwater when pumped directly but have the ability to provide a significant hydraulic connection within the context of a groundwater flow system (i.e. Figure 3.5 (b)). The subwatershed consists mainly of permeable and semi permeable units which gives rise to high levels of recharge and discharge. The recharge and discharge characteristics will be

discussed in more detail in Section 3.4.6 and Section 3.4.7.

The dolostone bedrock can vary in its hydraulic connectivity but can generally be characterized as fractured and interconnected in the upper bedrock. The upper bedrock has been found to be hydraulically connected to the overlying overburden. A more detailed description of groundwater flow system is given in Section 3.4.7.

A more detailed description of the geology and hydrostratigraphy, with accompanying cross-sections and maps, is presented in the Hydrogeological Technical Appendix.

3.4.6 Baseflow and Discharge

A major part of the hydrogeological component of the subwatershed study, from a linkage perspective, was the identification of the existing regional and local discharge conditions. It is the discharge of groundwater to the streams that maintains the baseflow. There are several components to groundwater discharge to the stream, one being direct discharge or "upwelling" in the stream bottom and the other being the volume of baseflow in the stream system. Direct discharge is critical with respect to spawning areas of fisheries habitat while baseflow is required to maintain moderate temperatures and perennial flows in the streams.

Data, used to quantify groundwater discharge, was collected during the field component and included stream flow measurements and data from streambed piezometers. Streambed temperature measurements were taken at various reaches throughout the subwatershed. In addition, detailed discharge data was reviewed from site specific impact assessment studies carried out along the reach of Mill Creek upstream of "C" Line. The data shows that the extent of groundwater discharge can vary substantially along reaches ranging in length from metres to hundreds of metres.

Stream flow measurements taken between precipitation events, the location(s) which are shown on Figure 3.8, provide a reasonable measurement in baseflow discharge directly through the streambed and from bank seepage. Evapotranspiration in the discharge areas would not be accounted for with this measurement. It is noted that the assessment of baseflow conditions for the main branch of the Credit River is complicated by the variable discharge from the reservoir and the Orangeville STP.

Streamflow data, shown in Table 3.4-1, indicates significant groundwater discharge in the

following locations:

- Mill Creek upstream of "C" Line, in particular at the confluence of the two tributaries south of Highway #9;
- The south branch of Monora Creek. In particular the south tributary of this branch in the vicinity of Bredin Parkway (SW19) where numerous springs contribute upwards of 5-10 l/sec, and the northern tributary of the south branch upstream of Blind Line;
- The entire northern branch of Monora Creek to the reservoir contributes upwards of 50 l/sec. in baseflow;
- The upper branch of the northeastern tributary in Concession IV EHS, Mono Township. This baseflow is eventually lost to the influent nature of the lower reach of this tributary;
- The Caledon North branch. The Caledon Middle and Caledon South branches from Sideroad 25 downstream to the Credit River; and
- The main branch of the Credit River between the two Highway 10 crossings.

The overall baseflow contribution of the tributaries of the Credit River is estimated on average, based on 1994 streamflow data, to be approximately 200 l/sec.

An assessment of the 1993 discharge hydrograph from the Melville station provides a yearly average of baseflow for the subwatershed on the order of 195 l/sec., taking into account the average flow at the Orangeville STP. A comparison of baseflow values between the tributaries and total subwatershed baseflow indicates that there does not appear to be a large volumetric contribution to baseflow in the main branch of the Credit River. Streambed piezometers and temperature measurements indicate upwellings in the Credit River between the two Highway #10 crossings but the amount of discharge was not quantified. It is expected that a substantial amount of groundwater discharging within the valley of the main Credit River is lost to evapotranspiration.

Contrasts of 4EC - 8EC in measurements between streamwater temperature and shallow streambed water not only correlate with general reaches (10's to 100's of metres) where baseflow has been quantified but correlate extremely well with the locations of specific spawning areas (i.e. 1 metre). Significant discharge areas are semi-quantified on Figure 3.8.

The above discussions and data are presented in more detail in the Hydrogeological

Technical Appendix.

TABLE 3.4.1
SUMMARY OF SPOT FLOW MEASUREMENT SITES, TECHNIQUES AND FLOWS

Site #	Site Description		Measurement Date	Flow ($l\ sec^{-1}$)
1a,b	Main Branch Credit River - near Highway #9 Bridge	1a	09/06/94	47
		1b	06/12/94	214
1c	Main Branch Credit River - at Highway 10 crossing near Reservoir		22/12/94	165
2a	Main Branch Credit River - upstream of bridge at Highway 10 (near SP10)		09/06/94	303
2b	Main Branch Credit River - downstream of bridge at Highway 10 (near SP10)		22/12/94	376
3a	Main Branch Credit River - at Highway 10 Bridge (SP12)		09/06/94	349
3b	Main Branch Credit River - at Hwy 10 Bridge (near SP12)		21/12/94	456
4a,b	Mill Creek - at Concession C bridge	4a	08/06/94	20
		4b	15/12/94	18
5a	Mill Creek - 80 m upstream of confluence with Credit		09/06/94	26
5b	Mill Creek, upstream of SP7		22/12/94	23
6a,b	North Tributary of Monora Creek - at Hockley Road culvert (Conc. 3W, Lot 6) Mono Twp.	6a	01/06/94	6
		6b	16/12/94	4
7a,b	North Tributary of Monora Creek - 20 m downstream of Blind Line Rd. (Conc. 2W, Lot 7) Mono Twp.	7a	01/06/94	16
		7b		
8a,b	North Tributary of Monora Creek	8a	01/06/94	23

Site #	Site Description		Measurement Date	Flow (l sec^{-1})
	- 20 m downstream of Hockley Rd. culvert (Conc. 2W, Lot 5)			
		8b	15/12/94	28
9a,b	North Tributary of Monora Creek - 5 m downstream of Cemetery Rd. Bridge/culverts	9a	01/06/94	69
		9b	22/12/94	46
10a,b	South Tributary of Monora Creek - 60 m upstream of Highway 10 # 24 Bridge crossing	10 a	08/06/94	32
		10 b	22/12/94	30
11a,b	South Tributary North Branch of Monora Creek - just before confluence	11 a	08/06/94	21
		11 b	22/12/94	12
12a,b	South Tributary South Branch of Monora Creek - just before confluence	12 a	08/06/94	11
		12 b	22/12/94	8
13a,b	North Eastern Tributary to Island Lake - at SP15	13 a	07/06/94	7
		13 b	6/12/94	0
14a	North Eastern Tributary to Island Lake - upstream of SP16		07/06/94	17
14b	North Eastern Tributary to Island Lake - downstream of SP16		21/12/94	8
15a	Caledon Tributary #1 flowing into main branch Credit River - by Culvert on Caledon 2nd line		31/05/94	0.6
16a,b	Caledon Tributary #1 flowing into main branch Credit River - upstream of culvert on Caledon 1st line	16 a	31/05/94	15

Site #	Site Description		Measurement Date	Flow (l sec^{-1})
		16b	21/12/94	8
17a	Caledon Tributary #1 flowing into main branch Credit River - 10 m downstream of pond		31/05/94	65
18a	Caledon Tributary #2 flowing into main branch Credit River - at Caledon Rd. #1 by former airport		07/06/94	5
19a	Caledon Tributary #2 flowing into main branch Credit River - upstream of SP17		07/06/94	12
19b	Caledon Tributary #2 flowing into main branch Credit River - downstream of SP17		21/12/94	6
20a	Caledon Tributary #2 flowing into main branch Credit River - 50 m upstream of confluence with Credit		07/06/94	14
21a,b	Caledon Tributary #3 - 5 m upstream of culvert at Caledon Rd. #1	21 a	07/06/94	4
		21 b	21/12/94	8
22a,b	Caledon Tributary #3 - 20 m downstream of culvert at Highpoint Rd.	22 a	07/06/94	5.5
		22 b	21/12/94	9
23a	Caledon Tributary #3 - 50 m upstream of confluence with Caledon Sub-tributary #3		07/06/94	9
24a,b	Caledon Sub-tributary #3 - at Caledon 1st line	24 a	07/06/94	0
		24 b	22/12/94	0
25a	Caledon Sub-tributary #3 - upstream of confluence with Caledon		07/06/94	9

Site #	Site Description	Measurement Date	Flow (l sec^{-1})
	Tributary #3		
26a	Caledon Tributary #3 - 300 m upstream of confluence with Credit River	07/06/94	18
27b	South Tributary (North Branch) Monora Creek - at Dudgeon Wellfield	15/12/94	15
28b	South Tributary Monora Creek - at Monora Park (near SP9)	15/12/94	48
29b	South Tributary Monora Creek - downstream of Site #11 and #12	15/12/94	20
30b	South Tributary (South Branch) Monora Creek - North of Bredin Parkway (near SW19 well nest)	16/12/94	6

3.4.7 Recharge Areas, Discharge Areas and Groundwater Flow

This section provides an overview of the delineation of the recharge areas and the discharge areas, and the groundwater flow systems linking the areas. An overview of general flow systems was provided in Section 3.4.1.

The term recharge area in the context of this section is an area where there is greater recharge or recharge potential than other areas of the subwatershed. Technically, any area that is not a discharge area is a recharge area. The recharge and discharge areas for Subwatershed No. 19 are shown semi-quantitatively on Figure 3.8. Recharge areas are delineated based on geology, water levels in both the overburden and bedrock, topography and land use.

Significant recharge occurs throughout much of the subwatershed as a result of the prevalence of high permeability sands and gravels as described in Section 3.4.5. These areas can provide high recharge rates, on the order of 200-350 mm per year depending on topography and land use. The lower permeability sandy silt tills provide moderate recharge rates on the order of 150 - 175 mm per year. Discharge areas delineated on Figure 3.8 were discussed in Section 3.4.6.

Groundwater flows from the recharge areas to the discharge areas through various scales of groundwater flow system (i.e., regional to very local) as discussed in Section 3.4.1. Within this flow system context it is important to emphasize that groundwater does not necessarily follow surface water flow paths on both the subwatershed scale or the subcatchment basin scale, therefore groundwater divides are not necessarily coincident with the surface water divides. It has been determined, from water level maps generated on a regional scale for both the overburden and the bedrock, that groundwater is entering the subwatershed from both the overburden and the shallow bedrock to the west of the subwatershed, and groundwater is leaving the northeastern portion of the subwatershed through deeper overburden and shallow bedrock, to the Nottawasaga river valley. The water table map and generalized overburden groundwater flow system is shown in Figure 3.9. The additional area for recharge to the west of the subwatershed boundary is approximately 6 km^2, and extends to the western boundary of Concession 2 in Amaranth Township.

The general groundwater flow paths within the overburden system are directed, on a regional scale, from the topographic highs to the main Credit River valley and reservoir. On intermediate and local scales groundwater is discharged to Monora Creek, Mill Creek, the Caledon tributaries, the Northeastern tributary and various springs. Groundwater generally is discharged where these surface water courses intercept the water table thereby acting to drain the groundwater flow system. The amount of baseflow discharging locally depends, in large part, on the height of the water table adjacent to the stream. This factor can account for seasonal variations in baseflow and can be reflected in reduced flows throughout the system in general, or cessation of flows in the upper reaches of the various tributaries during dry months. The actual source or recharge area of groundwater being discharged can vary.

Discharge to a number of the lower subcatchment basins is much greater than can be accounted for by local recharge and is an indication of interbasin groundwater flow. The recharge area beyond the western boundary of the subwatershed, as well as the recharge areas within the Monora and Mill Creek systems contribute baseflow to the Monora and Mill Creek systems with a higher percentage of regional and intermediate recharge contributing to the lower subcatchment areas.

The shallow bedrock groundwater system tends to follow the same flow path as the overburden system with the exception that the bedrock (and deep overburden) groundwater flow in the northeast portion of the subwatershed is directed towards the Nottawasaga

Valley system. This movement of groundwater out of the subwatershed results from the deep topographic incision of the Nottawasaga Valley acting as a regional groundwater drain.

In addition to the horizontal groundwater flow in the overburden and shallow bedrock system there is likely a vertical component of flow to the deeper bedrock which in turn will leave the subwatershed and become part of the large scale regional flow system.
The wetlands and bog deposits within the subwatershed can be a result of groundwater discharge to these features. Wetlands and bogs can also be a result of "perched" water where a low permeability unit in a depression traps water. Discharge wetlands are found along the main Credit River, with the discharge water feeding the wetland either coming in through the bottom of the wetland or laterally by interflow through the sides. The Anglers and Hunters wetland along the northern branch of Monora Creek and the baseflow in Monora Creek is likely fed by a portion of the recharge water to the west of the subwatershed as well as that within its own subcatchment basin.

The general similarity in groundwater flow systems within the overburden and shallow bedrock combined with the assessment of a number of site specific pumping tests leads to the scenario that these two systems basically act, hydraulically, as one system. This flow system scenario, in concert with the hydraulic connection between the overburden and the surface water, (i.e. springs, high baseflow rates) indicates the sensitivity of the overburden and bedrock groundwater flow system, and hence stream and spring discharge, to reductions in recharge and groundwater withdrawals. Historical water level data and pumping tests indicate direct connections between both bedrock and overburden wells and the surface water. Deeper wells can still be connected hydraulically to the surface even when there are lower permeability units in the shallow overburden, due to "windows" (i.e. lack of continuity) in these fine grained units. The level of hydraulic connection would generally have to be assessed in detail to address potential concerns relating to baseflow and fisheries.
Data from the deeper overburden and shallow bedrock in the north east part of the subwatershed indicates that the hydraulic connection between the deep overburden and shallow bedrock to the Eastern Tributary is not significant.

The available water level data is not detailed enough to present levels of water table decline or "drawdown cones" associated with major pumping wells. Qualitative and quantitative evidence, indicates that a number of pumping wells within the subwatershed have lowered surface water levels and, for example, in the case of Municipal Wells 5/5A have caused a

cessation of flow in the upper reach of Mill Creek north of Highway #9 and west of Townline Road. A review of data from pumping tests carried out within the subwatershed demonstrates that the pumping of proposed wells causes a lowering of water levels in streambed piezometers in adjacent water courses. The lowering of water levels within these monitoring wells indicates reductions and cessations of baseflow and upwellings in various reaches. These examples present the sensitivity of the flow system to groundwater withdrawal.

Groundwater Balance

An overview of the groundwater balance, is discussed below given the component volumes (yearly) presented in Table 3.4.2.

TABLE 3.4.2
GROUNDWATER BALANCE

	m^3 / year
Total Subwatershed	
	13-17 * 10^6
	3.6 * 10^6
	6.3 * 10^6
Western Portion	
	7.0 - 10 * 10^6
	3.6 * 10^6
	3.5 * 10^6

The estimate for groundwater recharge available to the subwatershed is approximately 13 * 10^6 m^3 - 17 * 10^6 m^3.

As described in Section 3.4.6 the average annual discharge measured at the Melville station is on the order of 6.3 * 10^6 m^3 per year.

The values for groundwater withdrawal represent the portion of water that is removed from the groundwater system by the Town of Orangeville and subsequently directed through the STP. Withdrawals from private and communal wells generally represent development which utilize tile fields and are not included in this balance as the water is re-infiltrated. This re-infiltration is generally in the proximity of the groundwater withdrawal. Also not included in the table is groundwater lost from the subwatershed through the deeper regional system and evapotranspiration in the discharge areas. What this general balance indicates is that, assuming baseflow is to be maintained, the combination of baseflow and existing groundwater withdrawal is approaching the low end of the total subwatershed recharge. If one considers only the western portion of the subwatershed where all the municipal wells currently exist the balance is more sensitive.

The high end of the recharge volume provides more of a buffer within this balance but the fact presented by this groundwater balance and the previous discussion on groundwater/ surface water interaction is that there is a sensitive balance between the locations and pumping volumes of future wells, from both a surface water perspective and well water interference perspective.

Contaminant Susceptibility

The concept of groundwater flow paths and hydraulic efficiency as generally described in Sections 3.4.1 and 3.4.5 gives rise to the potential for groundwater contamination or contaminant susceptibility.

The susceptibility of groundwater to contamination is related, to a large extent, to the ease of movement of groundwater, from the contaminant source to the water receptor being impacted. Potential contaminant sources may include, for example, leaking underground storage tanks, road salting, application of fertilizer, septic systems, old landfills, illegal dumping, etc. The water resource receptors could include (1) shallow or deep aquifer which provide a source of water to private and municipal wells or (2) streams and wetlands where the groundwater eventually discharges. Given the prevalence of permeable materials at ground surface and the connection of the surface to both the overburden and bedrock aquifers, extensive areas of the subwatershed are susceptible to groundwater contamination. Examples of existing contamination include the existence of nitrates in wells 5/5A, 2 and the communal well in Purple Hill. Groundwater quality results from various monitoring wells within the subwatershed indicate that water quality,

though hard (i.e. high calcium and magnesium), is generally good to excellent.

3.4.8 Aquifer Systems and Groundwater Supply

The concepts and hydraulic interrelationship of aquifers, aquitards, recharge areas and discharge areas has been discussed in previous sections.

The major aquifer systems within the subwatershed include the permeable sands and gravels in the overburden and the fractured bedrock (i.e. dolostone) at various depths. Aquitards exist where there are lower permeability layers, such as silts/clays or massive unfractured bedrock, that extend continually over relatively large areal scales.

Throughout the majority of the subwatershed the permeable sands and gravels are prevalent and the water within the unit is unconfined with respect to the unit above it, in this case the ground surface.

The lower permeable silts and clays are not extensively continuous but are generally interlayered with sands or sands and gravels. In this setting the lower permeable silts and clays act as a "semi-confining" layer as there is still a relatively significant hydraulic connection throughout this interlayering. The limiting factors for the level of hydraulic connection in the overburden include the extent of interlayering of the fine grained units and the overall thickness of the overburden.

The hydraulic connection within the bedrock is similar to the overburden in that the extensive fractured zones are considered permeable and the massive unfractured zones are considered relatively impermeable. Within the subwatershed the ability of the bedrock to provide adequate quantities of water and hence, be classed as a good aquifer, varies. Generally though, the bedrock throughout the subwatershed behaves as a reasonable aquifer.

The majority of wells in the subwatershed, including private, communal and municipal wells are drilled into the bedrock. In addition these wells are generally drilled into the upper 20-30 metres of bedrock. As was discussed in previous sections the water level data indicates that the upper bedrock within the subwatershed is generally hydraulically connected to the overburden and as such the overburden and upper bedrock should be considered as one hydraulic unit.

Figure 3.9 (a) presents locations of the major groundwater wells and well fields associated

with the subwatershed. Table 3.4.3 provides estimated well capacities and 1993 water consumption for the Town of Orangeville municipal wells.

TABLE 3.4.3

WELL #	Estimated Well Capacity (m^3/year)	Estimated Consumption 1994 (m^3/year)
PW 2A	$0.48 * 10^6$	$0.34 * 10^6$
PW 3	$0.48 * 10^6$	$0.23 * 10^6$
PW 4	$0.88 * 10^6$	$0.33 * 10^6$
PW 5/5A	$1.67 * 10^6$	$1.01 * 10^6$
PW 6	$0.88 * 10^6$	$0.68 * 10^6$
PW 7	$0.47 * 10^6$	$0.37 * 10^6$
PW 8	$1.11 * 10^6$	$0.64 * 10^6$
	$5.97 * 10^6$	$3.60 * 10^6$

Assuming an additional 650 residences within the subwatershed obtain water from private or communal wells at a rate of 1600 l/day/residence, the additional consumption would amount to $0.38 * 10^6$ m^3/year. The majority of these residences re-infiltrate a significant amount of the water into the ground through septic tile fields. The main municipal pumping wells therefore account for approximately 90% of the domestic water consumption obtained from the groundwater system.

Figure 3.9 (a) shows that the major operating wells are located in the western portion of the subwatershed. In addition it is readily seen that wells are generally located adjacent to the tributaries of Mill Creek and Monora Creek.

It has been discussed that both the permeable sands and gravels and the bedrock can be considered reasonable to good aquifers but the hydraulic connection of the overburden to the water courses, and the bedrock to the overburden, provide a sensitive environment with

respect to potential impact, as a result of groundwater withdrawal, on volumetric and localized baseflow. Given this perspective it is suggested that there is an opportunity for development of additional groundwater withdrawal within the subwatershed but that the amount of withdrawal and location and depth of the well must take into account the potential for baseflow impacts from a direct hydraulic connection, and the overall amount of groundwater available based on recharge within a given area of the subwatershed.

Areas which are potentially very sensitive to baseflow impacts include the overburden and bedrock aquifers in the immediate vicinity and upstream of the Mill Creek and its tributaries, Monora Creek and its tributaries, the Caledon tributaries and the Credit River, in particular between the north and south Highway #10 crossings. Groundwater supplies have been and can be developed within these areas but may be limited in the amount of water taken.

Areas that are less sensitive from a surface water connection perspective but appear to possess suitable aquifer units for municipal purposes include the south central portion adjacent to the subwatershed divide and the north east quadrant of the subwatershed.

3.4.9 Summary

Based on the background data review and data generated from the field program, the following conclusions can be made with respect to the existing hydrogeologic conditions in the subwatershed:

- the existence of extensive areas of high permeability sand and gravels lead to significant recharge in the subwatershed;
- the permeable nature of the overburden and the fractured nature of the bedrock provide an extensive aquifer system, with good quality water, through the subwatershed;
- the overburden and upper bedrock are hydraulically linked and act as one unit;
- the overburden/bedrock groundwater flow system provides significant discharge to the tributaries and main branch of the Credit River;
- the overburden/bedrock groundwater flow system and the resulting baseflow discharge are sensitive to the location and amount of groundwater withdrawals or reductions in recharge;
- the groundwater divide extends beyond the western boundary of the subwatershed and provides an additional 6 km^2 of recharge area;
- a positive opportunity exists to further develop the groundwater resources for domestic use, taking into account the sensitive hydraulic connection to baseflow; and
- the permeable nature of the overburden and bedrock throughout the subwatershed presents a high level of susceptibility to groundwater contamination.

3.5 Surface Water Quality

3.5.1 General

Water quality is often used as an indicator of environmental health. The study of surface water quality is important in the subwatershed planning process as it provides insight on the current health of the watershed, from which predictions can be made as to its future health as land use changes occur. Water quality may be used to assess the quality of aquatic habitat and also to determine the suitability of water for drinking, swimming, aesthetics and other uses. On one hand, aquatic life cannot survive in water without impurities in it; on the other, the presence of elevated concentrations of nutrients, metals

and organic substances in water can be toxic to aquatic life and render the water unfit for human uses, including aesthetics.

The concentration of constituents in stream water changes tremendously depending on many factors, such as land use, geology and soils of the watershed, climate, and groundwater quality. On a more local scale, pollutants enter watercourses from sources such as sewage treatment plants, feedlots, animal wastes, urban storm drainage systems, industrial discharges, automotive emissions, agricultural tile drains, spills and septic systems. Imbalances in the concentration of nutrients, metals, organic compounds and bacteria in watercourses can cause nuisance, and unsightly algae blooms, eliminate swimming opportunities and annihilate aquatic communities from dissolved oxygen depletion and excessive sediment loads. Even small increases in pollutant levels can reduce the capability or productive capacity of water to support aquatic life, perhaps making some fish more vulnerable to predators or less able to hunt for food.

Sediment is a special case, because many nutrients, metals and organic compounds become attached to sediment and carried into watercourses during periods of runoff such as storms and spring melt. On its own, excessive amounts of sediment entering watercourses can smother fish eggs and benthic invertebrates and kill aquatic life by clogging gill structures, An increase in the overland sediment supply to a stream can also de-stabilize the stream channel causing streambank erosion and degrading instream habitats. Contaminants carried to streams by sediment are often deposited throughout the stream bed or carried downstream to the mouth of the river. Here, they may accumulate and become incorporated into food chains through bioaccumulation rendering fish unsafe for human consumption.

Depending on the characteristics of the pollutant and the aquatic environment the time and space scale associated with the impact of the pollution may vary considerably. Figures 3.11 and 3.12 show typical time and space scale association with the impacts of various pollutants originating from storm water runoff.

Characterizing the water quality of streams requires sampling under a variety of different flow conditions. These include runoff events in all seasons, spring melt, bankfull conditions and low flow conditions. This allows for the calculation of pollutant loadings from different sources to be made and an assessment of the relative magnitude of a pollutant that each source contributes. In this way, existing problems can be addressed, and the effects of future changes can be predicted.

Characterization of water quality can also be interpreted from an assessment of the aquatic communities, benthos, fish, and aquatic vegetation. Discussion of the aquatic communities is provided in Section 3.8.

The objectives of this study component are to:

- determine existing water quality (baseline conditions) throughout Subwatershed No. 19;
- determine the impacts of future land use change on surface water quality; and
- determine the effectiveness of potential best management practices (BMPs) in mitigating the impacts of land use change on water quality.

This Phase I report focuses on presenting baseline conditions with respect to surface water quality.

The approach for this study included:

- selecting a few key water quality parameters to represent conditions in the Credit River and tributaries to Island Lake;
- reviewing historic water quality data available at five Provincial Water Quality Monitoring Network (PWQWN) stations;
- reviewing environmental monitoring reports of the Orangeville Marsh (BEAK 1994, 1992, 1990, 1989, 1985, IEC BEAK 1984, IEC 1982) and Island Lake (BEAK 1988) and the Credit River (BEAK 1981);
- reviewing Orangeville STP effluent records (MOE 1990);
- estimating water quality levels at one location (Figure 3.1) in the subwatershed by collecting and analyzing a series of dry and wet weather samples; and
- using Aquafor Beech Limited's MBQUAL (Mass Balance Quality) Model to represent existing conditions in the subwatershed, assess impacts of land use change and test alternative BMPs.

The primary sources of contamination in Subwatershed 19 are the Orangeville Sewage Treatment Plant as well as urban and rural land uses. Discharges from the Orangeville Sewage Treatment Plant are presently regulated by requirements of a Certificate of Approval
(C of A). Historically instream water quality, and the effluent quality and treatment

capacity of the Orangeville STP have been responsible for limiting urban growth in the Town of Orangeville (Triton 1990). No industries exist within Subwatershed No. 19 which require a Certificate of Approval for discharges of effluent. Most of the information presented in this report deals with water quality in the main branch of the Credit River.

3.5.2 Key Water Quality Parameters

The surface water quality study focused on a set of key water quality parameters which could provide a good indication of overall water quality. These parameters address potential contamination from excess concentrations of solids, nutrients, bacteria and heavy metals in both solid and dissolved states. The selected indicator parameters include:

Suspended solids (SS), which is a commonly used indicator of water quality. Knowledge of the instream concentrations of SS is important since the particles associated with SS transport additional pollutants (e.g., heavy metals) to a receiving water body. High concentrations of SS also deteriorate the quality of fisheries resources in an area (i.e., by clogging fish gills and covering spawning beds) and degrade the visual appearance of a river system.

Dissolved Solids (DS), which is useful to assess the quantity of all dissolved material which may provide an indication of high pollutant loadings or groundwater conditions.

Total Phosphorous (TP), to assess nutrient loadings. Total phosphorous is a nutrient on which aquatic plants thrive, and is generally the limiting nutrient (compared to nitrogen, another nutrient) controlling algae growth and consequently eutrophication. TP levels also impact fish indirectly, since eutrophication decreases the dissolved oxygen concentration in a river system. To avoid nuisance concentrations of algae in lakes, or rivers TP concentrations should not exceed 0.02 or 0.03 mg/L, respectively (MOE 1984, MOEE 1994).

Total Kjeldahl Nitrogen (TKN), is a measure of all the nitrogen in the trinegative state. It is primarily a measure of nitrogen present in the organic form (soluble or particulate). It does not include nitrogen present as nitrite or nitrate. It is most useful in interpreting the effectiveness of the waste stabilization process at sewage treatment plants.

Nitrite and Nitrate (NO2+NO3), is used to interpret the effectiveness of the waste stabilization process at sewage treatment plants. Their abundance in treated water is an

indication of how far treatment has progressed. Excessive nitrate levels are objectionable because they tend to promote the excessive growth of algae and other aquatic plants.

Faecal Coliform (FC) and E. Coli, to assess bacterial levels in the water relative to human contact limits. Traditional limits for human body contact activities were 100 counts/100 ml of faecal coliform (MOE 1984). The current criteria is 200 counts/100 ml of E. Coli. bacteria.

Copper (Cu), to represent the presence of heavy metals in surface waters. Copper is toxic to aquatic life. Current PWQO require copper concentrations not to exceed 0.005 mg/L to protect aquatic life (MOE 1984, MOEE 1994).

3.5.3 Historical Water Quality Data Review

A review of existing water quality data was completed from the following data sources:

- the Provincial Water Quality Monitoring Network (PWQMN)
- the Town of Orangeville Report on the Performance of the WPCP November 1990 (Triton 1990); and
- Feasibility of Aquatic Plant Harvesting in Water Quality Amelioration and Nutrient Management in a Shallow Impoundment - Island Lake (Beak 1988).

The review of this data is useful in determining the geographic and temporal changes throughout the watershed and past and current trends in water quality.

PWQMN Water Quality Database

Six PWQMN stations exist on the Credit River within the subwatershed from the discharge at the Orangeville Dam to the discharge from Melville Pond. The location of the water quality stations are shown in Figure 3.1 and summarized below:

Station 019: discharge from Island Lake (includes inputs from all upstream drainage areas including Monora Creek and consists primarily of rural land use with some urbanization in the Monora Creek drainage area)

Station 020: located downstream of the Orangeville STP (includes urban and rural

land use discharges directly from the Town and from the discharge of Mill Creek)

Station 006: located at the north crossing of Highway 10 and the Credit River (includes discharge from undeveloped land and discharge from Melville Marsh ESA (Orangeville Marsh))

Station 024: located at the south crossing of Highway 10 and the Credit River (includes flow from the three Caledon tributaries with rural land use)

Station 023: located at the discharge from Melville Pond

A review of the water quality database and trend analysis were performed for the selected list of parameters for five of the water quality stations. The trend analyses were performed using a program prepared by the MOEE. The results of these analyses are graphicly presented in Figure 3.13 to 3.14. Detailed plots of the raw data, annual and long term trends are provided in the technical appendix. Along with the data plots and discussion are observed concentrations obtained from other data sources and the PWQO for parameters in which objectives exist.

Results of the historical data review and trend analysis indicate the following:

Total Phosphorus

Total Phosphorus concentrations have varied significantly over the past 30 years throughout the study reach of the Credit River. The lowest concentrations which were reported occur at Station 019. Concentrations at this location are presently below the Provincial Water Quality Objective of 0.03 mg/L.

The highest measured concentrations of TP occurred at Stations 020, just downstream of the STP discharge, and at Station 006. Concentrations at Station 006 were reported to average 0.85 mg/L in 1964 and have reduced to 0.18 mg/L in 1994. Reductions are attributed to improved sewage treatment performance and reductions in phosphate use in cleaning detergents. These concentrations exceed PWQOs. The higher concentrations of TP at station 006 is attributed to STP discharge where effluent concentrations average 0.2 mg/L.

A significant reduction of 67 percent in TP concentrations occurs between stations 006 and 024 located only 1500m downstream. The lower concentration may be attributed to dilution by water flowing from three Caledon tributaries located east of Highway 10. TP concentrations at station 024 are 0.06 mg/L, and are in exceedance of PWQOs.

Since 1986, the trend data indicate a slight increase in TP at all monitoring stations. This increase is most noticeable in data reported at stations 006 and 019. Increases at station 019, from Island Lake, is considered the primary reason for higher concentrations observed at station 006. Reasons for this recent increasing trend are unknown, however, it could be related to recent climatic and hydrologic trends or the recent urban development which has taken place in the Monora Creek subwatershed.

Concentrations of TP measured in 1986 for streams flowing into Island Lake vary from 0.026 to 0.041 mg/L. These concentration are within the PWQO of 0.03 mg/L for streams, but are slightly higher than those desired in lake environments. These concentrations are generally an order of magnitude lower than concentrations typically observed for rural drainage areas.

Nitrite plus Nitrate

The sum of Nitrite plus Nitrate concentrations in the Credit River have four distinctive characteristics. First, concentrations from Island Lake are distinctly lower (less than 0.3 mg/L), than those which occur at the downstream stations. Secondly, there is relatively little difference in the nitrite plus nitrate concentration between each of stations downstream of the STP. Thirdly, concentrations have not varied significantly for the period of record. Present concentrations of nitrites plus nitrates are at the same level as those observed in 1980. The current level is attributed to a recent increase in concentrations from Island Lake. Lastly, due to the existing marsh conditions and the associated natural uptake and release of nitrites and nitrates by the vegetation, there is significant variability in concentration on an annual basis. Except for a slightly lower nitrite plus nitrate concentration in 1986, concentrations typically average 1.5 mg/L. Concentrations of Nitrites plus Nitrates for stream flows entering Island Lake vary from 0.42 to 1.28 mg/L (Beak 1988), clearly indicating the reservoir acts as sink for nitrogen.

Total Kjeldahl Nitrogen

Concentrations of TKN have significantly reduced from 2 mg/L in 1964 to less than 0.9

mg/L under present conditions. This is largely attributed to reductions in ammonia discharging from the STP. This is shown by the data available for Station 006 located downstream of the STP. Of particular significance is the reduction in TKN concentration recorded for Station 020 which was located immediately downstream of the STP. This data illustrates the critical conditions which existed in 1980 as a result of STP discharges and how the STP upgrade in the 1980s significantly improved conditions in the Credit River. Similar to other water quality parameters, measured concentrations were at their lowest in 1986 and 1987 and have recently shown a slight increasing trend. Increases are greatest for measurements obtained from Island Lake discharge. This observed increase in TKN from the reservoir is attributed to the observed increased concentration in the stations downstream of the STP. For the most part TKN concentrations are presently consistent between each monitoring station. Concentrations at the Melville pond are presently slightly lower than those measured for the discharge from Island Lake.

Dissolved Oxygen

The most significant changes in dissolved oxygen have occurred in the Credit River downstream of the STP. The poorest conditions existed from 1979 to 1987 at station 006. Although the average annual concentrations were 8.0 mg/L at this time, concentrations below 3.0 mg/L were regularly observed. These conditions are below those required for healthy warm and cold water fish communities (>4 mg/L and >5 mg/L, respectively). Levels from the reservoir discharge and at Melville have not changed significantly for the period of record. Conditions at Station 020, 006 and 024 have shown a slight increasing trend. In recent years concentrations have stabilized in this reach with an annual average of 10 mg/L and with rare occurrences of concentrations below 5 mg/L. These conditions reflect the natural potential oxygen saturation levels given the seasonal water temperature, marsh and stream conditions that naturally exist. Recent changes in DO concentration are not apparent as with other water quality parameters. It appears that recent increases in nutrients have not influenced DO concentrations. The current dissolved oxygen concentrations that exist are suitable for supporting both cold and warm water aquatic communities.

Bacteria

No consistent trends in faecal coliform bacteria densities are shown by the database. In general bacterial densities are lowest for discharges from Island Lake and typically average 100 counts/100 ml. Densities of 200 to 800 counts/100 ml occur for data reported at stations downstream of the Town of Orangeville. The higher densities are likely attributed to urban stormwater sources. Discharges of Ecoli Bacteria in urban stormwater runoff from the Town of Orangeville were measured to be as high as 1600 counts/100 ml, and as high 540 counts/100 ml in dry weather discharges. The Orangeville STP effluent is chlorinated and as such bacteria densities would be negligible.

Copper

Historical trends in copper concentrations are consistent between each of the monitoring stations. Concentrations increased in the early 1980's and began a reducing trend in 1983. Concentrations have remained relatively constant since 1988. Concentrations of copper are consistently lowest for discharges from Island Lake and consistently below the PWQO of 0.005 mg/L. Higher concentrations downstream of the Town of Orangeville are likely due to discharges from the STP and from urban runoff. Reductions in copper concentrations

are noticeable at Station 024. This reduction could be attributed to dilution from the three Caledon tributaries. Current concentrations of copper are below the PWQO at each station.

Suspended Solids

Suspend Solids concentrations are highly variable, ranging from less than 1 mg/L to 200 mg/L. The variability is largely attributed to hydrologic conditions at the time of sampling and the nature of sediment sources flowing into the watercourse as well as the morphologic characteristics. There is generally no significant differences in suspend solids concentrations between monitoring stations. Current concentration trends indicate average concentrations varying from 2 to 6 mg/L. Concentrations were higher in the early 1960's and reduced to their lowest levels in the early 1980's. There was an increasing trend in the 1980's to the current conditions which appears to have stabilized since the early 1990's. Generally concentrations are lowest for discharges from Island Lake and higher downstream of the Town of Orangeville. Increased loadings of suspended solids from surface runoff, particularly from construction activity, is considered to be the primary source for higher instream concentrations.

STP Operating Records and Performance

The Town of Orangeville sewage treatment plant discharges its effluent into the Credit River downstream of Island Lake and the confluence of Mill Creek, see Figure 3.1. The plant provides tertiary treatment (primary sedimentation, secondary activated sludge, and sand filtration) and in addition to chlorination, nitrification and denitrification processes.
In 1982, the sewage treatment plant was expanded to meet MOEE requirements. The Certificate of Approval, which regulates the discharge quality from the plant, also included a requirement for a program to monitor the conditions within the Orangeville Marsh from the STP effluent to the Melville pond. The Orangeville Marsh is considered an integral part of the overall treatment system. As such monitoring of the benthic and vegetation community is conducted every two years by Beak Consultants Limited. In the event that the monitoring program revealed a degradation of the marsh quality, the Town of Orangeville is obligated to take corrective measures to ensure that the water quality in the Credit River is maintained.

The marsh conditions reported by Beak Consultants Limited can be summarized as follows.
The initial baseline conditions in 1982 prior to plant expansion indicate that the marsh is

not a static entity and that changes that may occur within the marsh may not be attributed to the STP operation. Overall, the data collected in the past 12 years indicates that there has been no significant changes in the composition of both the benthic macroinvertebrate and marsh vegetation communities. Although slight changes may have occurred the observed difference can be attributed mostly to differences in ambient air and water temperature conditions rather than STP discharges.

The Ontario Ministry of the Environment prepares routine reports on the performance of sewage treatment plants throughout Ontario. Presented in Table 3.5, is a summary of the plant performance for 1990 to 1993. The table presents monthly and annual effluent water quality and the average annual treatment efficiency. The data indicate that the STP is maintaining a high treatment efficiency having removal of BOD, TSS and TP at 99%, 98% and 97%, respectively. Overall the Orangeville STP was reported to be one of the few plants in Ontario to have successfully complied with MOEE criteria for five consecutive years, 1986 to 1990. As such, the Orangeville Plant was ranked as one of the top 10 performing STP in all of Ontario.

The Orangeville STP also monitors effluent concentrations for ammonia, TKN, Nitrite, Nitrate, pH and alkalinity, and recent (1994) temperature. Since TKN is the only one of these parameters monitored in the influent, its removal efficiency of 97 percent can be reported. The 1994 average concentrations of TKN, ammonia and NO_2 + NO_3 were 0.7 mg/L, 0.14 mg/L and 5.2 mg/L, respectively. The maximum temperature measured was 19 EC in July 1994.

The plant is currently treating approximately 11,000 m^3/day of sewage and is operating at 80 percent of its rated design capacity of 14,400 m^3/day.

Island Lake Nutrient Budget Study

In 1988 Beak Consultants Limited completed an intensive study of the role plant harvesting had on the nutrient budget of Island Lake. The key finding relevant to baseline water quality conditions is that the Orangeville reservoir acts as a sink for phosphorus and nitrogen. Of the nutrients entering the reservoir, 54 percent of the nitrogen and 52 percent of the total phosphorus are retained by the reservoir, thereby reducing downstream export to the Credit River.

3.5.4 Water Quality Monitoring Program

Water quality samples of urban drainage during wet and dry weather conditions were collected as part of this study in order to better characterize baseline conditions and assess the potential impacts of urban development. Measurements of water quality including, temperature, conductivity, dissolved oxygen and nutrients were obtained by the groundwater, benthic and fish community studies and not included in this section.

Five wet weather and two dry weather samples were collected from April 1993 to October 1993. Table 3.6 presents a summary of the water quality monitoring data. The key findings of this monitoring program are summarized as follows:

Ecoli (Escherichia coliform) counts during wet weather exceed current MOEE guidelines for body contact recreational activity, however, they are typical of urban stormwater runoff from other Ontario municipalities. Dry weather concentrations are slightly elevated and suggest possible contamination with sanitary sources.

Mean suspended solids concentrations are typical of urban stormwater runoff. Although the sampling results indicate typical suspended solids concentrations, high quantities of sediment in the form of stream bedload have been observed on several tributaries, including two tributaries of Monora Creek and within the ditch at the water quality monitoring site. These high loadings are attributed to construction activities within the Subwatershed No. 19. Concentrations of suspended solids from urban runoff exceed concentrations in discharges from Island Lake and the Orangeville STP.

Total Phosphorus concentrations of 0.2 mg/L to 0.4 mg/L are highest for wet weather samples. They exceed dry weather concentrations by an order of magnitude. Concentrations of 0.036 and 0.014 mg/L were reported in dry weather samples. The

observed concentrations are slightly lower than those typically reported for total phosphorus in urban runoff (0.3 to 0.8 mg/L, MOEE 1992 and EPA 1983). In comparison, the concentrations in stormwater runoff currently exceed those of the Orangeville STP effluent (0.2 mg/L) and from Island Lake (0.02 mg/L).

High nitrate, TKN and ammonia concentrations were reported in dry weather discharges, compared to those observed in wet weather discharges and typically found naturally in groundwater. The higher dry weather concentrations may be attributed to localized sanitary contamination of the groundwater. This condition may be related to the slightly elevated densities of bacteria observed in dry weather samples. Dry weather nitrate concentrations of 0.7 mg/L exceed those reported for discharges from Island Lake but are below those reported in the Credit River downstream of the STP. TKN concentrations generally exceed those observed at each of the instream monitoring stations.

Copper concentrations of 0.054 mg/L were highest during wet weather conditions. Dry weather concentrations of 0.004 mg/L. The wet weather concentrations exceed observed instream concentrations and PWQO by an order of magnitude and are slightly higher than those typically observed in urban runoff (0.034 mg/L and 0.045 mg/L, TAWMS and NURP EPA, respectively).

Dissolved solids are several times higher for dry weather samples averaging 775 mg/L. The high dry weather concentrations reflects the high groundwater content in base flow. They also suggest that the higher concentration of pollutants observed in stormwater runoff are likely attributed with particulate matter.

3.5.5 Water Quality Modelling

A mass balance water quality model is presently being developed for this study. The primary purpose of the model is to assess the impacts of future land uses changes and the benefits of alternative Best Management Practices (BMPs). The model will also provide estimates of water quality for unmonitored locations. The model assumes that the water quality parameter is conservative (not affected by instream process of decay or sedimentation, for example Ecoli will not be modelled) and excludes any instream sources as a result of channel erosion or groundwater sources. This report includes the findings for existing conditions. The impacts of land use change and an assessment of alternative BMPs scenarios will be presented in the Phase II/final report.

Table 3.7 presents the water quality and quantity data base used to obtain preliminary estimates of annual pollutant loadings. This table presents typical water quality concentrations reported for urban and rural land uses, concentrations observed in the urban discharge sampling program performed in this study, water quality of the Orangeville STP effluent and annual discharge volume from each source.

Presented in Figure 3.15 is the relative contribution of pollutant loadings to the Credit River downstream of Island Lake. The data indicates the following:

- Island Lake contributes 50% of the annual flow;
- the Orangeville Sewage Treatment Plant is the primary loading source of nitrite and nitrate (65%), copper (82%) and total phosphorus (51%); and
- urban stormwater runoff is the major source of faecal coliform (56%) and suspended solids (52%) loadings.

3.5.6 Summary

Existing water quality throughout the Subwatershed 19 is considered to be good. Water quality is not considered to be a limiting factor in the present health of the aquatic communities. The good water quality conditions are attributed to the following conditions:

- the lack of major industrial pollution sources;
- the high level of treatment provided by the Orangeville Sewage Treatment Plant;
- pollutant removal by Island Lake;
- the relatively high percentage of flow from clean groundwater sources;
- the current level of urban development; and
- the type of rural land use which is predominantly passive agricultural.

The existing water quality conditions in the main branch of the Credit River downstream of the Town of Orangeville are significantly better than conditions which existed in the mid 1960's. Improved water quality is largely attributed to improvements in sewage treatment at the Orangeville STP. Improvements have resulted in higher levels of dissolved oxygen, controlled algae growth and a healthier benthic community. Water quality conditions have also preserved the quality of the Melville Marshes and seasonal populations of Brook Trout.

Under existing conditions the Orangeville Sewage Treatment Plant remains the primary loading source of nitrite and nitrate (65%), copper (82%) and total phosphorus (51%) to the Credit River, however, the conditions which exist do not presently impact the river. Urban runoff is the major source of faecal coliform (56%), suspended solid (52%) loadings. Except for contributing 33 % of the Faecal Coliform load the quality of discharge from Island Lake does not have a negative impact on the Credit River. The high volume of discharge (50% of the annual total) and relatively lower concentration of the reservoir discharge has a significant effect in monitoring good water quality downstream.

3.6 FLUVIAL GEOMORPHOLOGY

3.6.1 Overview

The purpose of this component of the study was to determine the current 'health' of the river system and provide baseline data for long term monitoring and impact assessment. Specific objectives were to:

i) Determine the relative stability of the following water-courses: Monora Creek, Mill Creek, the Caledon Tributaries and the main Credit;
ii) Discuss the role of the principal factors in determining the stability of these systems; and
iii) Document detailed descriptions of river form and function to provide a basis for environmental monitoring.

The first three objectives are addressed in this summary. The fourth will be addressed in the next phase of the study.

3.6.2 Geomorphic Principles

In order to interpret and manage fluvial forms at a site specific level, instream geomorphic processes must be viewed within a watershed context. The factors controlling river form are many, however, the principal factors can be grouped into those which occur at the site (instream zone) and those factors which occur outside of the river valley (the upland zone, Figure 3.16). The conceptual relationship between the upland zone, the instream zone, and the governing geologic formations within the watershed is illustrated graphically in Figure 3.16 (MacRae, 1991). This figure indicates that for fluvial systems of similar geology, climate and valley slope, the upland flow and sediment regimes constitute the primary and

secondary factors controlling bankfull channel cross-sectional area. Within the instream zone, the characteristics of the boundary materials within which the channel is formed (cohesion, stickiness and compaction) and the type, density and distribution of riparian vegetation control and modify, respectively, bankfull channel width.

Changes in these factors beyond a critical threshold, will result in a disturbance to the system. The channel will adjust to these new conditions and the morphology of the new channel may look quite different than the original. The channel typically adjusts in stages. For sand bed streams, which are typical in Subwatershed No. 19, the first sign of adjustment (tier 1) involves a change in the bed configuration. These changes occur over very short time scales (minutes to days). The next stage occurs (tier 2) over longer time periods (months to tens of years) and involves changes in the channel cross-section form (e.g. bankfull width and depth). These changes are eventually reflected in the third level of adjustment which includes changes in meander pattern and the slope of the channel. These tier 3 adjustments may take from tens to hundreds of years to reach a new stable configuration.

To illustrate these 3 tiers of river adjustment consider a straight sand bed channel experiencing a steady increase in flow. Initial increases in flow velocity would lead to the development of ripples on the bed (tier 1). The thalweg (fastest area of flow) begins to wander from bank-to-bank causing erosion at these locations. This leads to scour on one bank and deposition on the other bank changing the cross-sectional form (tier 2). As these bars are formed laterally across the floodplain the straight channel begins to meander (tier 3). The meander amplitude and wavelength continue to adjust until the slope of the channel has been reduced and the corresponding erosive energy of the water carried by the stream reaches an equilibrium with the resistance of the bed and bank materials to entrainment and transport. In a stable channel system, the size (cross-section area) and plan form (meander characteristics) represent a dynamic balance between the erodability of the materials within which the channel is formed and the ability of the waters carried by the channel to erode its boundary.

This investigation attempts to characterize the fluvial system within a watershed context for Subwatershed No. 19 by relating observed fluvial features such as cross-section width and meander wavelength to the principal factors controlling channel form.

3.6.3 The Study Area

Subwatershed No. 19 is characteristically hilly and consists of moraines, gravel terraces, and swamps in which forest is still fairly abundant (Chapman and Putnam, 1984). There is a predominance of glacially deposited sand and gravel within the basin (Figure 3.7). These sand and gravels are found in the banks of streams and are very erodible materials. However, the channels have not cut deeply into the broad flat valleys through which they flow due to a lack of overland flow generated in the upland area. The sands and gravels promote high infiltration and consequently overland flow may comprise less than 10% of the total annual precipitation. Overland flows are the runoff component responsible for high flood flows in the streams. These flows are also the primary vehicle responsible for the movement of sediment and the primary cause of channel erosion. Therefore stream discharges subside very slowly after a rain event. Consequently the stresses of very high flood flows, experienced in more impervious basins, are not currently operating on the channel systems within the basin. The presence of riparian vegetation along stream corridors and the occurrence of coarse bed material (associated stratified drift) also promote channel stability. The main land use in the area has traditionally been agriculture, however, in the past decade the amount of urban development has increased significantly. This has resulted in an increase in impervious area within some basins and a corresponding increase in overland flow. Water taking in the form of municipal wells and the operation of Island Lake have also impacted stream morphology. The extent to which these impact have occurred is discussed below.

3.6.4 Study Methodology

These study goals were accomplished in two stages.

The first stage involved a screening level assessment of the following streams: Monora Creek tributaries, Mill Creek Tributaries, Caledon Tributaries, the Eastern Tributary and the main Credit River. The objectives of these visits were: to examine, in a qualitative manner, the degree of disturbance and modification within these systems; to discern any linkages between disturbed sites and changes in land use practice, and; to collect data to characterize the current geomorphic state to aid in the selection of sites for detailed study (phase II). The data which were collected consisted of the width across the bottom of the channel (bank toe to bank toe), width across the top of the channel, depth of flow, bankfull width, bankfull depth, floodplain width, and associated riparian vegetation. These data allowed for a cursory classification of stream types based on the entrenchment ratio and

bankfull width/depth ratio using the Rosgen (1993) classification system. Data were collected at 44 riffle sections along the aforementioned streams (Figure 3.17).

The second stage involved a detailed survey of five sites shown on Figure 3.17. The objective of this survey was twofold: to document currently stable stream sections for long term monitoring, and to collect data on bank stability necessary for a computer simulated assessment of future land use conditions. The following data were collected: planimetric form, longitudinal profile, channel and valley cross-sections, velocity, bank material composition and susceptibility to scour; substrate and substratum composition; descriptive accounts of bedforms, descriptive accounts of riparian vegetation; photographic documentation, and; descriptions of these characteristics upstream and downstream of the surveyed reach. These data were used to classify of the fluvial system using the Rosgen (1994) method, and determine channel stability. These data are presented in the Technical Appendix.

3.6.5 Results

Summaries of the data from phase one (Table 3.8) and two (Tables 3.8 to 3.11) of the surveys are presented below. An example of the geomorphic survey conducted at each site is presented for site 4 on the main Credit (Figures 3.18, 3.19 and Photo 1).

These data document the baseline geomorphic state of the following tributaries: the north and south branches of Monora Creek, Mill Creek, the Caledon Tributaries and the Credit River. Qualitative observations and photographic evidence were collected on site visits to the middle tributary of Monora Creek and the North Eastern Tributary. These latter systems were not sampled because of their small size and intermittent nature.

3.6.6 Baseline Geomorphic State

The main Credit River and tributaries remain in a relatively 'natural' condition compared to other southern Ontario headwater basins. This may be partially attributed to the lack of and decline in intensive agricultural practices within the basin. The soils are well drained so the amount of 'improved' drainage is minimal and restricted to areas with less permeable soils and areas with shallow slopes. Steep valley walls and marshy conditions along stream corridors has inhibited the removal of riparian vegetation however cattle access to wooded stream corridors was not uncommon. The impacts of cattle access are local and stream recovery is rapid after access is restricted. There is a moderate amount of development

within the basin mostly located in the Town of Orangeville. Development is primarily concentrated in the lower catchment areas of Mill and Monora Creek, although development is currently underway in the headwater area of Mill Creek. Development is also planned for much of Monora Creek. Channel instability was noted in the lower reaches of these creeks. This erosion was associated with stream corridor fragmentation, increased sediment loads, channel hardening and possibly an increase in flow. The geomorphic state of each of the main tributary and the Credit River itself are provided below on a tributary-by-tributary basis.

North Branch of Monora Creek

This system has been modified mostly by agricultural practices. Some channel straightening has occurred in the upper reach and there are a number of farm ponds on the system. A subdivision was being built east of the creek and north of Fifth Sideroad. Sandy sediment was noted in the channel next to this development. The lower reach was quite sinuous and appeared stable in grassy sections (Photo 2). An unstable section was observed east of highway 10, behind a cemetery, where the stream flowed through a stand of mixed conifers and deciduous trees (Photo 3).

Middle Branch of Monora Creek

Upper reach consists of a steep narrow channel with abundant riparian vegetation however slope of the lower section was very flat. Gabion baskets had been put in place to stabilize this lower reach suggesting that the channel had been unstable.

South Branch of Monora Creek

This system has been modified by urban and agricultural practices. The stability of the lower reach of the north tributary was compromised by a sediment spill downstream of Milady pond however mitigative measures have been taken (Photos 4 and 5). The south tributary appears to be stressed with bank erosion and siltation observed in the lower reach (Photo 6). The stream corridor downstream (east) of the Blind line is fragmented and flowing through an urban residential area. Some sections appear to have been straightened upstream of the Blind Line historically. Most of the riparian vegetation has been removed from this upper section except between the Blind Line and Townline Road. This area is slated for development.

Mill Creek

The majority of Mill Creek has been modified downstream of the C Line. Modifications include straightening at road intersections and residential property boundaries. Beaver activity upstream of the C Line has disturbed the riparian vegetation and caused sediment to build up however stable sections of channel were present. Silty debris was found downstream of the B line which may have originated from land clearing for an estate development south of Highway 9. The channel immediately downstream of this development, however, remains stable.

Eastern Tributary

This tributary flows through agricultural lands and has a good deal of riparian vegetation in the upper watershed. Some localized stream bank erosion and channel widening was associated with cattle access sites in the headwaters, however, the majority of the stream appeared stable.

Caledon Tributary (Northern)

The majority of this tributary is healthy and stable. The system has been modified by artificial ponds in the headwaters and at the outlet however the system appears to have adjusted to these changes.

Caledon Tributary (Middle)

The majority of this tributary is healthy and stable, especially from the confluence of the north and south tributaries to the outlet with the Credit River. Upstream of this point cattle access has disturbed the banks causing the creek to widen. This disturbance may have been aggravated by increases in flow due to improved drainage practices in the headwaters. The channel has been straightened in the vicinity of the airport.

Caledon Tributary (Southern)

This tributary is very healthy and stable. Channel straightening has occurred near the airport because of the less permeable soils found there and shallow slope. Flows from this straightened section pass through a wetland which may dampen their effect on the system. Changes in channel width and depth occur naturally as the stream channel cuts down

through the spillway deposits near the outlet of the creek.

Credit River

The Credit River between Island Lake and the Melville Reservoir is generally stable however sediment is accumulating over the majority of the reach. Conceivably, the stream power available to transport sediment has decreased since Island Lake was built in the mid-sixties. The stretch from the reservoir downstream to the Caledon Tributaries is swampy due to a lack of slope. This reach serves as an additional sediment sink catching sediment generated from the basin downstream of the reservoir. Downstream of the swampy reach (east of highway 10 and north of concession 25) the stream is steeper and narrower. The flows in this section are able to convey larger sediment loads (Photo 1) and particle sizes. A moderate amount of bank instability is present at the outlet of Caledon tributary #2. This instability may result from an increase in flow in the Caledon Tributaries, poor design of imposed habitat enhancement structures, a lack of sediment supply or a combination of these factors. Sediment is accumulating downstream of the caledon tributaries which may result from a decrease in slope and the ponding effects of the Melville Reservoir and the bridge crossing at highway 10.

3.6.7 Sensitivity to Change

The management interpretations of Rosgen (1993) for the stream types determined in this study suggests that they have a 'very high' sensitivity to disturbance. The tributary streams had a 'high' potential for bank erosion and the main Credit had a 'very high' bank erosion potential. The potential for recovery from disturbance was 'good' for tributary streams but only 'fair' for the main credit. The maintenance of channel stability for the main credit required a 'very high' sediment supply while tributary streams only required a 'moderate' amount. The role of vegetation as a controlling influence on stream stability and form was rated as 'very high' for all the streams tested. Stream morphology varies along the length of streams within the watershed and some sections are more susceptible to changes in the driving mechanisms than others however, in general:

- the lower section of the basin tributaries, contained within the sandy spillway (glaciofluvial outwash, Figure 3.7, are very susceptible to erosion due to upstream increases in flow;
- the upper catchment of basin tributaries may be susceptible to sedimentation problems because of the shallow slopes found there;

- the swampy section of the main credit below Island Lake is particularly susceptible to increases in sediment load;
- the section of the main Credit River which receives flow from the Caledon Tributaries may be particularly susceptible to both changes in the flows and sediment loads entering from the Caledon tributaries; and
- sections of stream within a fragmented stream corridor, with sparse ground cover and a lack of deep rooting plants (and/or coarse particulate) are particularly susceptible to increases in flow.

3.6.8 QUALHYMO Model Analysis of Instream Erosion Potential

The purpose of this component of the study was to use the characterization of the fluvial system within the study area on the fluvial geomorphology of the main Credit River and its principle tributaries: Monora Creek, Mill Creek; and the Caledon Tributaries. This involved setting up and calibrating a continuous hydrologic simulation model. The QUALHYMO (Rowney and MacRae, 1991), model was selected. This section of the report deals with the set up and calibration of the model to reflect existing land use conditions as the base case. Water Survey of Canada (WSC) flow records for Station 02HB013 near Orangeville for the year 1990 were used to fit the model. This year was selected because nearly complete hourly flow records were available.

Basin Discretization

The basin was discretized as shown in Figure 3.4 to distinguish between the major and minor tributary systems within the watershed and major hydraulic features, such as Island Lake. These basins were further sub-divided to isolate existing, future and ultimate land use scenarios, particularly within the Monora and Mill Creek areas. Using this level of discretization, flows can be generated at points upstream of, downstream of and within any specific development area. Flow series at these points provides a basis for the assessment of the probable impact of urbanization on the channel flow system as well as BMP measures which may be required to mitigate these impacts.

Hydrologic Model Results

The model was run for the period November 1, 1989 through to December 31, 1990. The November-December 1989 period was used to allow the model parameters to adjust to an equilibrium condition. The calibration protocol is described in the Appendix. A comparison between the simulated and observed flow series at Melville Reservoir is illustrated in Figure 3.20 for the period of January 1 to December 31, 1990. The agreement is considered to be good.

A hydrologic budget was obtained for the study area at Melville Reservoir for predicted and observed flows (Table 3.12). Predicted flows overestimated observed flows by 1.29 times on an annual basis. This is primarily due to an overestimation of flows during the summer months which may be due to water taking for irrigation and livestock watering, modelling assumptions concerning the aerial distribution of summer thunderstorms, and the retention of water in Island Lake to maintain recreational activities. However, the later

activity appears to be the single most significant factor. The budget also includes flow contributions from the Orangeville Sewage Treatment Plant.

On a sub-basin basis, hydrologic budgets were determined by fitting the model to reproduce baseflow observations while maintaining the overall fit obtained at Melville Reservoir. These data indicate that a significant difference exists between urbanized and non-urbanized sub-basins (Table 3.13). Average yield of overland flow for urban basins was between 120 and 175 watershed-mm (the equivalent depth of water over the basin). A proportionate decrease in infiltration and evapotranspiration losses was also noted along with a decrease in baseflow volume of between 5 to 70 watershed-mm on an annual basis.

Baseflow contribution as a percentage of infiltrated waters (I), are reported for each sub-basin in Table 3.14. From this analysis it was noted that some sub-basins, e.g. Sub-Basin 362, may be receiving a significant portion of these waters through extra-basin transfers of groundwater (groundwater flow which contributes to stream flow within the sub-basin but originates from outside of the sub-basin's drainage divide as defined by the surface water system).

3.6.9 Summary

The main Credit River and the lower reaches of the primary tributaries were assessed to be in a relatively 'natural' condition over most of their length. The exceptions being Mill Creek and the southern tributary of Monora Creek. Most streams had been modified in their headwater areas. The Mill Creek and the south branch of Monora Creek showed signs of instability in their lower reach which may suggest that they are responding to the surrounding urban environment. Despite the general health of the watershed the potential for disturbance due to changes in the upland flow and sediment regimes is very high. The bank erosion potential was assessed as high for tributary streams and very high for the main Credit River. This suggests that changes in flow and sediment characteristics of tributary streams may not only impact the morphology of those streams but may have a greater cumulative impact on the main Credit River.

3.7 Terrestrial Features

3.7.1 Introduction

Terrestrial features comprise the "land" element of the subwatershed. The features

described in this report include:

- **landform** as defined by the physical shape of the land through topography, and geological formations;
- **biological communities,** comprised of natural vegetation communities, such as upland forest, riparian vegetation and wetlands and wildlife communities consisting of mammals, birds, reptiles and amphibians, and their habitat; and
- **specially designated natural areas** that have been afforded provincial or regional protection status due to their ecological importance or rarity.

The terrestrial features of the subwatershed form the resource base upon which human activities are concentrated through land use. Achieving a balance between land use and protection of the quality of the terrestrial features is a fundamental objective of self-sustainable development. The environmental quality of terrestrial features can be largely defined through visual impression, and the areal extent and diversity of natural vegetation communities. In general, natural terrestrial features that are present in southern Ontario are remnants of a once extensive deciduous forest ecosystem that has been fragmented and degraded by a variety of land uses over the past two hundred years. Therefore protection of existing features and establishment of larger continuous natural areas through creation of continuous vegetation corridors between natural areas are key goals of environmental planning. Several key planning documents recognize the importance of protecting and re-establishing functional terrestrial systems, including:

- Planning Act Reform - Bill 163 and the Comprehensive Set of Policy Statements (MMA, 1994);
- the Natural Heritage of Southern Ontario's Settled Landscapes (Riley and Mohr, 1994);
- Credit River Watershed Management Strategy, Phases I and II (CVC, 1992);
- Town of Caledon, Official Plan Amendment 124, (1994); and
- CVC Watercourse and Valley Land Protection Policies (1992).

Important benefits of a healthy terrestrial system include:

- protection of rivers and streams from sedimentation and temperature increase;
- protection of groundwater recharge areas;
- biological diversity; and
- recreational opportunities, and visual and aesthetic benefits that enhance the quality of life.

3.7.2 Study Objectives

The objectives of the terrestrial features component of the Subwatershed No. 19 study are:

- to identify locations of existing specially designated areas including ESAs, ANSIs and wetlands;
- to review existing information concerning terrestrial features within the subwatershed and comment, where appropriate on features that serve important hydrological functions or that may be sensitive to changes in the hydrologic regime resulting from land use changes; and
- to recommend a strategy for establishing or maintaining components of a healthy terrestrial system within Subwatershed No. 19, comprised of a variety of natural areas linked by green corridors within the subwatershed and extending to adjacent natural areas in other subwatersheds within the Credit River or adjacent.

The first two objectives will be addressed in this chapter (see also Section 3.9).

3.7.3 Study Methods

The location, extent and condition of existing terrestrial features was established through a review of existing information, including published and unpublished reports and documents, Ontario Base Map data (1982), analysis of 1993 air photos, and contacts with provincial, regional and local agencies. Key information has been summarized (Figure 3.21).

Landform

Subwatershed No. 19 is an area of approximately 62 km^2 which forms the northern headwater area of the Credit River. It is characterized by flat to slightly rolling topography. Prior to agricultural settlement, the subwatershed area consisted of mature upland maple-beech deciduous forests and extensive poorly drained, cedar swamp complexes in low-lying areas. Over the past 150 years, much of the wetland area was cleared, and drainage became channelized into the main tributaries that are recognizable today. Valleylands associated with these tributaries are generally shallow and poorly developed. The construction of Island Lake in 1967 collected the outflow from the

northern reaches of the subwatershed, creating a 187 ha impoundment.

The surficial geology of the subwatershed consists of largely glacial deposits as described in Section 3.4. A north-south band of glaciofluvial till consisting of stratified sands and gravels underlies the majority of the subwatershed. This is reflected in the soils which consist in tableland and upland areas of coarse-textured grey-brown podzols of the Fox and Guelph soil families. The northwest portion of the subwatershed in the vicinity of the Town of Orangeville contains moderately fine-grained podzolic soils formed of very fine sands and silts belonging to the Honeywood soil family (Hoffman et al., 1964). Organic soils are associated with wetland areas which are characterized by poor drainage and low relief.

Biological Communities

The natural vegetation communities, wetlands and wildlife found within the subwatershed are the product of climate, physiography, soils and land use. In southern Ontario, these features usually represent remnants or fragments of pre-settlement communities which have persisted in areas that are unattractive for agricultural or urban development. The diversity and extent of forested areas and wetlands are good indicators of the health of natural biological communities.

Since a detailed woodlot inventory of the subwatershed has not been undertaken to date, estimates of forest cover were made from analysis of Ontario Base Maps and recent air photos. Existing forest cover and wetland areas within Subwatershed No.19 are shown in Figure 3.21. On the figure, upland forests are differentiated from wetland/riparian forest cover. Based on the map, approximately 17% of the subwatershed is presently covered by natural terrestrial areas comprised of upland forest, riparian or wetland vegetation. All mature woodlots and wetlands of significant size are located within the ESAs. In addition to the areas of natural vegetation identified above, large areas of agricultural tableland are currently vacant or abandoned, and these are naturally regenerating. Trees found in such areas appear to range from 5-20 years based on size.

Areas of riparian vegetation are limited due to the shallow, poorly developed nature of the valleys in most stream reaches. In agricultural sections of the subwatershed, riparian vegetation has been cleared, and there are numerous areas of livestock access to streams.
The subwatershed lies within the Huron-Ontario section of the Great Lakes - St. Lawrence Forest Region (Rowe 1972). Natural forests in the area are typically dominated by sugar

maple and beech. Coniferous species such as eastern hemlock, white pine and balsam fir are frequently found amongst the hardwoods in upland areas. Low lying areas,and wetlands are dominated by eastern white cedar.

The percentage of forest coverage reached a low point in the mid-1950s when agricultural production was at its peak. Since that time, agricultural land use has decreased, and much of the vacant agricultural land has become re-forested through natural regeneration, or planned reforestation. Island Lake represents the largest area of net gain in natural environmental area, since this land had been open farmland prior to its construction. Through extensive environmental restoration efforts, significant areas of upland forest and wetlands have been created. A detailed up-to-date inventory of the vegetation communities of Island Lake is contained in the most recent inventory of Island Lake Conservation Area (CVC, 1994).

Other areas within the subwatershed containing a significant coverage of natural vegetation include the uppermost reaches of all tributaries, the Monora Creek drainage area, and the floodplain of the main Credit River from the Reservoir to Melville, and the upper and lower reaches of the tributaries to the Credit River (at Highway 10).

While the growth of the Town of Orangeville has been largely at the expense of agricultural land, natural vegetation cover in the middle and lower reaches of Mill Creek remains limited to a narrow band of riparian vegetation, as is the case in other parts of the subwatershed in areas that are currently in agricultural use.

Specially Designated Natural Areas

In recognition of the importance of natural areas, a number of areas within the subwatershed have been identified as specially designated natural areas through provincial, regional, and or municipal initiatives. Within the present study the following environmentally significant features have been recognized:

- **Areas of provincial importance:** 1) earth or natural science Areas of Natural or Scientific Interest (ANSI), exemplifying a vegetation community or landform that is characteristic of the region; 2) provincially important wetlands (Class 1, 2, or 3); 3) habitat for provincially or nationally rare species of plants and animals, or other species-at-risk.

- **Areas of regional importance:** Environmentally Sensitive Area (ESA) and Possible Environmentally Sensitive Area (PESA) as identified by the Credit River Conservation Authority.

Current CVC files identify three ESAs within the subwatershed. These include:

- Rosehill Swamp (ESA #34);
- Island Lake (ESA #58); and
- Melville Marshes (ESA #57).

A number of other environmentally significant features are associated with the subwatershed. Caledon Lake (ESA #36) is located outside, but immediately southwest of the subwatershed. As shown on the map, a number of areas of "confirmed" wetlands have been identified in the subwatershed, but these have yet to be classified.

Rosehill Swamp (ESA #34) is a 205 ha wetland complex. The ESA lies within a depression surrounded by glacial hummocky and drumlinized terrain. It is in a poorly drained perched aquifer which is the headwater for the Caledon Creek tributaries of the Credit River. CVC identifies this as an ESA on the basis of hydrological significance and the presence of rare species, high species diversity and habitat features. The OMNR wetland inventory identifies areas of Class 1 wetland within the complex.

The ESA is botanically diverse. It is dominated by a coniferous swamp of predominantly white cedar and tamarack. There is a sphagnum bog located at the north end. This is a regionally rare habitat type. The regionally rare plant species, mountain fly-honeysuckle is present in the swamp. Whitetail deer are common in the area. The abandoned airport, located at the south end of the swamp has had some impact on the hydrology of the site (Ecologistics, 1979).

Island Lake (ESA #58) contains the reservoir (182 ha), and surrounding wetland complex and upland forest (162 ha). The environmental features within this ESA are well documented in environmental plans and resource inventories. The most recent inventory undertaken by CVC (1994) updates and summarizes most of the historical information. The associated Class 1 wetland complex contains cedar swamp, marsh and a small floating bog, located in the eastern arm of the reservoir. Small areas of mature forest have been identified on St. Chris Island and Moffat Farm Sugarbush, but significant regeneration and re-planting has occurred at a number of locations within the ESA. CVC (1994) notes the

presence of a number of rare or significant bird species including: the Great Egret (rare); Ruddy Duck, Black-crowned Night Heron and Horned Grebe (provincially significant); Northern Shoveller, American Widgeon, Ring-necked Duck, Merlin and Dark-eyed Junco (regionally significant). Several rare or uncommon plant species are also identified. The presence of the nuisance exotic purple loosestrife is noted in the western portion of the reservoir.

Melville Marshes (ESA #57), also historically known as Orangeville Marsh is a 92 ha riverine wetland located adjacent to the main Credit River south of the reservoir outflow. The southern part of the Melville Marshes is part of an earth science ANSI which extends south into the Niagara Escarpment. The ESA is also identified as containing significant upland wildlife area (OMNR, 1983).

The Town of Orangeville has conducted vegetation and benthic monitoring of the marsh on a bi-annual basis since the mid eighties in order to document the effects of sewage treatment plant effluent on the marsh ecosystem. There was a major expansion of the wetland community in the mid-1970s, with little significant change recorded since then. Minor annual variations reflect variations in the hydrological regime. Reed canary grass is the dominant marsh macrophyte.

Caledon Lake (ESA #36), located immediately southwest of the subwatershed is a 693 ha kettle lake characterized by a large surrounding area of hydrological infiltration. The ESA contains both earth science and biological ANSIs, as well as Class 1 wetland. There is currently no apparent hydrogeological connection between the Caledon Lake recharge area and Subwatershed No.19, which likely extends into Subwatershed No.19. However, pumping of the overburden in adjacent areas of Subwatershed No.19 may potentially affect subsurface drainage.

3.7.4 Summary

In summary, the key findings of the terrestrial component of the study are:

- there are a number of provincially and regionally significant areas within the subwatershed;
- there are three ESAs, all of which contain provincially important wetlands (Class 1);
- all provincially and regionally important wetlands are of hydrological

importance, since they are characteristically located in headwater areas;

- both Island Lake and the Rosehill Swamp contain small bogs, which are rare habitat types in southern Ontario;
- upland forest, riparian vegetation and wetlands cover 17% of the subwatershed;
- natural regeneration of vacant and abandoned agricultural tableland is significantly increasing the area of natural vegetation, however, this land area is currently not protected;
- since stream valleys are shallow and poorly, defined areas of riparian vegetation are relatively small, and in many parts of the subwatershed has been removed through agricultural clearing;
- the creation of Island Lake has resulted in a significant gain in natural area within the subwatershed;
- numerous potential natural area linkages exist along stream corridors.

3.8 Aquatic Features

3.8.1 Introduction

The aquatic features considered in this study include:

- **benthic macroinvertebrae communities**, comprised of aquatic macroinvertebrates such as insect larvae, freshwater molluscs; and
- **fish communities and fish habitat,** where fish habitat consists of key physical and chemical components of the aquatic ecosystem of importance to biota such as water flow rates, temperature and dissolved oxygen content, substrate condition and riparian cover.

These biological indicators of aquatic community health are routinely used by ecologists to evaluate the effects of human activities on aquatic ecosystems. Aquatic community health is closely related to hydrological and water quality characteristics, as described in Sections 3.3 and 3.5.

Two key trophic (food chain) levels of the aquatic community, fish and benthos, are routinely studied to evaluate the effects of human activities on watercourses. Studies of these communities not only focus on the abundance and diversity of aquatic life in a stream, but also on the physical, hydrologic and water quality characteristics of the habitats in which these animals live.

Benthic macroinvertebrates (benthos), which live on or in the sediments of aquatic systems, include crustaceans (e.g., crayfish), molluscs (e.g., snails and clams), oligochaetes (aquatic worms) and larval stages of insects (e.g., blackflies, mosquitoes, dragonflies and mayflies). The benthos serve as food for higher trophic levels, such as fish and waterfowl. Benthos reflect water quality because they are relatively immobile and sensitive to stresses, such as increased temperature, nutrient enrichment, increased turbidity (siltation), loss of habitat and flow alteration, which are directly related to land use practices.

The relative abundance of life cycle stages (fry, juvenile, adult) and types (species) of fish found in a watercourse not only can represent an important recreational resource, but also reflect the nature (quality and quantity) of aquatic habitats, the hydrology and the water quality within a watercourse which are impacted by human activity within the watershed.

Human activities such as forestry, agriculture and urban development, may destroy aquatic habitats, degrade water quality, increase sedimentation, increase streambank/channel erosion, reduce baseflows and increase storm flows. Consequently, these activities can cause a reduction in the abundance and number of species represented in the aquatic community to the point where some watercourses no longer support fish and benthos. The disappearance of a species may result from a change in a single habitat requirement, for example, trout may disappear from a watercourse when riparian vegetation is removed thus increasing stream temperature. On the other hand, several factors in combination may cause a species to disappear, for example, by reducing food supplies, overwintering habitat or protective cover from predators.

Aquatic community inventories and a number of habitat assessment tools are used not only to identify the existing community and the constraints placed upon it by human activities, but also to identify what habitat attributes and fish/benthic invertebrate species responses would result if human activities (e.g., land use) change or specific rehabilitative measures are taken. Rehabilitative measures or targets typically address each of the five components of aquatic habitat:

- flow, including surface runoff and groundwater;
- water quality, including temperature and dissolved oxygen;
- stream morphology;
- riparian and instream habitat; and
- biological interactions.

Aquatic resource studies were undertaken to identify:

- existing fish and benthic macroinvertebrate communities present in the main creek and flowing tributaries;
- existing aquatic and riparian habitats and fish migration barriers;
- extent of habitat disturbance from bank/channel erosion, channelizing/ditching, riparian vegetation removal, sedimentation and water quality impairment;
- aquatic/riparian habitat characteristics and fluvial geomorphological measures of relatively undisturbed stream reaches to provide guidelines for stream rehabilitation; and
- calculations of IBI, WQI, HSI and other measures/indicators of aquatic community/habitat conditions.

3.8.2 Study Objectives

The objectives of the aquatic features component of the Subwatershed No.19 study are:

- to assess existing aquatic ecosystem health within the subwatershed using bioindicators based on fish and benthic community parameters;
- to inventory stream habitat to identify physical-chemical requirements and limitations to aquatic communities;
- to develop the framework for a long-term aquatic monitoring strategy; and
- to develop a method for characterizing aquatic ecosystem health which can be used to develop aquatic ecosystem objectives.

3.8.3 Study Methods

The existing condition of aquatic communities in the subwatershed was evaluated through:

- a review of existing information, including field surveys conducted by OMNR, CVC, and consultants;
- a field sampling program was conducted to provide quantitative data that can be used as a benchmark against which to assess the significance of effects that may occur in the future as a result of changing land use; and
- a framework for assessing environmental quality was developed through technical analysis of field results.

Field Sampling Program

The objective of the field sampling program was to develop a current database that describes existing aquatic resources in the subwatershed, establishes stations for long term biomonitoring, and provides a basis for establishing future aquatic community management, objectives and targets. As shown in Figure 3.1, sampling stations were located on all major watercourses within the subwatershed. Station locations were selected through consultation with the project Technical Committee. In order to optimize environmental information collection, benthic community, fisheries and habitat assessment sampling stations were located in close proximity to each other, and to hydrogeological sampling stations, and to biomonitoring locations routinely monitored by CVC and OMNR. A detailed description of sampling protocols is contained in the Technical Appendix.

Benthic macroinvertebrate samples were collected at 13 stations on the 20 and 21 December 1993. Quantitative samples were collected at each site with the exception of Station 5. The purpose of these samples was to estimate the density (number of organisms per unit area) of each taxon that occurred in the sampled habitat. Field sampling procedures follow those described in the MOEE Biological Monitoring and Assessment Program (BioMAP) (MOEE, 1993). This program was developed by the Southwestern Ministry of Environment and Energy (MOEE) to provide an ecosystem-based environmental monitoring system for the management of Ontario's aquatic resources. Temperature, dissolved oxygen, conductivity and pH were measured at each station. Physical parameters measured included water velocity, depth, stream width, substrate type, presence of algae and aquatic macrophytes, water colour and transparency and riparian cover. Species were identified, and density and diversity were calculated. Biotic indices including the Water Quality Index (WQI) and the EPT Index were calculated for the data set. These indices are measures of sensitivity to degradation in water quality (Table 3.15).

Representative stream reaches for fish inventory and aquatic habitat classification were selected to cover the range of stream conditions found within the subwatershed. A total of 18 stations were inventoried for fish, and were classified according to the OMNR (1984) habitat classification system.

Key data from the biomonitoring program are summarized in Table 3.16.

Development of a Framework for Assessing Environmental Quality

A framework for characterizing environmental quality in Subwatershed No.19 has been developed by the study team. The framework utilizes key metrics for fish communities (IBI) and benthic communities (WQI) to define typical aquatic community types currently found in Subwatershed No.19 (Table 3.17). This approach has been successfully applied by BEAK in a number of subwatershed studies in southern Ontario (see Technical Appendix). Based on this framework, four characteristic community types can be identified in Subwatershed No. 19. These are:

- Class 1 - relatively pristine aquatic community;
- Class 2 - slightly degraded aquatic community;
- Class 3 - moderately degraded aquatic community; and
- Class 4 - severely degraded aquatic community.

The key findings from the biomonitoring program are discussed in the following sections in the context of these community types. Table 3.18 summarizes the aquatic habitat characteristics that are typical of each of the community classes. A more detailed technical discussion is contained in the Technical Appendix.

3.8.4 Key Findings

Class 1 Communities - Pristine

Class 1 communities contain self-sustaining native coldwater fish and benthic communities characteristic of pristine second order streams in southern Ontario. Brook trout and sensitive benthic taxa from the groups Plecoptera, Ephemeroptera and Trichoptera are representative of this community. High IBI (>36) and WQI (>13) scores indicate a high level of biotic integrity, and environmental quality can be categorized as excellent. This class would have typified the entire subwatershed prior to urban and rural development.

Class 1 communities are typically found in small tributaries within the subwatershed, in reaches that retain dense natural vegetation cover and have significant baseflow from groundwater. As shown in Figure 3.22, such areas are found in the upper reaches of the northern and middle Monora Creek tributaries, and in the lower reaches of Caledon tributaries 2 and 3. A small section of Class 1 community is found in the upper reaches of Mill Creek, where land development has not occurred.

Class 2 Communities - Slightly Degraded Coldwater Communities

Class 2 communities are best characterized as Class 1 communities that have been degraded as a result of land use. While coldwater species such as brook trout and sensitive benthic taxa are still present, slightly lower IBI scores (30-36) and WQI scores (11-13) suggest that physical impacts such as flow alteration, turbidity and organic enrichment, have occurred. Such effects are typical indicators of low to moderate levels of development within a drainage basin.

Class 2 communities are present in the middle and lower reaches of the Monora Creek tributaries,in areas adjacent to urban development or abandoned agricultural land. Coldwater community remnants are present in small sections of upper Mill Creek which retain natural vegetation cover. The Credit River between the Highway 10 crossings is also identified as Class 2. Despite vegetative clearing and obvious sedimentation, the large input of groundwater discharge from the Caledon tributaries provides the required thermal regime for coldwater species to survive.

Class 3 - Moderately Degraded Aquatic Communities

Class 3 communities are characterized by a healthy and diverse warmwater fish community comprised of native and non-native species, and moderately tolerant benthic organisms. Pike darters, sunfish, suckers and shiners are characteristic of the fish community. Taxa of Ephemeroptera, Trichoptera and Coleoptera which are moderately tolerant of increased water temperature, siltation, nutrient and organic enrichment are indicative of the community.

Class 3 communities are characteristic of the impounded areas within the subwatershed, such as Island Lake and Melville Pond. The Credit River downstream of the Reservoir is designated Class 3 reflecting the larger stream size and open aspect of the watercourse. Within the tributary system, Class 3 communities were found in areas where moderate clearing or urban development had occurred. Examples of such areas include the middle reaches of the southern tributary of Monora Creek within the Town of Orangeville, reaches adjacent to stable agricultural areas in which some streamside vegetation has been retained, eg., upper Mill Creek, and sections of the Eastern and Caledon tributaries.

Class 4 - Severely Degraded Aquatic Communities

Class 4 communities are indicative of stressed communities, which are significantly impacted by physical effects of land use. Fish and benthic species that are tolerant of warm temperatures, siltation, and nutrient enrichment are characteristic of this community type. Native warmwater fish species are present, as well as non-native tolerant forms. Benthic communities exhibit relatively high diversity, with moderately tolerant to tolerant species predominating. Further stress to this aquatic community could result in a shift to a degraded community and it would require significant efforts to re-establish a healthy warmwater ecosystem.

Class 4 communities are relatively rare within the subwatershed. They are typically found in tributary reaches that are under active agricultural use, where streamside vegetation has been cleared and direct access by livestock is permitted or in urban areas where significant impacts (morphologic, habitat) have occurred. Class 4 communities are found in Mill Creek downstream of C line where the stream runs through the Town of Orangeville.

3.8.5 Summary

In summary, the key findings of the aquatic features component of the study are:

- Subwatershed No. 19 contains a diverse aquatic system containing both warm- and coldwater elements;
- high-quality coldwater communities are found throughout the subwatershed in stream reaches that have not been developed, retain good riparian cover, and receive significant groundwater discharge;
- a diverse warmwater aquatic community has been created in Island Lake;
- impairment of aquatic communities is evident in stream reaches lying within or downstream of the Town of Orangeville, and adjacent to many active agricultural areas;
- sensitive areas, characterized by Class 1 and 2 communities, have been identified and will require protection from development impacts;
- there are opportunities for enhancement or restoration of impaired areas, characterized by Class 4 communities and some Class 3 locations.

3.9 Natural System Linkages

The ecosystem approach is the cornerstone of watershed and subwatershed planning. Simply put, an ecosystem approach considers that economic prosperity and environmental health are mutually inclusive goals. In the past only those natural features with special attributes were protected: an ecosystem approach recognizes that to maintain healthy, natural ecosystems, it is necessary, not only to protect a feature's important attributes, but also its functions and linkages.

An **attribute** is a physical characteristic, structure or uniqueness of a natural feature, for example woodlands are areas of natural forest cover that include mature trees, an understorey of shrubs and a ground cover of forbs and grasses that may include rare Carolinian species.

A **function** describes a process or an activity that an area serves within the context of the landscape, for example woodlands provide habitat for wildlife, shade streams to moderate temperatures and slow the rate of runoff into streams.

A **linkage** is a pathway, connection or relationship that an area shares with other areas that

is part of a larger complex, for example a woodland may provide a wildlife corridor between two larger natural areas which together, serve to sustain a white tail deer population. Another example of a linkage includes the flow path of water infiltrating into the ground and resurfacing at a discharge location, thereby providing baseflow for aquatic resources.

This section will define several of the key attributes, functions and linkages within the subwatershed. This information, together with the findings from Sections 3.2 through 3.8 will be summarized in Section 3.10, in order to:

- define the present state (or health) of the natural environmental resources; and
- determine the key attributes, functions and linkages that must be preserved if the natural environmental resources are to be protected, restored or enhanced under present land use conditions and as land use changes occur.

In a general sense, four factors: physiography (soils, topography, drainage); climate; land use; and land use practices strongly influence the type and diversity of the natural environmental resources to be found within a given geographic boundary.

This chapter, by way of two examples, will illustrate the function and linkages between the natural environmental resources.

Example No. 1

In Section 3.4, the location of areas with high recharge and discharge were identified. The importance of these areas, with respect to replenishing the groundwater system (recharge) and providing baseflow (discharge) for aquatic communities was also noted.

Section 3.7 discussed the importance of various terrestrial features as these areas provide habitat for birds and animals and may support provincially rare plants.

Woodlots, especially those located in high recharge areas, are also important as they trap precipitation which ultimately infiltrates slowly into the ground. Furthermore, vegetation located within valleylands shades streams thereby keeping water cool for aquatic life and stabilizes streambanks thereby reducing erosion potential.

Wetlands also provide habitat for birds, mammals and aquatic life. From a hydrologic

perspective, they may also provide a source of baseflow to streams.

Collectively then, wetlands and woodlots provide many valuable functions. The linkages between the terrestrial features and the hydrologic regime are especially important in high recharge/discharge areas.

The attached figure illustrates areas where wetlands and woodlots are located within areas of high recharge or discharge. These features are located within a majority of the tributaries and along the Credit River. The functions and linkages provided by these features, with respect to replenishing groundwater, providing baseflow, supporting aquatic and terrestrial resources as well as stabilizing streams, must be protected if the long term integrity of the natural environmental features is to be maintained.

Example No. 2

The above example discussed the interrelationship between woodlots, wetlands, areas of high recharge/discharge and their importance with respect to maintaining environmental health. The attached figure further illustrates the linkages between woodlots/wetlands in high recharge/discharge areas and the existing aquatic communities. Several factors which impact the relative health of the aquatic communities (see Section 3.8) are:

- percent baseflow (as compared to total flows);
- stream morphology (including pool depths, bankfull frequency);
- percentage of valley that has intact riparian canopy; and
- water quality conditions.

As is illustrated in the figure, streams which are located in high recharge areas, have significant forested areas (including streamside vegetation) and have wetlands in the headwaters, generally have the highest level (or class) of aquatic resource. These include the headwater areas of Monora Creek and Mill Creek and various reaches along the Caledon tributaries. Conversely, in areas where recharge/discharge is less significant or where the streams have been significantly altered, the resultant aquatic community tends to be more tolerant. Streams with these characteristics include the Mill Creek, the upper reaches of the Caledon tributaries and the headwaters of the Eastern tributary.

3.10 Summary

In general, the environmental health of Subwatershed No. 19 is quite good. Furthermore, in areas where deterioration of the natural environmental resources has occurred, measures may be undertaken to restore or enhance conditions under present land use conditions or as land use changes occur.

The relative health within the subwatershed is primarily attributable to two factors, physiography and land use.

The basin is characteristically hilly and consists of moraines, gravel terraces, and swamps in which forest cover is still fairly abundant. The permeable nature of a majority of the soils results in high groundwater recharge and, in turn, significant discharge back to the streams. Furthermore, the sands and gravels which are predominant within the basin promote high infiltration and consequently overland flow may comprise less than 10 percent of the total annual precipitation. Therefore, streams rise and subside slowly after a rainfall event. As such, the stresses of very high flows, which are experienced in more impervious basins, are not currently operating on the channel systems within this basin.

From a land use perspective, a relatively low percentage (25 percent) of the lands are in urban use. Furthermore, significant areas with forest cover exist (17 percent) and the remaining lands are generally classified as low intensity agriculture.

Provided below is a summary of the findings from sections 3.2 through 3.9:

- Groundwater recharge and discharge within the basin is considerable. Groundwater recharge ranges between 13 to 17 million cubic meters per year. Much of the groundwater resurfaces as discharge to the streams (6 million cubic meters per year or 195 litres per second).

- Groundwater discharges, together with the Sewage Treatment Plant effluent, typically account for approximately 80 percent of the overall volume of water within the river leaving the basin (i.e., at Melville).

- The high percent of baseflow (and thus the low percent of runoff) provide a dampening effect during extreme rainfall periods. The streams (with the exception of localized areas) are therefore not subject to the stresses of high flood flows. Furthermore, the groundwater discharge assists in reducing water quality levels in the streams by diluting runoff from the urban and rural areas.

- Water taking (primarily for municipal water supply) has been shown to impact streams (through the reduction of baseflow) in localized areas. Further water takings must consider the impact on aquatic and terrestrial resources as well as the traditional consideration of groundwater supply.

- The basin supports significant terrestrial resources, including three Environmentally Sensitive Areas as well as a significant number of woodlots and wetlands. The woodlots and wetlands, in addition to supporting vegetal species providing habitat for wildlife, play a key role in promoting groundwater recharge/discharge and thus maintaining the hydrologic cycle. Protection of the Environmentally Significant Areas and woodlots/wetlands is therefore of paramount importance. Furthermore, enhancement and restoration to improve the hydrologic and habitat functions provided by these features, should be considered in the management plan.

- Island Lake provides, in addition to the recreational value, several benefits to the basin, including removal of pollutants, habitat for wildlife and augmentation of baseflow. The reservoir may partially be responsible for changing stream conditions within the Credit River downstream of the reservoir (sediment is now depositing within the Credit River).

- The Credit River and associated tributaries support a healthy and diverse aquatic system, including both a warm and cold water fishery. This is primarily attributable to the significant groundwater discharge component, retention of riparian canopy, stable streams and low levels of contaminants within the streams. In areas where degradation has occurred, (due to both rural and urban practices), opportunities for enhancement and restoration exist.

- The streams, for the most part, are quite stable and therefore not subject to excessive erosion or deposition. The exceptions being the mid and lower reaches of Mill Creek and the southern tributary of Monora Creek, where the streams are responding to the surrounding urban environment. The potential for disturbance, due to upland flow and sediment regimes is, however, very high due to the sensitive nature of the soils.

- Water quality was generally found not to be a limiting factor to environmental health. Furthermore, as a result of upgrades to the STP and changes in regulatory acts (e.g., removal of phosphates in detergents), water quality has improved from the sixties to the eighties. A minor decline, probably attributable to the increase in urban development, has occurred since the nineties. The STP, although a primary contribution of nutrient loadings to the Credit River, does not seem to degrade water quality and based on bi-annual monitoring would not seem to be adversely impacting the Orangeville Marsh which is located downstream of the STP discharge.

The study goal is defined as "develop a plan for the protection, enhancement and restoration of the natural environmental resources under present conditions and as land use changes occur". The primary considerations from a protection standpoint would include:

- the groundwater resources, specifically the groundwater supply and discharge functions which are critical to the aquatic communities; and
- the terrestrial resources from the perspective of providing habitat for aquatic species, birds and mammals and especially a hydrologic function.

Restoration and enhancement opportunities also exist. Several measures which may be undertaken to protect/enhance or restore the resources will provide multiple benefits. For example, reforestation or revegetation may:

- enhance existing conditions for plant species and wildlife;
- augment groundwater recharge capability;
- restore riparian (streamside) habitat for aquatic communities; and
- stabilize stream reaches.

Other measures which may be implemented under present or future conditions in order to protect, enhance or restore the environment are outlined in Chapter 5.

4.0 STUDY GOALS AND OBJECTIVES

4.1 General

This chapter provides an overview of the goals and objectives for protecting, enhancing, restoring the resources which have been identified in Subwatershed No. 19. **Goals** may be defined as the long-term "vision" for a site, in this case Subwatershed No. 19. **Objectives**, which are set for each goal, define the scope of work required to meet a particular goal, and must be practical, achievable, and based on measurable effects.

The goals and objectives outlined herein were developed by the consulting team in consultation with the Technical Committee. A discussion of the goals and objectives, with the public, was held on 23 November 1994. The goals and objectives, together with environmental targets, will be revised as the study progresses. Collectively, the goals, objectives and targets will form the framework for ensuring that the Subwatershed Goal is achieved.

Goals and objectives have been developed for:

- water quality;
- aquatic communities;
- recreation;
- flooding;
- groundwater;
- natural features;
- aesthetics; and
- erosion.

These have been integrated into four (4) objective statements which emphasize that the protection of hydrologic regimes, water quality, aquatic communities and terrestrial communities ensures that all natural environmental resources will be protected.

Subwatershed Goal

To identify natural environmental resources and to establish appropriate strategies for the protection, enhancement and restoration of these important features under present conditions and as land use changes occur.

Environmental Goals/Objectives

Goal

1. Ensure that the hydrologic regime (surface flows in the tributary, as well as flows in the groundwater system) of the subwatershed is suitable to:

Objectives

- minimize flood risk to existing residents;
- restrict future development from flood-prone areas;
- protect groundwater supplies which provide drinking water and stream base flows;
- maintain natural channel stability in all watercourses;
- provide a flow regime suitable for the maintenance of healthy aquatic and terrestrial communities; and
- manage surface water withdrawals to protect stream base flows.

Goal

2. Protect the quality of surface waters in streams to:

Objectives

- support reasonable human uses, including body contact recreation, livestock watering, aesthetics;
- prevent eutrophication, stagnation and excessive algal growths;
- prevent contamination of groundwater which provides a source of drinking water and which supports local aquatic and terrestrial communities; and
- maintain healthy aquatic and terrestrial communities.

Goal

3. Establish a healthy aquatic ecosystem which supports resident, coldwater and warmwater fish populations by:

Objectives

- protecting critical reaches with healthy fish communities;
- protecting/restoring natural streamside vegetation;
- protecting/restoring the natural morphology, sediment transport and flow characteristics of streams;
- restoring the quality of surface waters necessary to support healthy aquatic communities;
- enhancing the microhabitats, such as pools and riffles, important to aquatic life;
- maintaining opportunities to provide for unrestricted movement of fish; and
- protecting groundwater baseflow.

Goal

4. Establish a healthy terrestrial ecosystem by:

Objectives

- protecting and restoring "valued" terrestrial features, such as Island Lake, as well as wetlands, valleys and woodlots;
- providing habitats suitable for native plant and animal communities; and
- enhancing terrestrial features that perform related ecosystem functions such as wildlife corridors, water storage and groundwater recharge/discharge.

Objectives are a logical extension of the goals, once the goals have been agreed upon. Environmental **targets** are specific criteria, standards or measures that must be achieved in order to fulfil the goals. These targets may include requirements such as maintaining minimum baseflows and cool water temperatures to support fish or incorporating a development setback adjacent to a stream valley to prevent erosion. Environmental targets are developed, based on the objectives, and are incorporated into the implementation plan for the study area. Targets may also be incorporated into other planning documents such as official plans. Targets will be discussed in detail in Chapter 7.

4.2 First Public Open House

At the onset of the study, a panel display was prepared. The display, together with an introductory newsletter was set up at several venues within the subwatershed. The display and newsletter introduced individuals to the study, outlined the study objectives and tasks, as well as provided information with respect to proposed public meeting dates.

The first public open house and public meeting was held on 23 November 1994 at the Orangeville Town Hall. The objective of the open house was to obtain public opinion with respect to:

- the resources that were mostly high valued, or used by the public;
- environmental issues, and relative importance;
- the perception of the public with respect to the environmental health of Subwatershed No. 19, including recent trends; and
- study goals and objectives.

The open house was held from 2:00 - 4:00 pm. The public meeting started at 7:00 pm, at which time a slide presentation of the subwatershed was given. Following the presentation, working groups were formed in order to discuss the study goals and objectives.

In total, approximately 75 people attended. Each person was provided with a Newsletter, questionnaire and a set of goals and objectives.

A summary of the responses from the public to each question is provided under separate cover. Outlined below is an overview as to some of the key statements by the public:

- the water resources of Subwatershed No. 19 are primarily used for recreation and drinking water;
- virtually all responses stated that the trail systems were an important recreational use of the Credit River tributaries and its valley;
- other significant uses of the tributaries and associated valleys included bird watching, nature appreciation, park usage for family outings and golfing;
- Island Lake and Monora Conservation Area were noted as the most popular recreational areas, however, many other locations within the valleylands were

noted on the responses;

- a majority of the individuals considered the protection, enhancement or restoration of the terrestrial features to be very important, most saw reasonable uses being:
    - habitats suitable for native plant and animal communities;
    - opportunities for passive (e.g., walking trails) usage by humans;
- in general, the environmental health of the subwatershed was perceived to be good (80 percent) or fair (20 percent). Everybody saw the importance of the environmental health as being important (25 percent) or very important (75 percent);
- half of the individuals thought that the environmental health of the subwatershed had not changed over the last 10 years, while the other half were split (i.e., improved or worsened); and
- a wide variety of environmental issues were noted, including:
    - protection of recharge areas
    - protection of drinking water source;
    - water quality;
    - balancing environmental issues with growth pressures;
    - gravel pits;
    - the compatibility of drinking water with sewage;
    - protection of wildlife, wetlands; and
    - use of prime land (environmental or agriculture) for urban growth.

5.0 ALTERNATIVE BEST MANAGEMENT PRACTICES

5.1 General

This chapter will describe the different types of Best Management Practices that may be implemented in order to protect, enhance or restore the environment. As there are many BMPs that could be considered for any given area, not all will be described in detail. Table 5.1 does, however, list all the BMPs that will be considered.

The chapter has been divided into two sections; urban and rural, as both types of land uses significantly impact present environmental conditions within Subwatershed No. 19.

5.2 General Types of Best Management Practices

Prior to presenting the various BMPs the general categories by which most BMPs will fall are described. Each of the BMPs that will be presented may be included in one of the following four categories;

- environmental protection or prevention;
- environmental control;
- regulatory control; and
- habitat protection, restoration or enhancement.

Definitions of each category is provided below.

5.2.1 Environmental Protection or Prevention

Environmental Protection or prevention is an umbrella term for a wide range of pollution reduction activities which are carried out at the source. These may include:

- public education - e.g., educate urban consumers on household hazardous wastes and lawn management practices; educate farmers on conservation land management;
- source control - e.g., Sewer Use Bylaw Enforcement, spill prevention and management at source control of urban runoff;
- inspection - e.g., regulatory inspection of erosion/sediment control devices; and
- alternative substance/material usage - e.g., replacing or substituting non-hazardous for hazardous materials in processes.

5.2.2 Environmental Control

Environmental control generally involves the implementation of technical solutions to reduce/minimize/eliminate the impact of a given contaminant. Prime examples include the upgrading of a water pollution control plant to treat combined sewer overflows or the installation of a storage facility to reduce water quality contaminants associated with stormwater runoff.

5.2.3 Regulatory Control

Regulatory control may be applied in one of many ways. For example, the Ministry of the Environment has various programs (e.g., Municipal Industrial Strategy for Abatement of Pollution (MISA) which set standards for the discharge of pollutants from various municipal and industrial plants. Regulatory control may also be used to protect environmental features (e.g. through the Wetlands Policy or Fisheries Act). Lastly, regulatory control may be applied in conjunction with environmental control alternatives. This approach is used in the Region of Ottawa-Carleton where proposed stormwater management facilities which discharge flows to the Rideau River must have effluent levels of faecal coliform less than 100 E coli./ 100 mL.

5.2.4 Habitat Protection, Restoration or Enhancement

The protection, restoration or enhancement of habitat is generally used to improve conditions for aquatic species, waterfowl or wildlife. Improving habitat also has ancillary benefits with respect to baseflow and groundwater resources (as increased vegetation generally increases infiltration to the soils). Also, habitat enhancement may have multiple benefits in situations where the stability of streams are improved.

Prior to describing the BMPs, several points should be noted. These are summarized below:

1. Several of the BMPs, such as public education or source control, should be implemented in all cases, while others such as infiltration facilities are feasible only in specific areas.

2. For several of the BMPs, it is relatively straightforward to quantify the impact.

For others, it will not be because of the type of BMP (e.g., buffer strips) or because the benefit of the BMP is not yet quantified.

3. Several alternatives, i.e. reforestation, habitat restoration, buffer zones, natural channel design may be applied in both urban and rural settings.

The following sections outline the alternative BMPs. For several of the alternatives, a brief description is provided as is a listing of potential constraints which may limit the feasibility of applying the given BMP. A statement as to whether the given BMP should always be applied (i.e., if there are no technical constraints such as is the case for public education) is also given.

5.3 Urban Best Management Practices

5.3.1 Water Quality/Quantity Control Facilities

Water quality/quantity control facilities, as a group, include detention (dry) ponds, extended detention ponds and retention (wet) ponds.

Dry ponds have historically been constructed in order to reduce the impacts of urbanization on flooding and erosion. Dry ponds have a minimal impact on reducing water quality pollutants, and recent studies have shown that erosion benefits are inconsistent, and site specific.

Wet ponds are generally constructed in order to remove pollutants from stormwater runoff, and have been found to be efficient in reducing particulate matter, including suspended solids, organic nutrients, heavy metals and BOD. Biological processes may also be used to reduce soluble nutrients. Reduction of peak flows to reduce downstream erosion or flooding may also be incorporated into a wet pond; however, the design must ensure that resuspension of settled material during severe events does not occur. Wet ponds may also be used to augment baseflow during low flow conditions.

An extended detention pond may be either dry or wet. Extended facilities are an effective means of removing suspended solids and associated particulate matter (e.g., heavy metals), and reducing erosion downstream. Removal of nutrients is, however, minimal. The effectiveness in reducing bacterial loadings is significant if stormwater is detained for 48 to 72 hours.

Several items should be considered when designing a water quality/quantity control facility. These include:

- safety;
- liability;
- integration into the surrounding area; and
- operation and maintenance.

One potential drawback with any storage facility that detains water for any considerable time period is the adverse impact on temperature within the downstream receiving body of water. This is of particular concern in areas where cool or coldwater fisheries are present.

There are several constraints which must be considered prior to selecting water quality/quantity facilities as a potential BMP. These include:

- space requirements;
- minimum upstream drainage area (for water quality facilities);
- soils (facilities constructed in areas containing sands and loams may wash out during severe events);
- safety; and
- existing aquatic resources (existing or potential aquatic resources precludes the use of an in-line facility as the facility will create a barrier to migration).

5.3.2 Infiltration Facilities

One of the key impacts urbanization has on the environment is the change on the hydrologic cycle.

Infiltration at all levels (e.g., on-site and on a centralized basis) will assist in reducing the impact by (see accompanying photos):

- reducing the rate and volume of water and pollutant loading reaching the local streams and rivers by overland routes;
- replenishing the groundwater supply;
- augmenting the baseflow to the local streams and rivers; and
- potentially reducing the water temperature to the receiving body of water.

Methods for promoting infiltration on an on-site basis are described in Section 5.3.6. On a centralized basis, infiltration may be carried out by constructing:

- infiltration trenches; or
- infiltration basins.

Several factors must be considered when designing and constructing infiltration facilities. These include:

- soils type;
- depth to watertable; and
- depth to bedrock.

Any infiltration device will be susceptible to clogging. Therefore, erosion/sediment control during construction should be strictly enforced, and grassed buffers, sediment traps or special inlets should be constructed upstream of the trench to reduce long-term sediment loadings.

One potential risk of infiltrating stormwater is the possibility of contaminating the local groundwater drinking source. This risk must be assessed prior to the selection of this BMP.

5.3.3 Site Planning

Various measures may be carried out on-site to reduce the impact of urbanization from the individual residential, commercial or industrial sites. In general, all the alternatives are based on one of two principles, i.e.:

- reduce the volume of runoff from the site; and
- filter the runoff prior to discharge from the site.

Several alternatives which should be considered include:

- discharging of roof leader flows to grassed areas or soakaway pits;
- filtering runoff from impervious areas by conveying flows across grassed areas;
- replacing impervious materials with alternatives such as interlocking stone,

crushed stone or porous pavement which promote infiltration;
- grading sites, where the soils permit, to promote infiltration (i.e., provide depressions to store runoff); and
- minimizing alterations to original grades.

The above alternatives may, for the most part, be implemented within new developments or incorporated into redevelopments. They are therefore not subject to any technical limitations.

5.3.4 Aquatic Habitat Restoration

A number of methods are available for restoration of physical habitat. The two primary alternatives relate to streambank stabilization and creation of in-stream structures. Other BMPs, such as buffer strips and wetland creation or enhancement can also contribute to habitat improvement and it is recommended that wherever possible, these methods be used in conjunction with the habitat restoration methods described below.

A number of techniques are available for streambank stabilization. The use of any one technique will be dependent on factors such as bank size, erosion potential and cost.

Several techniques that should be considered include:

- placement of rock rip rap or other inert materials such as log walls, timber cribs and tree revetments;
- bioengineering approaches (commonly referred to as biotechnical bank stabilization), such as soft gabions and live crib walls composed of dogwood, willow and alder; and
- streambank fences and crossings to prevent livestock or human intrusion in sensitive areas - fences should be set back from the top of bank to allow establishment of the riparian zone and lateral stream movement.

As for streambank stabilization, there is a wide selection of techniques used to provide in-stream cover for fish. These techniques involve the installation of rocks and/or wooden structures within the stream channel. Examples are weirs, ramps, deflectors, boulder groups, large organic debris, submerged half logs and log bank cover structures. In some instances it is possible to create spawning beds or channels. Summaries of these techniques are provided in several documents (OMNR, 1984; Alberta Environment, 1986;

Adams and Whyte, 1990). The selection of a particular technique depends on site-specific features such as the species or aquatic community objectives, stream size and gradient, and peak flows.

Installation of bankside and in-stream structures requires that they be able to withstand hydraulic forces. Such structures must be adequately secured, and proper installation is essential. Improper installation may result in overall habitat loss if the structure is dislodged, and may cause further damage downstream. The durability, maintenance requirements, and installation costs of available techniques is highly variable.

5.3.5 Terrestrial Habitat Restoration

Reforestation and wetland creation as a terrestrial habitat enhancement are discussed in Sections 5.3.9 and 5.3.6 respectively. Emphasis should be placed on use of native plant materials and avoidance of monoculture plantations. Re-establishment of floodplain connections and maintenance of flood frequency and depths on riparian areas are key measures to improve terrestrial habitats. Opportunities exist to enhance terrestrial habitats through natural landscaping around stormwater management ponds, particularly if the pond is located adjacent to a woodlot, thus diversifying habitat. On a micro scale, habitat enhancement may include provision of nest boxes, brush piles for cover and islands within wetlands to provide shelter from predators and establishment of temporary wetland features as habitat for amphibians and reptiles.

5.3.6 Wetland Creation

Artificial wetlands have been used in many parts of the United States and Europe for treatment of many types of effluent including acid mine drainage, sewage treatment and food processing effluent. They are gaining increasing popularity as a means of controlling downstream effects of urban runoff, and for reducing suspended solid, nutrient and trace contaminant concentrations. Contaminants are removed from the water column through sedimentation and through anaerobic chemical and microbially-mediated reactions. Vegetation, substrates and microbial populations are key components of the system. Such systems can have the additional benefit of attracting wildlife, and adding wetlands to areas where existing wetlands have been destroyed by draining or developing. Four types of system are currently in use: 1) densely vegetated overland flow; 2) subsurface flow through a crushed rock bed; 3) pond/island wetlands; 4) channel wetlands with floating vegetation.

Sites suitable for construction of artificial wetlands must be depressions, have a gently sloping downstream gradient, adequate water supply and an ability to retain water at required levels. Good knowledge of the water budget, including groundwater discharge is required. This requires pre-construction monitoring of surface and sub-surface flows for at least one full hydroperiod.

Depending on design requirements such as retention period and removal efficiency, such systems may require large land areas.

Removal efficiencies for contaminants which are achieved through temperature-sensitive reactions (eg., nutrients) are much lower during the winter months, and the system may require special maintenance during ice-covered periods.

5.3.7 Municipal Source Control Practices

The primary philosophy behind using source control measures is to stop the problem at source, thereby reducing the downstream impacts. There are various source control measures which are frequently used by municipalities and homeowners. These include:

- street sweeping;
- catchbasin cleaning;
- installation of spill control devices;
- management of hazardous household wastes;
- pet litter and general litter control; and
- sediment/erosion control during construction.

Other measures, such as using sumpless catchbasins (where the soils are permeable) or filter bags within catchbasins, have been used in several municipalities.

Source control practices are quickly gaining favour over control alternatives and should therefore be implemented wherever possible.

5.3.8 Public Education

In recent years, considerably more effort has been spent on educating the public as to the potential impacts of urbanization and defining ways in which they can assist in reducing the impact.

Several measures which may be carried out by the public include:

- water conservation;
- reducing use of toxic/hazardous chemicals;
- composting;
- increasing the reuse, recycling and reduction of non-renewable resources;
- minimizing use of fertilizers; and
- controlling pets.

There are no technical constraints to implementing a public education or public awareness program. Indeed, many municipalities are actively trying to educate the public as to how they may help reduce the impacts of urbanization. The UTRCA has used public education

as a key component for two proposed stream restoration projects (Hall Creek and Avon River).

5.3.9 Reforestation

Reforestation is an alternative that has recently been proposed in many regions within Canada. If applied on a wide-scale basis, reforestation may be used to offset the impact on the hydrologic cycle due to urbanization. The programs are especially effective in upland areas where the impact on the smaller streams due to urbanization may be more pronounced.

Reforestation of the valleylands also provides many benefits, including:

- improvement of the riparian stream buffer zone;
- reduction in streambank erosion;
- improvement to wildlife habitat;
- improvement of riparian canopy; and
- provision of a continuous wildlife corridor.

The Town of Markham has recently undertaken an extensive reforestation program for several of the reasons as described above.

There are no technical constraints to carrying out reforestation programs. Large-scale programs will require innovation with respect to implementation of the program and acquisition of funding.

5.3.10 Erosion and Sediment Control During Construction

The use of erosion and sediment controls during construction can significantly reduce the potential for sediments entering the receiving body of water. All construction activities, whether they include stream crossing work, projects within floodplain lands or some distance away, must consider the potential for sediment transport to receiving waters. The principles of control are based on preventing or minimizing erosion of soil and trapping of suspended soil particles during wet weather conditions.

The use of a well prepared erosion and sediment control plan will ensure the maximum benefits are obtained.

The plan should consider:

- the prioritization of erosion controls over sediment controls;
- construction scheduling; and
- areas of sheet and concentrated flow.

Common types of controls include:

- rock check dams;
- temporary sediment basins;
- soil covers (mulches, seeding, sodding, etc.);
- locating and stabilization of soil stock piles;
- cofferdams;
- gabion and slope sediment traps;
- catchbasins and sewer outfall capping; and
- buffer zones.

There are no technical constraints to implementing the above works. Many municipalities within Ontario have recently passed Top Soil By-Laws to ensure that the works as shown on the design drawings are carried out.

5.3.11 Natural Channel Design

One means by which the impact of future development on a watercourse may be limited is through the preservation of existing channels, and the design of natural channels for new developments. In fact, existing channels are often in the process of adjusting to an altered hydrologic/sediment regime as a result of existing land uses. Consequently the channel may continue to degrade even if appropriate controls are placed on new development. This requires that planners and drainage engineers rethink drainage practices. Traditional techniques of straightening and channelizing drainage swales, and lining watercourses with manmade materials (e.g., concrete), need to be abandoned. Rather, the principles of fluvial geomorphology need to be incorporated into urban drainage designs. These principles stress that natural watercourses normally have three distinct channels for flow conveyance, and that each of these channels plays an important role in establishing and maintaining the ecosystem in and adjacent to a watercourse.

These channels include:

- a low flow channel for baseflow and flow conveyance of typical (e.g., weekly) runoff events;
- a bankfull channel to convey runoff from less frequent (e.g., 1-2 year) runoff events; and
- a floodplain to convey flows which exceed the bankfull capacity of the watercourse.

Fish habitat is most frequently found in the low flow channels. Similarly, the floodplain normally contains habitat for wildlife, and this habitat requires flooding to preserve its distinct characteristics. In addition, each watercourse has a natural sinuosity at which it functions best, and which should remain undisturbed to preserve its velocity characteristics and sediment carrying capacity.

Although these principles differ substantially from current practices, they should be incorporated into existing and future developments to help limit the impact of development on a watercourse and its ecosystem.

Furthermore, in areas where alteration of the channels are required, techniques which promote the use of natural materials should be used to ensure that both the **hydraulic** and **environmental** capacity are optimized.

There are no technical constraints to applying natural channel design using the principles of fluvial geomorphology. The successful adaptation of this approach will, however, require rethinking and education of the designers to ensure that the proposed designs are appropriate.

5.3.12 Urban Retrofitting

Redevelopment within urban areas will provide an opportunity to improve upon existing conditions and ultimately be more environmentally conscious. Whenever possible, methods which promote infiltration, improve both water quality and quantity and are cognizant of the potential impact of spills should be promoted.

In general, there are three categories where retrofitting could occur. Retrofitting (or restoration) may occur:

- at source;
- within existing BMPs (e.g., retrofitting a dry pond to provide water quality benefits) and urban infrastructure; and
- within the urbanized streams and rivers.

Source retrofitting is particularly applicable to individual commercial sites or industrial sites as they are redeveloped. Retrofitting of the municipal infrastructure will, in the long-term, provide benefits as the existing infrastructure is replaced. Restoration of existing streams and rivers is detailed in other sections (natural channel design, reforestation, aquatic habitat protection).

Urban retrofitting, depending upon the application, will generally be dependent upon the same considerations as outlined for a proposed application for new developments. The applicable constraints have been outlined in various sections.

5.3.13 Buffer Zones

Buffer zones are areas of permanent self-sustaining indigenous vegetation communities located between development sites and sensitive features.

Buffer zones should be considered along stream banks and valley tops, and around wetlands, woodlots, and sensitive areas which require control of human intrusion. Riparian planting techniques include seeding, sodding, stake, wattles, transplants and nursery stock. Key functions of buffer zones include:

- wind control;
- sediment control;
- reduction of runoff and control of input of dissolved and particulate contaminants to watercourses;
- provision of terrestrial/aquatic habitat and food sources;
- stream shading;
- bank stabilization; and
- greenspace/passive recreational opportunities/aesthetics.
- sight and noise barriers

Current MNR specifications require riparian buffer zones, 15 m wide along each bank of

warmwater streams, 30 m wide along each bank of coldwater streams, and 9 m wide buffer zones along the top of steep slopes. For other locations, a typical guideline is that the width of the buffer zone from the water's edge should be 20 m plus 1.5 times the slope gradient (i.e. for a 10% slope, add 15 m).

Provision of buffer zones along non-regulated features usually requires dedication of land that might otherwise be developed. Site preparation is critical to the success of riparian plantings, and the degree of preparation will vary with the techniques used and the soils present. Machinery may be required in some instances. Adams and Whyte (1990) provide advice and details on riparian planting methods.

5.3.14 Groundwater Recharge and Baseflow Protection

Cold baseflow in streams is maintained during the hottest days of the summer time if cold groundwater discharges to augment baseflow and if overhanging riparian canopy shields the surface of the stream water from the hot sun. The amount of groundwater which discharges as baseflow is protected if several factors are maintained in their present state, including present groundwater levels and the amount of water recharging the aquifer.

The quantity and quality of water which recharges into the aquifer is a key variable. The principal concerns include ensuring that an equivalent volume of water of suitable quality infiltrates into the ground after urbanization, as before urbanization occurs. This can be accomplished by infiltration BMPs and maintaining key recharge areas in a pervious state.

Recharge areas, maintained in a pervious state can be used for a variety of other uses; including:

- wetlands;
- wooded areas;
- recreation uses (e.g., soccer fields); and
- walking corridors.

Protection of the recharge areas may require dedication of the land to public ownership. Maintenance of the quality of infiltrating water may preclude certain land uses where specific types of chemicals (e.g., herbicides, spills of petroleum products) pose a risk to groundwater quality.

5.4 Rural Best Management Practices

Table 5.4.1 lists a range of possible BMP's, which are grouped under the same headings as urban BMP's, to the extent possible. Under each heading, the more commonly used name for these groups of BMP's is also given.

5.4.1 Quality/Quantity Control Facilities

These are generally structural measures for reducing runoff, sediment and contaminants from rural point source problems. Examples include:

- settling basins that trap sediment before it enters grassed swales or field tiles, or at the point of discharge of the field tile to the watercourse;
- storage facilities for solid or liquid manure;
- milkhouse wastewater treatment; and
- farm septic systems.

These facilities require significant capital investment and regular maintenance to maintain their performance. Subsidization in the form of design assistance and grants are available through programs such as CURB, sponsored by the MOEE and OMAF. Although settling basins are effective, they are prone to damage from high flows and are difficult to maintain. Manure and milkhouse storage systems provide an effective means of reducing nutrient and bacteria loadings to streams and are generally cost effective in the long term.

5.4.2 Site Planning

Site planning controls refer to modified cultivation practices such as conservation tillage, contour ploughing and no-till, and cropping practices such as crop rotation, strip cropping and cover cropping. The focus of these BMP's is to maintain a vegetative or litter cover on croplands or a portion thereof in order to inhibit sheet and rill erosion.

For example modified cultivation practices leave the stubble from last year's crop on the field over winter, which leaves fields less prone to erosion during snowmelt. In addition, the soil may be worked to a shallower depth or not at all prior to seeding, which reduces soil erosion during seed germination. Some disadvantages of these practices relative to conventional tillage are:

- litter on the ground surface inhibits drying delaying spring seeding and shortening the growing season;
- specialized equipment such as seed drills and cultivators may be required representing a significant capital outlay;
- weed production is increased often resulting in an increase in pesticide use; and
- soil fertility may be reduced and compaction increased reducing crop yields.

Modified cropping practices include alternating crops from year to year, growing crops on alternating narrow bands of land following the natural field contour and planting a fall cover crop such as winter wheat to be plowed under in spring and replanted with a crop such as corn or soybeans. These are effective measures in reducing sediment and contaminants and have few disadvantages. Increased planting and harvesting time may result from strip cropping and crop rotation may reduce the overall crop yield because less land is in cash crops in a given year.

5.4.3 Source Controls

As with urban BMP's, rural source controls are typically "good housekeeping" practices that generally should be implemented wherever possible. Measures include proper storage, timing of application and rates of application of fertilizer, pesticides and manure to reduce nutrient and contaminant runoff and maximize the benefits to soil fertility and crop production. Application of these materials should also require a setback from watercourses to avoid direct application. These practices generally have both an environmental and a farm productivity benefit.

5.4.4 Buffers

Buffers as rural BMP's provide the same benefits as outlined in Section 7.3.13, but the benefit in controlling sediment runoff is greater because sediment loading from rural areas is usually greater than urban areas. Buffers included grassed swales/waterways and filter strips, and stream fencing for livestock (which generally also includes riparian plantings). Buffer plantings are often difficult to implement since they represent a direct loss of productive farmland to the farmer, unless it can be demonstrated that the lands are only marginally productive. Fencing for livestock is particularly difficult, if the stream is the only source of drinking water. Fencing projects usually also include provision for a controlled access watering site and stream crossing points.

5.4.5 Reforestation

Reforestation includes woodlot management and critical area planting (retirement of fragile lands). Woodlot management usually involves management practices to increase wood production or maple syrup production while improving wildlife habitat. Critical area planting includes revegetation of steep slopes, windbreaks, floodplains, lowlands and poorly drained soils. Taking these lands out of active agriculture provides benefits in terms of reductions in sediment and contaminant loads and offers real benefits in terms of wildlife habitat. As with reforestation in urban areas, large scale reforestation offers hydrologic benefits as well. This may be possible when farms are sold to owners who are not interested in farming.

5.4.6 Natural Channel Design

Municipal drainage practices, traditionally have straightened and deepened watercourse channels to facilitate conveyance of water from tile drainage systems. Unfortunately, this has disrupted the streams natural capacity to maintain itself, resulting in sedimentation, bank erosion and a regular maintenance requirement. By applying fluvial morphologic principles, in concert with overland sediment controls, the re-establishment of dynamically stable channels is feasible. The benefits are a reduction in the frequency of maintenance and instream habitat benefits for aquatic communities. Disbenefits are higher upfront design costs and some loss of farmland required to allow the stream to establish a natural meandering course.

5.4.7 Wetland Creation

Wetland creation opportunities exist in marginal farmlands such as low lying areas and in conjunction with facilities such as grassed swales and tile drainage outlet controls. Many farms also have ponds which may offer wetland creation opportunities. Finally, UTRCA is experimenting with the use of a created wetland to assist in treating manure runoff and milkhouse wastes, which is analogous to treatment of sewage and stormwater in urban settings.

5.4.8 Public Education

Refer to Section 5.3.8 for discussion.

5.4.9 Terrestrial Habitat Enhancement

Refer to Section 5.3.5 for discussion.

5.4.10 Groundwater Recharge and Baseflow Protection

Generally the same discussion applies to rural areas as outlined in Section 5.3.14. Reduced reliance on field tile drainage in areas of high recharge may promote greater infiltration of water and less surface water runoff. Reforesting these areas or creating wetlands may provide additional benefits, however these measures would likely result in a decrease in crop production.

6.0 EVALUATION OF ALTERNATIVE ECOLOGIC LEVELS

6.1 Background

Previous chapters identified existing environmental conditions as well as the linkages between the natural environmental resources. Primary considerations for protecting, enhancing and restoring the natural environmental resources were also defined in Section 3.10.

This chapter will present ALTERNATIVE ECOLOGIC LEVELS OF PROTECTION, ENHANCEMENT AND RESTORATION. For the purposes of this document, an Ecologic Level of protection, enhancement, restoration is defined as:

- an ecological condition or state of health where the functions and linkages of the natural components of an ecosystem are in balance with the human components of the ecosystem. In other words, any trends toward progressive deterioration or degradation of the natural environment will be halted, reversed or redirected to achieve an equilibrium with the human environment. This state of balance or equilibrium may be maintained at different levels based on the value that the local community places on natural ecosystem components.

For example, a stream with catchable size brook trout or a forest that harbours wood thrushes and pileated woodpeckers may represent valued ecosystem components to a community. Maintaining an ecosystem at this level requires different actions than maintaining an ecosystem which includes streams with white suckers or forests with blue jays and chickadees, but both will require some actions to achieve an equilibrium state with the human components of the ecosystem. Brook trout and pileated woodpeckers represent a community of associated plants, animals and biophysical habitat requirements for sustainability that typically are much harder to achieve in a human land use dominated environment than the requirements to sustain a community represented by white suckers and bluejays in the same environment.

This approach allows the stakeholders to establish ecologic alternatives that could exist if appropriate physical measures are undertaken and programs/policies developed. This is in contrast to the current practice commonly undertaken which defines, based on cost and feasibility, a series of physical measures to be undertaken without establishing the degree of ecologic protection, enhancement or restoration which results.

Three ecological levels were initially selected and discussed with the Steering Committee and Public Advisory Group. The two most representative ecologic levels will be presented in this report.

The two levels range from a minimum of protecting the present ecologic integrity (as various stakeholders were unwilling to accept a lesser standard) to a level where the key ecologic constraints which presently limit ecologic health are, in the long term, restored or enhanced.

Consistent with the approach taken for this study, each ecologic level was based on existing land uses (with the exception of lands which are yet to be developed and have Official Plan status). The approach will also provide a basis, or framework, for decision making (see Sections 8.4 and 8.5) should land use changes occur in the future.

For each alternative ecologic level, the following was defined:

- an Ecologic Goal; which is consistent with the study goal;
- an Ecologic Objective; the principle natural environmental resources to be protected, enhanced and restored;
- the Key Ecologic Constraints; the key constraints which must be overcome to meet the ecologic objective; and
- the Key Measures; the key physical measures which must be undertaken to meet the ecologic goal and objective.

The following sections describe each of the alternative ecologic levels and the consultation/evaluation process used to select a Preferred Ecologic Level.

In this chapter, the ecologic goal, ecologic objectives, key ecologic constraints and key measures are described in a relatively straightforward manner. The primary objective is to provide insight for each ecologic alternative as to the relative cost, the land requirements and environmental benefits which result in order that a comparison of the two alternatives may be made. A further, more detailed description of the Recommended Alternative is provided in Section 7. Tables 6.1 and 6.2 and Figures 6.1 and 6.2 summarize the findings.

Approximate costs to undertake the proposed measures are provided in Tables 6.1 and 6.2. The estimates as provided were established based on traditional sources of funding (e.g.,

municipal/provincial agencies). The use of special interest groups and members of the public to implement the proposed measures and the pursuit of additional funding sources (e.g., special interest groups, environmental foundations, corporations) will reduce municipal/provincial funding requirements. This item is further addressed in Chapter 8.

6.2 Ecologic Alternative No. 1 - Maintain Existing Ecologic Conditions

6.2.1 Ecologic Goal

To identify existing natural environmental resources and to establish appropriate strategies to protect these important resources under present conditions and as land use changes occur.

6.2.2 Ecologic Objective

Consistent with the ecologic goal, the primary objective is to protect existing environmental resources (i.e., measures to enhance or restore existing resources would not be undertaken). In order to meet this goal, some measures will have to be undertaken to mitigate existing problems. Furthermore, as discussed in Section 8, policies, guidelines and by-laws will have to be developed in order to protect the environmental resources under present conditions and should land use changes occur.

In summary the environmental resources to be protected include:

- the woodlots, wetlands and Environmentally Significant Areas which provide habitat for various species of plants and animals and are also critical for the protection of a clean and continuous supply of groundwater and baseflow;
- the streams and associated valleylands, such that they are stable, provide habitat for resident fisheries, plants and animals, protect existing terrestrial features such as wetlands, and are not subject to excessive erosion or deposition; and
- the quantity and quality of groundwater and surface water which collectively are used as a drinking water source, for recreation and is critical to the preservation of a healthy and diverse resident fish community.

6.2.3 Ecologic Constraints

Although the subwatershed does contain significant and valuable environmental resources, there are several key ecologic constraints which presently limit the overall environmental health. These include:

- the lack, due to past land use practices, of diverse native upland and valleyland plant and animal communities;
- a sensitive groundwater system which is susceptible to localized drawing down of the water table and to contamination;
- localized stream reaches which are subject to excessive erosion thereby potentially resulting in the loss of public/private property and stressing of the local aquatic and terrestrial communities;
- localized flood potential of approximately 45 buildings at seven flood damage centres under regional storm conditions; and
- deteriorating urban forests.

6.2.4 Key Protective Measures

The key protective measures which are necessary to meet the Ecologic Goal are illustrated in Figure 6.1. Table 6.1 summarizes each measure together with:

- the measure to be undertaken;
- a general description of the measure together with technical considerations where appropriate;
- the environmental benefits of undertaking the measure;
- the capital cost of the measure, excluding land costs; and
- comments, which generally relate to basis for establishing costs.

Also provided at the end of the chapter is Table 6.3 which cross references the proposed measures to the benefitting environmental resources.

A description of the proposed measures together with the rationale for undertaking each measure is provided below.

Stream Restoration

A total of 1.3 km of stream reaches along the Monora Tributaries need to be restored. These reaches, due in part to recent land use changes upstream, are unstable and if left unattended, will further erode resulting in loss of aquatic habitat, degradation of water quality and potential damage to private property. The streams, when they are restored, should be constructed using natural channel techniques which ensure the long term stability of the reaches and provide appropriate terrestrial and aquatic habitat.

Agriculture Stewardship Fencing and Buffers

Livestock access at several locations along the streams has resulted in excessive bank erosion which in turn results in excessive sediment loads downstream and may be detrimental to terrestrial (e.g., wetland) and aquatic (e.g., spawning beds) habitat. Furthermore, livestock access may contribute to nitrate loadings resulting in reduced water quality. An agriculture stewardship fencing and buffer program which directs and minimizes livestock access is proposed along stream reaches within the Caledon Tributaries.

Groundwater Management Strategy

This study defined, based on existing and approved land uses, recharge volumes, withdrawal rates and baseflows within the streams. Should additional water taking, due to change in land uses (or to service approved development) occur a Groundwater Management Strategy must be developed. The strategy, which would include an assessment of the impact of further groundwater withdrawal, would be undertaken prior to approval of additional groundwater taking. The strategy would define suitable locations for groundwater withdrawals such that baseflows are not diminished, overall productivity of existing wells are not reduced and contamination of existing/potential wells does not occur.

Urban Forestry Program

A majority of the trees within the urban areas are mature (greater than 50 years old) and in some cases declining in health. An urban forestry program is proposed to address tree health and to ensure that younger trees are planted which, over time, will replace the deteriorating mature trees and thereby ensure succession of selective species.

Recreational Trail System

A community-based recreational trail system which would increase public awareness of the natural environment and control access to sensitive resource features is proposed. A program to establish a combined recreational trail and natural heritage system often represents an appealing and economically attractive project to communities, interest groups and corporations. This proposed undertaking is not part of this study and has therefore not been priced. A conceptual recreational trail system which is consistent with the co-existence of human and environmental requirements is presented in Chapter 7.

Measures for Approved/Proposed Land Use Changes

A variety of measures or Best Management Practices will be required as a result of approved or proposed land use changes. These measures, particularly for urbanizing areas, have been described in a general sense in Section 5. Further refinement of the types of measures that are appropriate within each tributary are provided in Section 7.5.

6.2.5 Summary

In summary, the goal of this ecologic alternative is to protect the existing natural environmental resources. As discussed, the key resources and associated environmental linkages/functions include:

- the woodlots, wetlands and Environmentally Significant Areas which provide habitat for various species of plants and animals and are also critical for the protection of a clean and continuous supply of groundwater and baseflow;
- the streams and associated valleylands, such that they are stable, provide habitat for resident fisheries, plants and animals, protect existing terrestrial features such as wetlands, and are not subject to excessive erosion or deposition; and
- the quantity and quality of groundwater and surface water which is used as a drinking water source, for recreation and is critical to the preservation of a healthy and diverse resident fish community.

The key measures to be undertaken in order to meet the ecologic objectives include:

- restoration of 1.3 km of streams;
- agricultural stewardship fencing and buffering of 2.0 km of stream;
- the development and implementation of a groundwater management plan;
- the expansion of an urban forestry program;
- the development of a recreation community based trail system; and
- implementation of appropriate BMPs should land use changes occur.

Furthermore, as will be discussed in Sections 7 and 8, policies, guidelines, by-laws, education and stewardship programs will have to be developed in order to protect the environmental resources under present conditions and as land use changes occur.

6.3 Alternative No. 2 - Restoration/Enhancement of Key Ecologic Constraints

6.3.1 Ecologic Goal

Several ecologic functions/linkages within Subwatershed No. 19 have, as a result of human activities associated with rural and urban practices, diminished. The goal of this alternative, in a general sense, is to restore many of the ecologic functions/linkages that used to exist prior to disturbance as well as enhance existing ecologic functions/linkages that presently exist. In this manner, the key ecologic constraints which presently limit ecologic health will, in the long term, be removed. More specifically, the ecologic goal is defined as:

- to identify natural environmental resources and to implement strategies to protect, restore and enhance these important resources under present conditions and as land use changes occur.

6.3.2 Ecologic Objective

This ecologic alternative builds upon the objectives and measures as outlined under the Maintain Existing Conditions alternative. *As such, the objectives and key measures as presented, are in addition to those presented in the Maintain Existing Conditions alternative.* The objectives were based on an understanding of the present environmental health (and thus the opportunity to enhance/restore the ecologic functions/linkages) as well as the opportunity to restore ecologic functions/linkages which presently do not exist;

based on physiographic and land use considerations.

The key objectives, as well as the *primary natural environmental resources* for which the objective relates to, are defined below.

Groundwater

- enhance the overall hydrologic budget (specifically recharge capability) by revegetating idle lands and by restoring historic baseflow conditions in Monora and Mill Creeks (wells are currently located adjacent to a number of sensitive streams).

Groundwater/Terrestrial

- increase groundwater recharge capability and supporting habitat for sensitive species of mammals, birds, reptiles, amphibians and plants by enhancing the function, i.e., size and integrity, of large remnant natural vegetation features (Eastern Tributary Lowlands and Melville Marsh Uplands Extension);
- provide increased groundwater recharge and habitat connections for sensitive species of mammals, birds, reptiles, amphibians and plants by creating upland vegetated corridors, i.e., 100 m strips of forest, wetland, prairie meadow communities, along the Monora Tributary headwaters to Caledon Lake Forest ESA and to the Humber Wetlands (Speersville Wetland Complex) from Rosehill Swamp;
- increase groundwater recharge capability and the area of upland forest habitat for sensitive species of mammals, birds, reptiles, amphibians and plants along the Monora and Mill Tributary headwaters corridor; and
- increase the naturally vegetated width, ie., a minimum of 100 m of several stream and valley corridors along tributaries linking Rosehill Swamp to the Credit River, Monora Park to Island Lake ESA, and Island Lake ESA to Melville Marsh ESA.

Terrestrial

- improve core habitat for sensitive species of mammals, birds, reptiles, amphibians and plants by enhancing the function, i.e., size and integrity, of significant natural vegetation features (ESA's, Monora Park, Dufferin Anglers and Hunters property); and

- provide habitat connections for sensitive species of mammals, birds, reptiles, amphibians and plants by creating vegetated corridors, i.e., 100 m strips (width) of forest, wetland, prairie meadow communities, between significant natural vegetation features and similar features adjacent to the subwatershed (Nottawasaga Valley, Credit at Alton ESA and Caledon Lakes Forest ESA).

Stream Morphology/Aquatic Resources

- stabilize stream reaches and increase terrestrial habitat and aquatic community productivity, i.e., fish abundance, in selected stream reaches (Monora Creek and Caledon Tributaries); and
- minimize impacts on aquatic life and recreation by remediating local surface water quality problems from urban inputs.

Aquatic

- restore native aquatic communities in Island Lake and the Credit River by providing fish passage and reducing populations of non-native fish.

Flooding

- reduce potential for flood damages by increasing the level of flood protection at flood damage centres.

6.3.3 Key Ecologic Constraints

The constraints that would have to be overcome in order to meet the Ecologic Objectives include:

- lack of continuous core natural areas which support diverse plant/wildlife communities;
- inadequate linkages between these core terrestrial areas;
- lack of upland forest habitats;
- inadequate upland forest linkages;
- unstable stream reaches which lack natural instream habitat;
- barriers to habitat use;
- localized property damage from flooding;
- localized interference problems: water supplies, baseflows of stream, brook trout spawning habitat; and
- competition for aquatic resources between native and non-native species, e.g., brook trout and northern pike.

6.3.4 Key Enhancement/Restoration Measures

The key restoration/enhancement measures are described below. The measures, as outlined, are in addition to those defined under the first ecologic alternative. It should be noted that several of these measures, particularly those related to restoration of significant features and corridors will take a considerable time (20 to 50 years) to complete. Particular emphasis has been placed on improving long term habitat conditions for plant and animal species and the ability to recharge water into the ground. These measures, in turn, will increase the availability of groundwater as a drinking water source, increase baseflows thereby benefitting resident fish communities, improve water quality in streams and strengthen the potential for supporting diverse plant and animal communities.

Stream Restoration

An additional 5.2 kilometres of streams along Monora Creek, Caledon tributaries and Second Avenue ditch need to be restored. These stream reaches have been altered as a result of development of adjacent lands. Restoration of these reaches, using natural channel techniques, would restore the natural channel morphology, provide habitat suitable for a resident coldwater fishery and improve valleyland habitat for native plant species and animals.

Agriculture Stewardship Fencing and Buffers

An agricultural stewardship fencing and buffer creation program along 0.3 km of stream along the Eastern Tributary would assist in restoring downstream terrestrial and aquatic habitats.

Flood Protection

A total of seven (7) flood damage centres within the subwatershed have been identified through previous studies (CVC, Philips, 1988). As part of this study, restorative works to reduce the frequency of flooding at each site were determined (see Appendix A.1). Based on this assessment, it was determined that cost-effective flood protection works could be undertaken at two of the seven flood damage centres. At one other site floodproofing has already been implemented. At four sites the "Do Nothing" option is recommended. Floodproofing of structures located in the floodplain along First Street and Hansen Boulevard (Monora Creek) could be undertaken. Construction of berms adjacent to flood susceptible buildings located along Dawson Road (Mill Creek) could reduce flood susceptibility.

Naturalization of Significant Natural Features and Valleyland Corridors

Naturalization plans for 1,250 hectares (ha) of lands within and adjacent to the 3 ESA's, Monora Park and the Dufferin Anglers and Hunters property to enhance habitat conditions for sensitive species within these significant natural features should be developed and implemented. In addition, the development and implementation of naturalization plans for corridors linking the significant features in and adjacent to the subwatershed should be undertaken. The following corridors (length in km) should be considered:

- Rosehill Swamp to Melville Marshes: 0.7 km;
- Dufferin Hunters and Anglers/Monora Park to Island Lake: 0.9 km;
- Island Lake to Melville Marshes: 1.5 km;
- Island Lake to Nottawasaga Valley: 0.0 km; and
- Melville Marshes to adjacent Credit Valley: 2.8 km.

The focus of this initiative, as described above, is to improve habitat conditions such that the diversity and abundance of plant and animal species native to this area will be enhanced or restored. Additional initiatives which not only improve habitat conditions but also enhance linkages between the groundwater, terrestrial and aquatic ecosystems are provided below.

Collectively, the above two measures require plans for 1,250 ha of lands and may require revegetation of approximately 430 ha. The actual amount of land to be revegetated depends on the degree to which natural revegetation has already occurred.

Naturalization of Upland Vegetated Corridor and Key Tableland Woodlots

Naturalization Plans for upland vegetated corridors from the Dufferin Hunters and Anglers lands to the Caledon Lake Forest ESA and from Rosehill Swamp to Humber Wetlands should be developed and implemented. This measure will create/improve habitat conditions for plant and animal species unique to upland vegetated corridors. Furthermore, a majority of the lands proposed for revegetation are located in high recharge areas. Therefore, revegetation will provide a significant additional benefit in that groundwater recharge will be enhanced.

Consistent with this initiative, key woodland areas which, if revegetated, would improve habitat conditions and enhance recharge capability have been identified. All woodlots, as identified in Figure 6.2 are located in high groundwater recharge areas.

Approximately 450 ha may require planting (again, depending upon how quickly the natural revegetation process occurs).

Restoration of Existing Stormwater Management Facilities and On-Line Ponds

Restoration of three existing Stormwater Management Facilities and one private on-line pond is recommended, as is the removal/bypassing of one public pond and one private pond. The locations of the facilities/ponds to be restored or removed are shown on Figure 6.2.

The objectives to restoring or removing the facilities and pond are to:

- provide water quality benefits;
- remove barriers to fish migration;
- reduce instream water temperatures; and
- provide educational, recreational and habitat opportunities (Milady Pond only).

Restoration of two facilities and one private pond would generally involve modification to the outlet structures to provide fish passage and reduce instream water temperatures. For the Milady Pond, located along Monora Creek, the objectives would be to retrofit the facility in order that a variety of environmental benefits (in addition to the control of peak flows that is currently provided) are achieved. These benefits, as listed above, could include water quality improvements, provision of habitat for waterfowl and aquatic species, as well as educational and recreational opportunities. Projects similar to the Milady Pond restoration are currently being undertaken in several municipalities including the Town of Markham, City of Scarborough and the City of Cornwall.

Relocation of Well No. 5/5A

Construction of Well No. 5/5A resulted in the drying up of the north tributary of Mill Creek in the vicinity of County Road 16. Relocation of the well or significant reduction of the pumping rate would return natural baseflow to Mill Creek, This, in turn, would improve habitat conditions for the aquatic and terrestrial communities within Mill Creek. Replacement can only be done when a suitable replacement well has been found and can be connected to the Town's municipal system. Furthermore, an alternate source of supply is required to make up lost capacity of this well field.

Removal of Melville Dam

Melville Dam is a century old structure which currently represents a migratory obstacle preventing brook trout movement up and down stream. If fish passage was provided, brook trout populations from the Monora and Caledon Tributaries could utilize the extensive adult habitat in the Credit River downstream through Alton. This would also benefit brook trout populations in the Alton portion of the Credit River by providing access to excellent spawning habitat in these upper tributaries.

Removal of the dam would result in the loss of wetland (open water and marsh) habitat within Melville Pond. An option was costed which would retain some of the marsh habitat by replacing the dam with a natural step-pool cascade or reach, lowering the pond level to the surface of accumulated sediments and, over time, rehabilitating the stream to a natural meandering pattern. The exposed sediment in the pond would gradually regenerate into a marsh-wet meadow condition. This project would have the added benefit of reducing adult pike habitat. Pike, an introduced species, prey on native brook trout and a reduction in pike populations is a long term priority.

6.3.5 Summary

In summary, the goal of this ecologic alternative is to restore/enhance existing and potential natural environmental resources. The primary focus of the ecologic objectives has been placed on enhancing habitat (terrestrial and aquatic) conditions and the ability to recharge water into the ground. In order to meet the ecologic goal, several key ecologic constraints relating primarily to the terrestrial ecosystem, and to a lesser degree the aquatic and stream systems, have to be overcome.

The proposed measures to be undertaken have focused on enhancing habitat (terrestrial and aquatic) conditions and the ability to recharge water into the ground. Implementation of the measures as defined in Section 6.3.4 will increase moderately the availability of groundwater as a drinking water source, increase baseflows thereby benefitting resident fish communities, improve water quality in streams and support the potential for supporting diverse plant and animal communities.

Subwatershed planning is not a precise science. Quantification of the precise environmental benefits which will accrue as a result of implementing the measures, as outlined in the previous section, can therefore not be provided. A review of environmental

documents, findings in other subwatersheds with similar physiographic features and land use patterns, together with our understanding of the environmental linkages/functions in this subwatershed, would suggest that the following qualitative benefits will result once the proposed measures are implemented:

- restoration (through the revegetation of approximately 13 percent of the subwatershed area) of a healthy terrestrial ecosystem which is capable of supporting diverse and abundant species of native plants and animals;
- increase in groundwater recharge capability of approximately 200,000 cubic metres per year;
- significant reduction in the flood susceptibility of 11 buildings located within Mill and Monora Creeks;
- enhanced productivity and diversity of the aquatic community through the restoration of 6.7 km of stream and removal of existing barriers to migratory;
- moderate reduction of instream water quality concentrations as a result of initiatives such as reforestation, restoration of valleyland buffers and restoration of an existing stormwater management facility; and
- opportunities to integrate recreational activities through the appropriate use of table and valleyland corridors.

This ecologic alternative, as described, will take a considerable number of years to implement all components and will be subject to various social, economic and environmental considerations. Success of the plan will also largely be dependent on working cooperatively with landowners, as a variety of the proposed measures would be undertaken on privately owned lands.

6.4 Consultation Process

6.4.1 General

The consultation process used to select the preferred ecologic level involved meetings with the Steering Committee, two meetings (one involving a field reconnaissance of the subwatershed), with the Public Advisory Group, a meeting with the local Homebuilders Association and representatives of the agricultural community, as well as a public open house held on 24 October 1995.

Initial meetings with the Steering Committee and the Public Advisory Group were used, in part, to establish the format of the questionnaire for the 24 October 1995 public open house as well as the evaluation criteria for selecting the preferred ecologic level.

Outlined below is a summary of the input received from the Public Open House, the evaluation process used to select the preferred ecologic level and the selection of the preferred ecologic level.

6.4.2 Second Public Open House

The format of the second public open house was similar to the first open house held on 23 November 1995. The open house was held from 2:00 - 4:00 pm. The public meeting started at 7:00 pm, at which time a slide presentation was given. Following the presentation, working groups were formed in order to discuss a series of questions relating to the natural environmental resources, importance of evaluation criteria and selection of the preferred ecological level.

The objective of the public open house was to obtain public input with respect to:

- the natural environmental resources that were most highly valued, or used by the public;
- the relative importance of each proposed measure to be implemented;
- the relative importance of each evaluation criteria used to select the preferred alternative;
- the process used to convey information to the public;
- define types of programs the public may wish to participate in; and
- preference with respect to the ecologic level.

In total, approximately 35 persons attended the afternoon session while 20 attended the evening session. A significant percentage of those attending represented the development and consulting industry. Each person was provided with a newsletter and questionnaire (samples are provided in the appendix).

A summary of the responses from the public to each question is provided under separate cover. Outlined below is an overview as to some of the key statements made by the public:

- the most important natural environmental resource is the groundwater supply, followed by terrestrial resources, aquatic resources and water quality;
- the public were primarily interested in the development/implementation of:
  - a groundwater management plan;
  - naturalization plans for valleyland and upland corridors;
  - restoration of streams; and
  - development of a recreational trail system.;
- public acceptance, potential to enhance the environment and impact of the strategy on future land uses were considered to be very important evaluation criteria while ease of implementation and cost were considered to be moderately important;
- implementation of the proposed measures should be a combined effort by the government agencies and the public;
- the public showed an equal interest in participating in community awareness (e.g., stream clean-up days) and special projects (e.g., tree planting, stream restoration works); and
- there was a significant preference for an ecologic level involving restoration and enhancement.

6.4.3 Evaluation Criteria and Review of Alternative Ecologic Levels

The two alternative ecologic levels, as presented earlier in this section, were compared using a series of evaluation criteria. Provided in this section is a listing and description of the evaluation criteria. Also provided is a brief overview of the criteria relative to the alternatives. Input received from the Steering Committee, Public Advisory Group, Homebuilders, OFA representatives and the public has been incorporated into the following statements.

1. **How easily can the ecologic level be implemented (i.e., the technical feasibility):** technical considerations associated with each ecologic level and associated management measures were evaluated, such as feasibility, practicality, and ease of implementation.

   Both ecologic levels are feasible from a technical perspective as the proposed measures are relatively straightforward and have been used elsewhere. From an implementation perspective, cooperation from landowners, particularly with respect to the naturalization components of the strategy will be required.

2. **Public Acceptance:** two public open houses were held over the course of the study prior to the selection of the preferred ecologic level. Furthermore, a Public Advisory Group comprised of representative stakeholders was formed and meetings were held with the Orangeville Homebuilders and OFA representatives. The alternatives were evaluated based on input from the above noted groups.

   A majority of the responses from the public meeting indicated that restoration/enhancement of the natural environmental resources was preferred. The Public Advisory Group found it difficult for them to choose an ecologic level, given all the implications that would go with any choice. The Homebuilders did not provide direct input with respect to a preferred alternative but did express interest in participating in restoration works if this, in turn, would streamline the approval process or save time or money elsewhere. Agricultural representatives expressed some concern with respect to loss of lands associated with Agricultural Stewardship Fencing and Buffer programs.

3. **Potential of the strategy to enhance the environment:** the overall environmental benefit associated with each ecologic level was evaluated based on the ability to

protect, enhance or restore the natural environmental resources.

A description of the two alternative ecologic levels is provided in Sections 6.2 and 6.3. As discussed, the first alternative will protect the existing natural environmental resources while the second will attempt to restore/enhance existing and potential natural environmental resources and key ecologic linkages. The primary focus of the Restoration/Enhancement alternative is on restoring/enhancing terrestrial and aquatic habitat conditions and increasing groundwater recharge capability.

All groups expressed an interest in restoring/enhancing various features within the subwatershed. Priorities were generally based on groundwater supply, terrestrial resources, aquatic resources and water quality.

The restoration/enhancement alternative reasonably reflects the interests of the public groups from the perspective of restoring/enhancing the system and focusing on groundwater supply, as well as terrestrial and aquatic resources. The restoration/enhancement alternative is orientated more toward restoration/enhancement of terrestrial, aquatic and stream systems as opposed to groundwater supply as the technical studies undertaken during the course of this study showed that:

- *groundwater resources and water quality were found to be suitable; and*
- *reasonable measures, if undertaken, could considerably enhance the terrestrial ecosystem and on a more localized basis, the aquatic and stream system.*

4. **Cost of the strategy:** cost considerations were made and used in the evaluation of the ecologic levels.

The participants at the public open house noted that costs to achieve a given ecologic level had to be considered. The importance of this criteria was, however, less than others including public acceptance, potential to enhance the environment and impact of the strategy on future land uses. The Public Advisory Group did not have any direct comments with respect to cost while the Homebuilders group expressed interest in an overall cost savings (i.e., the Homebuilders Association would spend money on restoration works if monies on other works could be saved). The municipal representatives on the Steering Committee did express considerable

concern with respect to the cost implications (should the municipalities have to pay for the proposed measures) of the second alternative, especially in light of todays economic situation.

5. **Impact of the strategy on future land uses:** several of the proposed measures (e.g., those related to naturalization) required to implement the second alternative would require conversion of land from its present land use to a land use consistent with the approach to restore or enhance terrestrial resources. Other alternatives, e.g., removal of a private pond, would change the current use of an existing resource.
   Comments with respect to the impact of proposed measures on both existing and future land uses were noted during the discussions held with various groups. The potential impacts will be discussed in detail in the Implementation section of the report (Section 8).

6.5 Selection of the Preferred Ecologic Level

The input received from the various groups was reviewed and discussed with the Steering Committee. Based on review of the input and discussions with the Steering Committee, it was agreed that the Restoration/Enhancement of Key Ecologic Constraints alternative be selected, with the understanding that the monies required to undertake the proposed measures be forthcoming on an as available basis (see further discussion on funding alternatives, Sections 8.3 and 8.6). The primary reasons for the selection of the restoration/enhancement alternative are:

- this alternative, with the appropriate mechanisms as well as public support, is implementable;
- there was general consensus by all groups that environmental health of the subwatershed is very important and that restoration/enhancement of the natural environmental resources, is desired; and
- the restoration/enhancement alternative, as presented meets the requirements, objectives and goals as expressed by the various stakeholders within the subwatershed.

In summary, this alternative provides a framework for the long term protection, enhancement and restoration of the natural environmental resources while providing flexibility for future land use changes. The following chapter will provide further details of the Preferred Alternative or, as it will subsequently be referred to as the Recommended Plan.

7.0 THE RECOMMENDED PLAN

7.1 Background

Chapter 3 described the natural environmental resources that presently exist within the subwatershed. Chapter 6 outlined two alternative ecologic levels which considered both present and potential resources.

This chapter will describe the second alternative ecologic level, which will subsequently be referred to as the Recommended Plan. The focus of this chapter will be to describe the plan and the associated measures necessary to meet the goal and objectives for the plan. Chapter 8 will discuss items which must be considered if the Recommended Plan is to be successfully implemented.

Prior to describing the Recommended Plan, a review of the natural environmental resources as they presently exist as well as key linkages, functions and constraints will be provided.

The present environmental health of Subwatershed No. 19, as compared to many other Southern Ontario areas is quite good (see Section 3.10 for details). Some of the important features to note include:

- permeable soils, which results in high groundwater recharge (which provides groundwater to local residents) and, in turn, significant discharges back to the streams (baseflows account for approximately 50 percent of annual stream flows);
- overland flow, which typically comprises less than 10 percent of total annual precipitation, resulting in streams which rise and subside slowly after a rainfall event;
- terrestrial resources, covering 17 percent of the subwatershed which include three Environmentally Significant Areas, woodlots in high recharge areas and wetlands;
- water quality levels, which do not limit environmental health;

- stable streams, which are capable of supporting brook and brown trout which require the coldest, cleanest and most pristine habitat; and
- strong linkages between the woodlots/wetlands, high recharge areas and aquatic resources (i.e., wherever significant woodlots and wetlands, particularly in high recharge areas exist, brook trout, which are indicative of a pristine environment are found in adjacent streams).

Much of the environmental health associated with this subwatershed is attributable to the unique physiography which is not only important to this subwatershed but also to the entire Credit River as approximately 60 percent of all baseflow within the Credit River originates from the headwater areas.

The primary environmental constraints relate to terrestrial and aquatic resources and to public safety (flooding); and are generally attributable to historic land use practices.

Clearing of the land has removed a majority of the native vegetation. This has resulted in a terrestrial ecosystem which is limited with respect to the number and diversity of species which could exist within the area. Furthermore, recharge capability has been diminished.

Alteration of streams and recent development has resulted in stream reaches which are no longer stable, and cannot support aquatic and terrestrial resources which historically existed.

Lastly, several areas, as a result of encroachment of buildings into the floodplain, are flood susceptible.

The goal of this plan is to identify natural environmental resources and to implement strategies to protect, restore and enhance these important resources under present conditions and as land use changes occur.

In this manner, the key ecologic constraints which presently limit ecologic health will, in the long term, be removed.

A series of recommendations, which are necessary to achieve the plan, are presented in Table 7.1 and highlighted in Figure 7.1 (in map pocket). These recommendations are described in more detail under the following plan components:

Section
No.

7.2 Surface Water Management Plan which describes protection, enhancement and restoration measures to sustain streams in a stable, natural, state, manage flood and erosion risks and avoid future water quality problems.

7.3 Groundwater Management Plan which identifies key measures necessary to enhance recharge, avoid natural resource and water supply conflicts and protect groundwater quality.

7.4 Greenlands Plan which describes the terrestrial, aquatic and recreational systems and outlines required protection, enhancement and restoration measures.

While each recommendation is presented under one component plan for ease of reading, it is important to recognize that most recommendations represent integrated solutions to problems that address each of the component systems: greenlands, groundwater and surface water. For example, restoration of an unstable stream will reduce excessive sediment supplies which, in turn, will protect sensitive spawning areas, protect stream morphology (e.g., pool/riffle habitat), improve water quality and protect sensitive plant species in wetlands which are susceptible to turbid waters.

Similarly, reforestation not only improves habitat for plant and animal life thereby increasing plant and animal abundance and species diversity, but also filters water entering streams or the groundwater system. Furthermore, reforestation may also augment existing groundwater supplies and help shade streams thereby keeping water cool for aquatic life.

The recommended plan represents a long range environmental management plan for Subwatershed No. 19 which, of necessity, looks well beyond typical municipal planning horizons, i.e., 30 to 50 years, instead of 5 to 20 years. This is realistic because it approximates the timeframe for an ecosystem or its functions to recover. *Consistent with the approach taken throughout this study, the Recommended Plan, as presented in Sections 7.2 through 7.4, is based on existing and approved land uses.*

This long range environmental plan may also be used to help guide municipal growth by identifying areas where this growth is best accommodated without jeopardizing the integrity and functions of the natural environment. In this regard, the plan serves as a key resource at a municipal official plan scale as well as various stages of the planning process, where appropriate. This scale also is appropriate for targeting stewardship and publicly-funded initiatives.

Municipal growth, however, requires more detailed environmental planning in order that secondary, draft and site plans can proceed in an environmentally sound and timely manner. Section 7.5 provides more detailed direction for this level of municipal planning in the form of a series of tributary factsheets. These focus particularly on providing direction concerning areas to be protected and implementation measures/studies that are required should land use change. Components of the factsheets are described in more detail in Section 7.5.

7.2 Surface Water Management Plan

The Surface Water Management Plan describes protection, enhancement and restoration measures to manage flood and erosion risks, sustain streams in a stable, natural state, and avoid future water quality problems. This plan, as described in this section, provides recommendations for *restoration and enhancement* of currently impacted or degraded environmental resources. Section 7.5 provides the surface management plan recommendations for the *protection* of environmental resources from the potential impacts of future land use change on a tributary basis.

7.2.1 Flood Control Management

Flood control management focuses on two initiatives, correcting existing problems associated with flood damage centres and protecting against flood risk associated with approved land use changes.

A Flood Damage Centre is defined as a site that includes structures and/or private property that will experience flooding during storms up to and including the Regional Storm Event. A total of seven (7) such flood damage centres have been identified on Mill Creek, Monora Creek and the Credit River (CVC, Philips, 1988). Each of these sites have been assessed to determine the severity of flood risk under existing conditions. Alternative remedial measures for each site were examined to determine what measures, if any, should be implemented at each site to control the extent of existing flood conditions. A summary of the preferred alternatives for each site is provided in Table 7.2.

Five of the seven sites have been considered for implementation as part of the Subwatershed 19 Management Plan. Two sites are not included since works to control flooding on Mill Creek at the Credit River east of Broadway/Townline have already been implemented, and purchasing and removal of structures that are at risk along Mill Creek from Centre Street to East Broadway, is considered unacceptable from a benefit-cost perspective.

Of the five sites to be included in the plan, flooding is limited to one or two buildings at three sites for storm events equal to or greater than the 100 year storm event, therefore flood risks and costs are very low and the "Do Nothing" approach is recommended. For the remaining two sites, Flood Damage Centres 1 and 4, floodproofing works are recommended. The recommended strategies for these two sites are summarized below.

Flood Damage Centre 1 is located in the vicinity of the Monora Creek tributary adjacent to the intersection of Hansen Boulevard and First Street in the Town of Orangeville. The floodline mapping indicates that six (6) buildings will be flooded during the Regional event, four of which will experience some degree of flooding during storms as frequent as

the 10 year event. Since relatively few structures are affected by flooding at this site, fairly straightforward floodproofing measures will provide the required level of flood protection. Floodproofing measures consist of works which would seal or alter the openings which allow for flood waters to enter the building.

Flood Damage Centre 4 is located in the vicinity of the Dawson Road crossing of Mill Creek. Five (5) structures would be affected by flood in the event of the Regional Storm or the 100 year storm. Two (2) of these would be flooded during events as frequent as the 10 year event. The structures that are susceptible to flooding should be flood proofed by sealing or altering the low openings into the building to minimize flood damages. Of these buildings, only the Westdale Mall on Broadway between Dawson Road and Centre Street would require floodproofing measures based on revised two-zone floodplain mapping.

Development of lands in the headwaters of Monora and Mill Creeks is proposed. The effect of developing these lands on the existing flood damage centres was assessed. Furthermore, a proposed strategy for the protection of flood susceptible lands was also developed. In summary the analyses require that existing and proposed stormwater management ponds in the upper Mill and Monora Creek drainage areas (ponds A1, A2, B, E, 3 and 4, see Appendix A.1) control peak flows to less than or equal to existing development conditions to maintain the Regulatory Storm flood elevations at or below existing conditions. Further details of the analyses are provided in Technical Appendix A.1.

For all other areas which are currently undeveloped a similar analysis of flood risk will be required should land use changes occur. The recommended strategy to protect against potential flood risks associated with future land use changes is to implement the existing Credit Valley Conservation AAuthority Policies on Flood Plain Management (CVC 1994)". As such the potential impacts of any future development must be controlled by restricting development within the flood plain, by maintaining, as a minimum, existing flood plain conditions including peak flows, and flood plain conveyance and storage. In much of the undeveloped areas of the watershed suitable hydrologic analyses and flood plain mapping is not available. As such, proponents of land use change are required to complete the necessary technical analyses to identify potential flood risks and requirements

for flood control. Further details on the tributary requirements for flood control management are provided in Tributary Factsheets, Section 7.5.

7.2.2 Stream Corridor Management

Managing stable, natural stream corridors is an integral component of protecting, restoring and enhancing aquatic and terrestrial resources, controlling damages to private and public property, and maintaining the conveyance and hydraulic capacity of watercourses and structures (i.e. culverts and bridges). Conversely, the protection of terrestrial resources and control of land use practices is important to the overall management of stream corridors. This section focuses on the management of stream corridors from a requirement to implement in-stream works. Protection of streams and valleys from an aquatic, hydrologic, morphologic and terrestrial perspective is discussed in Sections 7.4.1 and 7.4.2.

From an environmental perspective, protecting streams corridors to the extent where they can provide self sustaining indigenous fish communities, works towards providing a healthy ecosystem from which both humans and wildlife may live. Currently several streams in Subwatershed 19 support coldwater communities, which in turn reflect a very healthy natural environment. Providing stable, natural channel systems will work toward providing the physical, biological and chemical habitat requirements to sustain fish communities. For example clean riffles with well sorted channel bed materials supply food supplies and spawning habitat, overhead cover provides food supply, temperature control and shelter, and deep pools provide shelter and over wintering habitat.

From a non environmental perspective stable, natural channel systems can provide a very cost-effective approach to long term erosion control, improve the aesthetic quality of channel systems compared to concrete or gabion channels, and add value to property and land.

In Subwatershed No. 19, management of channel systems requires that a variety of instream initiatives be implemented. These initiatives will work towards restoring and enhancing stream resources which are currently degraded by historical land use changes/practices and protect all other streams from future land use changes. This section

presents the short and long term *restoration and enhancement* requirements for those stream reaches which are currently impacted or degraded.

Stream restoration and enhancement initiatives have been organized into two basic types of works; those required for channel stabilization, and those required to mitigate the impacts of existing inline ponds. Within each group there are works which require implementation in the near term to control present channel instability problems, in the moderate term to counteract pending instability problems, and in the long term to restore habitat suitable for the target aquatic community. A description of the various initiatives recommended within each of these type of works is provided below. A summary of the technical considerations, environmental benefits, land requirements and costs associated with each initiatives is presented in Table 7.1.

7.2.2.1 Natural Channel Stabilization Recommendations

The recommendations listed below work towards restoring remnant populations of coldwater fish habitat within Monora Creek and the Credit River. Both initiatives deal with correcting recent and ongoing impacts on sensitive brook trout streams and as such should be implemented in the short term. The recommended actions include:

- restoring 2.1 km of stream along the lower tributary of Monora Creek, upper branch, from Blind Line to Cemetery Road; and
- controlling livestock access on the middle Caledon Tributary, both branches from 1st Line East to the Credit River.

Both of these stream reaches are impacted by excessive sediment supplies which are affecting the stability of the streams, and in turn the quality and quantity of fish habitat (eg. spawning substrate conditions, overhanging cover and food supply). The impacts on Monora Creek have resulted from recent land use changes including construction impacts and altered hydrology, and on the Caledon tributary they are related to livestock access to the creek. To maintain the existing high quality potential of these streams requires measures to remove and reduce excessive sediment supplies and restore channel stability. Restoration of these stream reaches will also contribute towards the long term protection of channel stability in the lower reach of Monora Creek upstream of Island Lake, and in the Credit River main channel, by reducing excessive sediment loadings. Furthermore, the Monora Creek works, along with the recommended Milady Pond retrofit recommendation (described in Section 7.4.2.2), provides an important linkage between the aquatic communities in the upper and lower reaches of this branch of Monora Creek.

The use of natural channel design and soil bioengineering works (see Chapter 5) are recommended for stream restoration works on Monora Creek. This approach may include measures which require the construction of natural channel sections and/or allowing selected stream reaches to establish a new state of equilibrium on their own over time. To determine the specific design requirements for implementing natural channel design works additional geomorphic studies are required which build upon the existing baseline information obtained in the Subwatershed 19 Study. Details of the geomorphic

investigations required are provided in the Technical Appendix.

The recommended works to control sediment supplies on the Caledon Tributary is to control livestock access from approximately 2 kilometres of stream by fencing livestock from the riparian zone, providing some riparian plantings to initiate channel stability, (allowing the majority of the disturbed riparian zone to revegetate on its own), and the provision of an alternate livestock water supply. No extensive instream works are considered necessary for the lower stream reach to reinstate its stability.

Examples of natural channel design works and livestock control are illustrated in Photos 7.1 and 7.2. In this example (Photo 7.1) a section of Monora Creek has been restored as a requirement for realignment. This stream section has been successfully stabilized and presently supports a cold water fish community (brook trout). The livestock control example (Photo 7.2) limits the access of cattle to the stream banks and is promoting natural revegetation and stabilization of the stream banks.

Stream restoration and enhancement initiatives recommended for channel reaches which are at an earlier stage of degradation include:

- restoring the lower tributary of Monora Creek, lower branch, from Blind Line to its confluence with the upper branch; and
- controlling livestock access on the Eastern Tributary upstream of 3rd Line.

Similar to the upper branch of the lower Monora Creek tributary, the lower branch is being impacted by recent urban development. The natural response of this channel will be to widen and downcut, however; this will likely occur at an accelerated rate resulting in a loss of fish habitat and excess sediment supply to downstream reaches. Restoration and enhancement of this channel reach will control the rates of channel erosion and maintain suitable fish habitat linking existing fish communities in the upper and lower reaches of this tributary.

Controlling livestock access on the Eastern Tributary is recommended to protect existing downstream warmwater communities. Protection of this aquatic community is important

since this tributary is poorly connected to other fishery resources and the presence of fish is an integral component of the aquatic and wildlife food chain for this area. The recommended works include fencing to control livestock access, partial revegetation of the riparian zone to restore bank stability and aquatic community habitat, and the provision of an alternate offline water supply for livestock.

The last group of natural channel recommendations include:

- restoring and enhancing a reach of unstable stream channel on the Upper Monora Creek tributary from Highway 10 to Cemetery Road;
- creating a natural channel section on the middle Monora Creek tributary from Starview Street to First Street;
- restoring the degraded lower channel reaches on the upper and lower Caledon Tributaries; and
- creating a natural channel section on the roadside ditch along Second Avenue in Lions Park.

Recommended works on the Upper Monora Tributary and lower channel reaches of the Caledon Tributaries are similar and consist primarily of soil bioengineering works for channel stabilization and habitat enhancement.

Recommended works on the Middle Monora Creek Tributary and along Second Avenue in Rotary Park consist of creating natural channel system in locations where natural channel systems have been lost due to channelization.

The purpose of these recommendations is to provide a net gain in coldwater fish habitat through the implementation of natural channel design and soil bioengineering works. Although these initiatives provide some level of enhancement the incremental increase and cost-benefits are considered less than those provided by initiatives recommended in the first two groups of natural channel design works, and as such they generally have the least priority for implementation. However, most of the works recommended are fairly

straightforward and could be implemented by organized volunteer support in which case the total cost can be reduced.

7.2.2.2 Existing Inline Pond Retrofits, Bypassing and/or Removal Recommendations

The objectives of the following recommendations are to enhance the quantity and quality of existing aquatic communities by providing a net gain in indigenous fish habitat and providing educational and recreational opportunities (Milady Pond only). The recommendations consist of retrofitting, bypassing and/or removing existing inline ponds. Enhancement is achieved through the following actions:

- connecting of upstream and downstream fish communities;
- reducing peak summer temperatures; and
- re-establishing historical channel systems.

An important consideration to note in the implementation of the following recommendations is that each of the ponds serve an existing function, some are located on private property and have existed for many years. As such, some conflicts may occur with their existing uses.

Presented below is a list of each of the pond retrofit bypass/removal recommendations followed by a brief description of the rational, benefits and estimated costs.

Pond Works Upstream of Island Lake

The following recommendations are proposed on the Monora Creek tributaries. Each of these tributaries currently or recently supported self sustaining population of Brook Trout. They are the only remaining tributaries upstream of Island Lake which currently support Brook Trout populations. Recent, and ongoing urban development has had an impact on this fish community. The following recommendations will work towards maintaining and restoring fish habitat in the Monora Creek watershed .

- Retrofit three (3) existing ponds on the Lower Monora Creek Tributary including, the Cook Pond, Milady Pond and North Credit Estates Pond; and
- removal or bypass of the existing Quarry Pond, and Monora Creek Park Pond on the Upper Monora Creek Tributary and online ponds on the lower Monora

Creek Tributary (lower branch) at Townline.

Removal of barriers and improvements of fish passage at each of the three stormwater management ponds would be obtained by modifying the existing flow control structures, pipes and culverts associated with the ponds, and the creation of connecting low flow channels upstream, downstream and through the ponds. The connecting channels should consist of natural channel systems which provide suitable aquatic habitat as well as providing access between the upper and lower reaches. Temperature improvements can be obtained by reducing permanent pool volumes and the provision of riparian canopy along the newly formed channel sections.

Retrofitting of the stormwater management ponds must maintain the existing levels of flood flow control and storage capacity, and should also consider measures which may contribute to improving surface water quality. Furthermore, the Milady Pond offers opportunities to provide additional value to the community through the provision of educational and recreational facilities and integration with existing terrestrial resources.

The "Cook" pond, located on Monora Creek immediately upstream of Blind Line is a historical farm pond but provides a flood storage function. Retrofit of this pond would require the following considerations;

- it has been evaluated as part of the provincially significant Orangeville Wetland Complex and has a Class 1 brook trout fishery upstream and downstream;
- the flood storage function must be maintained; and
- the potential impacts of historic sediment accumulations and the acclimation of the downstream watercourse to these conditions.

For the Milady Pond, the objectives would be to retrofit the facility in order that a variety of environmental benefits (in addition to the flood control function) are achieved. The benefits could include water quality improvements, provision of waterfowl and stream aquatic habitat, as well as educational and recreational opportunities. Photos 7.3 and 7.4 present a picture of the Milady pond in its present condition and an example of a pond retrofit project for a traditional BMP flood control facility. Although the example does not

illustrate the specific recommendation for the Milady Pond it does demonstrate that retrofit options are very realistic solutions which can provide a variety of benefits. Retrofit projects are currently ongoing throughout Ontario to provide multi-purpose facilities which add to the traditional of flood control function. Additional retrofit functions include; surface water quality control, baseflow augmentation, Distributed Runoff Control to maintain natural channel stability, wildlife habitat, and educational and recreational opportunities.

Removal or bypass of the Quarry Pond, Monora Creek Park Pond and Ponds I and J are recommended for maximum water temperature and fish access (Monora Park Pond only) management. Each of these ponds are fairly small yet have permanent pools which are inline with the existing coldwater stream systems. Removal or bypass would involve abandonment of the existing flow control structures and the creation of natural channel systems upstream and downstream of the ponds and, through or around the pond reach. Control of accumulated sediment within the ponds would be an important consideration in their removal. Furthermore, removal of these ponds will require consideration for the loss of their current function. This may include sediment control requirements at the Quarry Pond, and alternate recreational and aesthetic amenity at the Monora Park Pond and property value at Ponds I and J. If removal or bypass of Pond I is not possible, then retrofit of the outfall structure should be considered.

Pond Works Downstream of Island Lake (Island Lake)

The following recommendations address existing coldwater fish habitat located downstream of the Island Lake Reservoir in the Main Credit River and in the Caledon Tributaries. Recommendations in this area include:

- removing or by-passing existing private online ponds on the upper Caledon Tributary and on the middle Caledon Tributary; and
- removing or by-passing the Melville pond which is online with the Credit River.

Removal or bypassing of the two private ponds on the Caledon Tributaries and on the Lower Monora Creek Tributary are intended to provide reduced maximum water

temperature impacts on the lower reaches of these tributaries and to the main branch of the Credit River.

Removal or bypassing of the Melville Pond are intended to provide water temperature benefits to the main branch of the Credit River, removal of an existing fish migration barrier, a net gain in indigenous cold water fish community habitat and removal of pike spawning habitat believed to exist within the pond. Other possible benefits of the retrofit may include a reduction of flood susceptible land and a reduction in flood risks.

If the pond was removed or bypassed a new natural channel reached would be required to connect the upper and lower reaches. Removal will require special consideration for large sediment loads within the pond and the aesthetic benefits provided by the pond versus those provided by a natural channel system. Bypass of the pond may allow the pond to retain much of its existing wetland and aesthetic function while providing the desired net gain in fish habitat. The channel system used to bypass or replace the pond would require a detailed geomorphic investigation in order to design a channel system which is technically suitable for the target aquatic community as well as one which takes into consideration the existing land availability, vegetation, physiographic and hydrologic conditions.

7.2.3 Surface Water Quality

The goal of surface water quality management in Subwatershed No. 19 is to maintain or enhance through measures directed at other resources existing surface water quality conditions. Surface water quality is presently not a watershed wide problem and not a factor limiting the overall health of natural resources. This was not the case in the past, when the Orangeville Sewage Treatment Plant was identified as a significant pollution source to the Credit River. As such, the majority of the surface water quality control initiatives focus on controlling the potential impacts from land use practices and land use change in the future as addressed in Section 7.5.

To maintain existing surface water quality, the current treatment efficiency of the Orangeville STP should be maintained under existing and future land use conditions. The

plant should also ensure that suitable measures are in place to deal with emergency spills or bypass conditions.

Measures to improve water quality have been suggested in various other initiatives such as the management of stream morphology through natural channel design and livestock access control, which provides some measure of improvement on sediment, nutrient and bacterial loadings to receiving waters. Furthermore, recommendations for retrofitting stormwater management ponds provide an opportunity to enhance the current water quality treatment function of these facilities. Those initiatives which provide surface water quality benefits have been noted Table 7.1.

7.3 Groundwater Management Strategy

Detailed discussions have previously been presented in Sections 3.4 on the hydrogeological system within the subwatershed and the sensitive linkages between recharge and discharge areas not only on a regional scale but on an intermediate (eg. tributary) and local scale (reach). The level of detail of characterization was limited on the tributary scale to generalized flow systems and significant large scale discharge areas. Characterization on the reach scale centred around examples of more localized impacts of groundwater withdrawal. The detail necessary to more fully characterize the groundwater flow systems on the tributary and reach scale, to make appropriate impact assessment, are discussed in Section 8.5.2.2. This section provides an overview of the hydrogeological system and presents groundwater strategies within the context of our current level of understanding.

The most significant hydrogeological features governing groundwater flow within the subwatershed included the permeable sand and gravel overburden associated with the ice contact stratified drift of the Orangeville Moraine and the bedrock geology and topography. The highly fractured nature of the upper bedrock combined with the permeable sands and gravels contacting it within a large portion of the subwatershed sites a hydrogeological scenario where the permeable overburden and shallow bedrock act hydraulically as one unit and commonly have a significant hydraulic connection to the streams. In addition the bedrock and surficial topography tend to coincide.

This leads to a groundwater flow system where relatively high rates of infiltration (eg 200 - 350 mm/yr) occur throughout a majority of the subwatershed. Lower rates of infiltration (150 - 175 mm/yr) occur on the sand silt tills which exist east central, west central and south east portions of the watershed.

The general groundwater flow paths are directed, on a regional scale from the topographic highs to the main Credit River Valley, and on intermediate and local scales to the major tributaries. Significantly, it was determined that a 6 km^2 area immediately to the west of the subwatershed acts as a recharge area and contributes to groundwater flow in the western portion of the subwatershed. Aside from this area and an area in the northeast portion of the subwatershed, where deep overburden and shallow bedrock flow is directed to the Nottawasaga Valley, the groundwater flow in the overburden and shallow bedrock follows the topography.

Major discharge areas include the north and south branch of Monora Creek, the upper reaches of Mill Creek above C-Line, the upper reach of the Eastern Tributary and the Caledon Tributaries.

In order to maintain and/or enhance the groundwater levels and associated significant levels of baseflow, and the excellent groundwater quality, it will be necessary to apply appropriate levels of management in the following areas:

- emulation or enhancement of existing recharge, taking into account local groundwater divides;
- minimizing contaminant loadings; and
- selecting locations of wells and the associating pumping rates which are based on the hydraulic connection to the streams and potential impact on baseflow.

7.3.1 Groundwater Recharge

It is critical to manage the groundwater recharge areas to maintain a high quality and quantity of water for domestic water supply and to provide the excellent baseflow link for the high quality aquatic resources.

The recharge component for the regional groundwater balance presented the potential recharge capability to be on the order of 13 - 17 x 10^6 m^3/year. This value is based on applying the estimated recharge for surficial geological units and associated soils (Table 7.3) over the groundwater watershed.

TABLE 7.3: Average Annual Recharge (mm)

Glaciofluvial Outwash	175-350
Sandy Silt Till	150-175
Stratified Drift (Sand and Gravel)	175-350
Dolostone	175-350
Alluvium	175-350
Glaciolacustrine Deposits	150-175
Peat and Muck	150-175
* Approximate annual precipitation 875 mm	

It is noted that the actual values of recharge will vary as a result of topography, vegetation and existing groundwater levels. The promotion of recharge is increased in vegetated, flatter lying topographical higher areas.

Maintenance and/or enhancement of recharge must take into account local groundwater divides, in particular in the high recharge areas as recharge on a local or intermediate flow system has a greater probability of localized baseflow.

A groundwater balance for the western portion of the subwatershed indicates that the available recharge is on the order of 7.0 - 10.0 * 10^6 m^3/year, with groundwater withdrawal from municipal wells in the area being 3.6 x 10^6 m^3/year. The groundwater balance indicates that the concentrated groundwater withdrawal in the western portion of the subwatershed is a significant percentage of existing recharge. It would be appropriate to promote recharge in this area, taking into account the potential for contaminant susceptibility.

Efforts to enhance recharge through revegetation, where there would be no concern for contaminant susceptibility, are discussed in Section 7.4. It is possible to promote groundwater recharge through various stormwater BMP's, particularly in the highly

permeable sands and gravels of the western portion of the subwatershed, as discussed in Section 5.3.2. The potential for contamination is minimal in the sandy silt tills. More detailed studies are necessary to assess the viability of infiltration BMP's with respect to groundwater quantity and quality, and are discussed in Section 8.5.2.2.

7.3.2 Groundwater Withdrawal

The continuity and high permeability of the sands and gravels, overlying the fractured upper dolostone bedrock provide the flow system and hydraulic connection which delivers the large amount of baseflow to support the coldwater streams. It is this same hydraulic connection which gives rise to a significant potential for baseflow impact due to groundwater withdrawal from local wells. Historical water level data and a number of more recent pumping tests reflect the impact potential and is discussed in Section 3.4.

Areas in the subwatershed which have a lesser degree of sensitivity for baseflow impacts but posses suitable aquifer units include the northeast quadrant of the subwatershed and the south central portion of the subwatershed.

Groundwater supplies can be developed in the more sensitive areas of the western portion of the subwatershed and the Caledon Tributaries but location, depth and amount of water taken must be based on a detailed hydrogeological investigation addressing the extent of hydraulic connection and potential long term baseflow impacts as discussed in Section 8.5.2.2.

In addition to promoting recharge in the western portion of the subwatershed, which would decrease the ratio of groundwater withdrawal to recharge and hence minimize existing and potential baseflow impacts, it is recommended that a water taking management study be carried out to maximize the water takings from each well while minimizing the more local impacts on baseflow. This study, which would include contributing areas outside of the subwatershed boundary, is discussed in more detail in Section 8.5.

It has previously been discussed that there is an existing impact due to the pumping of Well 5/5A that has dried up the upper reach of the north tributary of Mill Creek. The removal or

substantial reduction of flow at this well field would serve to bring baseflow back to this reach.

Generally speaking, throughout the majority of the subwatershed potential baseflow and wetland impacts are greater than water level interference between water wells (e.g., municipal and private).

7.3.3 Contaminant Susceptibility

The permeable nature of the sands and gravels allows for more rapid movement of surface contamination to the water table and within the groundwater flow system, with little ability for attenuation. Minimizing groundwater quality degradation is necessary to maintain the current quality for a drinking water supply and to support the cold water aquatic habitat.

The protection of groundwater quality should take into consideration the following:

- the different BMP's regarding varying levels of stormwater quality and groundwater recharge;
- minimizing the application of fertilizers, pesticides etc. in the high recharge area;
- minimizing septic system installation in the high recharge areas;
- options for road maintenance de-icing in the high recharge areas;
- restrictions on existing industry and service or locating future industry and services that utilize or distribute materials which could seriously impair groundwater quality if a spill occurred (eg. gas stations), particularly in the high recharge areas. These restrictions may preclude the land use or include on-site early warning monitoring and Emergency Spill Programs; and
- educational programs for industry (eg spills) and homeowners (eg application of fertilizer, pesticides etc.).

The level of detail for site specific studies regarding potential groundwater contamination is discussed in Section 8.5.2.2.

A contaminant sources inventory (Section 8.3.3) should be carried out to locate existing contaminant sources and where necessary consider requesting early warning monitoring and Emergency Spill Programs.

7.4 Greenlands Plan

The Greenlands or Natural Heritage Plan consists of three separate, yet integrated components:

- **a stream and valley corridor system** which protects important stream functions, habitats, fish and other aquatic life, and provides the backbone of the natural landscape system;
- **a terrestrial system** consisting of a mosaic of core natural areas with inter-linking, forested corridors which provide important functions necessary to support healthy, self sustaining communities of plants, birds and other animals in their native habitats; and
- **a recreational trail system** which provides a complementary network of recreational trails and passive recreation nodes to promote the value of these natural systems to the community.

7.4.1 Stream and Valley Corridor System

In general, the tributaries and the Credit River within Subwatershed No. 19 support high quality coldwater aquatic communities relative to other southern Ontario streams. This is largely because of the significant baseflow component (about 50%) which maintains cold water temperatures. In spite of this, however, the presence of online ponds, destabilizing flows and sediment loads, other fish passage obstacles and localized baseflow reductions caused by wells are causing conditions in these streams to deteriorate. Unless these trends are halted and reversed, the coldwater aquatic communities in these headwater tributaries may be lost. These communities are not only important to the individual tributaries but also to the upper Credit River. Brook trout in these tributaries are the only remaining populations that can colonize parts of the Credit River within the subwatershed. Restoration of brook trout in the Credit River provides the potential for a sportsfishery to develop.

Target Communities

Although the streams contained both warmwater and coldwater communities, stream morphology is typical of a coldwater stream. As a result, the target aquatic community for each stream and the Credit River is to establish the physical characteristics and riparian vegetation communities typical of a coldwater stream (although temperature and base flows may remain unsuitable for coldwater species in some streams). Existing communities and target communities were outlined in Section 3. Only Island Lake, the Eastern Tributaries and several small streams tributary to Melville marsh are considered as warmwater communities.

Existing communities and habitat requirements are shown in Tables 3.16 and 3.17. Under the recommended plan, habitats in a number of tributaries would be significantly improved, thus causing a shift in aquatic community class to a lower number. The tributaries are listed below showing their existing community type and the target community class:

Tributary	Existing Community	Target Community
Monora Creek - Northern Branch	Type 1/2	Type 1
Monora Creek - Middle Branch	Type 4	Type 2
Monora Creek - Southern Branch	Type 1/2/3	Type 1/2
Mill Creek	Type 1-4	Type 1-3
Caledon Tributary - Northern Tributary	Type 1-4	Type 1/2
Caledon Tributary - Middle Tributary	Type 1-4	Type 1/2
Caledon Tributary - Southern Tributary	Type 1-4	Type 1/2
Eastern Tributary	Type 3-4	Type 3
Credit River	Type 2-3	Type 2

Based on these targets, all existing coldwater communities (Types 1 and 2) would be protected; other reaches of Monora/Caledon tributaries and Credit River would be restored

to coldwater communities (Type 2), and other reaches of the Mill and Eastern Tributaries would be protected/enhanced to support warmwater aquatic communities (Type 3).

Restoration and enhancement works required to re-establish Type 1 and 2 aquatic communities are as follows:

1. stream restoration works in the Monora and Caledon tributaries;
2. livestock access control in the Caledon and Eastern tributaries;
3. pond/stormwater facility retrofits/bypasses in the Monora and Caledon tributaries;
4. removal of Melville dam and associated stream restoration works; and
5. revegetation of riparian zones.

In addition, opportunities to enhance baseflows in Mill Creek as development proceeds are recommended.

Items 1 to 4 above were previously described in Section 7.2 and are highlighted, as Level 1/2 stream restoration, in Figure 7.1 and Table 7.1. Revegetation of riparian areas is discussed below.

In addition to identifying target aquatic communities, one of three levels of protection was assigned to reaches of each tributary and to the main Credit. These three levels of protection were defined, based on the Guidelines developed in support of DFO=s Fisheries Habitat Policy (1994), as follows:

- **Level 1**: habitat which provides critical life support functions for the target aquatic community. This includes spawning areas, habitat of special status species, nursery habitat and groundwater discharge areas. It may also include other habitat types which are determined to be limited in supply based on a biological inventory. Level 1 protection should also be afforded to stream reaches upstream and/or downstream of critical habitats as required to ensure their protection. This includes both cold and warm water habitats.

- **Level 2**: habitat which is generally not limiting, but provides habitat for various life stages and functions. This includes reaches exhibiting common habitat characteristics such as pool:riffle sequences, riverine wetlands and backwater areas and floodplains of permanent streams. This includes reaches which, with rehabilitation could provide critical habitat (i.e., level 1). In general, maintaining the stability of these reaches is important in maintaining critical habitats in the long term. This includes both cold and warm water habitats.

- **Level 3**: this level of protection is provided to severely degraded streams or reaches of streams that function only to provide for fish passage. It also includes intermittent streams and other drainage features whose primary aquatic function is limited to runoff conveyance, maintenance of downstream flow and water quality regimes and limited food production for downstream habitats. These reaches are generally perceived to have no potential to be restored to provide critical habitats (i.e., level 1).

Stream reaches requiring level 1, 2 or 3 protection are identified as Riparian Corridors as shown in Figure 7.1. The lines highlighting level 1, 2 and 3 corridors are 50 m wide for illustrative purposes. Riparian Corridors are defined, for the purpose of this report, to include those components of the stream, floodplain, valley and adjacent tableland necessary to protect aquatic functions. As discussed in Section 7.2.2, some of these riparian corridors have also been identified as terrestrial corridors with a minimum width of 100 m, which may extend beyond the minimum required to maintain aquatic functions.

Level 1 Riparian Corridors currently support coldwater fish populations or represent areas of groundwater discharge to streams. These areas are considered critical habitat. Level 2 Riparian Corridors currently support warmwater fish populations, or are important in maintaining the overall stability of critical habitats supporting coldwater fish populations. Rehabilitation of these areas is necessary to prevent degradation of level 1 reaches. Level 3 Riparian Corridors generally are intermittent streams important in conveying flows downstream and maintaining water quality in order to support downstream habitats.

In order to provide protection consistent with each of the stream levels, a vegetated corridor centred on the stream centreline is necessary. The width of this vegetated corridor for Levels 1 and 2 streams should extend sufficiently far back from the banks to provide shading, sediment control, food supply and woody debris, and create a cool microclimate around the stream. In addition, this zone should support other aquatic/hydrologic functions, such as maintain sufficient room for natural morphologic changes, protecting wetlands and discharge areas adjacent to the stream and valley. As a minimum, the setback criteria as outlined in the CVC Watercourse and Valleyland Protection Policies (CVC, 1992) should be applied. In addition, the following other sources were consulted: MTRCA (1993), Rosgen (1994) and MNR (1994). As a guide, the following additional criteria may be used to assist in determining the corridor width:

- **Level 1**: the greater of any of the following: the valley or floodplain width, a multiple of 16 - 20 times the bankfull width, a multiple of 3 times the natural meander width of the stream, a multiple of 10 times the average bank slope, the edge of a discharge area or riverine wetland, a 60 m corridor as defined by MNR policy, the criteria as outlined in CVC Watercourse and Valleyland Protection Policies, a corridor equal to the valley width at 2 times bankfull depth, a setback from the valley wall equal to the 100 year erosion recession limit.

- **Level 2**: the greater of any of the following: the valley or floodplain width, a multiple of 16 - 20 times the bankfull width, a 30 or 60 m corridor as defined by MNR policy, the criteria as outlined in the CVC Watercourse and Valleyland Protection Policies, a corridor equal to the valley width intersected by a horizontal drawn at 2 times bankfull depth.

- **Level 3**: generally defined by the floodplain width, however the size of the corridor may be adjusted to accommodate development provided that the requirement to convey flows and maintain water quality is preserved.

Many of these areas are already naturally vegetated or are actively regenerating to natural vegetation, since previous land uses have been abandoned or discontinued. A revegetation program is required to re-establish these areas in natural vegetation.

7.4.2 Terrestrial System

Terrestrial Communities - Past to Present

The dominant physiographic feature is the Orangeville Moraine, which is inter bedded particularly in the east by till plain and bisected by a glacial spillway which follows the course of the Credit River. The subwatershed is generally comprised of hilly moraines, gravel terraces and scattered swamps. Soils are generally well drained, dry mesic to wet mesic, silty to sandy loams and tills which are moderately fertile. Agricultural capability is generally restricted by steep slopes and low to moderate fertility; however, the range of crops is also restricted because of the cooler temperatures and short growing season due to the higher elevations.

Presettlement vegetation was predominantly broadleaf (deciduous) forest with some extensive swamp and bog features in low lying areas and possibly some scattered areas where fire and other disturbance provided conditions suitable for transitional communities such as shrub thickets and savannas. This region contains vegetation typical of the Mixed Forest or Great Lakes St. Lawrence Forest Region, although there are also elements of the Boreal and Eastern Deciduous (Carolinian Life Zone) Forest Regions which border the region to the north and south respectively. Because of the elevation and short growing season, a number of species typical of boreal forest communities, such as white/black spruce, balsam fir, paper birch, aspen, alder and tamarack, occur here. Carolinian species such as black maple, sycamore, hackberry, black walnut and shagbark hickory may also be found here. Large swamp/bog communities existed at the site of the Orangeville reservoir, Caledon Lakes ESA and Rosehill swamp ESA (included within the Speersville wetland complex in the Humber watershed) and a riverine marsh community was established along the Credit River (Melville Marsh ESA). These wetland communities likely comprised about 20% of Subwatershed 19, with the remaining 80% consisting of bottomland and upland forest communities. Of these, upland forests were the dominant forest type.

Today, about 17% of the subwatershed is in natural vegetation, including the open waters of the reservoir (162 ha), and the distribution of vegetation is concentrated in bottomlands,

represented by stream valleys and swamps, with only a few remnant upland deciduous forest communities representing the once dominant community type. Marsh and open water habitats have increased with the creation of the reservoir, at the expense of the swamp/bog community types. The remnant upland forest communities are typically small (less than 16 ha), second growth or mid-successional (versus mature or old growth), and disturbed (by forest cutting practices, grazing, trail cutting or invasion by non-native species). As a result, there has also been a shift in the types of plant and animal species that inhabit these upland forest remnants, away from Atrue@ forest dwellers toward species which have adapted to forest edge and Anon-forest@ environments (primarily old field, meadow, scrubland, cultivated and built environments) (see Tables 7.4.2 through 7.4.5).

The current terrestrial system bears little resemblance to the presettlement environment, for the reasons described above, however the subwatershed and areas adjacent to it contain remnants of many of these former habitats. These remnants contain some of the attributes of former communities and may be partly self sustaining on an individual basis, however, because of isolating, fragmenting and disturbing processes, they are unable to function as a whole system.

It is also important to note that there have been some significant gains in natural vegetation over the past 25 years as a result of stewardship efforts by landowners and by agencies such as CVC (Photos 7.5 and 7.6). In addition, many areas which represent marginal agricultural lands have been allowed to regenerate on their own. These lands may not require an active revegetation program, but rather a strategy to protect them and allow the natural regeneration process to continue undisturbed.

In summary, a highly diverse upland forest community once dominated the landscape, where now only remnants of this forest type remain along with several wetland associations and riparian corridors. The loss of terrestrial vegetation has reduced the biodiversity of the area, reduced the diversity of plants and animals that once lived here, and reduced the quality/quantity of groundwater recharge. Restoration of the lost vegetation to a level of about 30% (Riley and Mohr, 1994) of the watershed is necessary to restore the diversity and integrity of the terrestrial system and to enhance groundwater recharge.

In Chapter 3, the existing resources were described based on existing information, interpretation of aerial photographs and field investigations which focused on identifying the extent to which areas within the subwatershed were naturally regenerating. A review of physiographic features, general soil types and literature describing typical vegetation types for the area and further field investigations were undertaken to assist in identifying the types of vegetation communities which should be targeted by revegetation initiatives.

Finalizing the terrestrial component of the Recommended Plan involved the following steps:

- developing a **terrestrial system model** which represents the characteristics of the target terrestrial system to be protected/enhanced/restored;
- describing to what extent the **existing terrestrial system components** satisfy the recommended model and what areas need to be protected/enhanced/restored; and
- prioritizing the components of the **recommended terrestrial system** for implementation through stewardship programs and opportunities that would occur should land use change.

Terrestrial System Model

In order to rehabilitate the existing natural features to a functioning system, the following model/vision of a functional terrestrial system in a settled landscape was used:

- a local landscape that includes large natural areas, linked to the regional mosaic by a network of smaller natural areas and corridors, offers the highest probability of maintaining overall ecological integrity on the landscape (Noss and Harris, 1986).

This is consistent with the system proposed by Riley and Mohr (1994). Key characteristics/components of this rehabilitated system should include:

- **core areas**: some extensive areas of natural habitat, over 400 ha in size, that are of sufficient size and quality to support sustainable populations of sensitive plants, wildlife and birds in their native habitats (eg. forest interior species), and to serve as core areas that will help to colonize surrounding fragmented areas (Tables 7.4.4, 7.4.5);
- **secondary core areas**: smaller areas, approaching 100 ha in size, with interior forest conditions that are capable of supporting subpopulations of the unique assemblage of forest dependent plants, wildlife and birds that require this habitat (Tables 7.4.4, 7.4.5);
- **terrestrial corridors and support areas**: corridors of continuous vegetation at least 100 m wide and Aislands@ of natural habitat at least 36 ha in size (the minimum size that offers some habitat for forest interior species), particularly mature deciduous forest, providing links to core areas and providing supplementary natural areas in support of core/secondary core areas;
- **unique community types**: greater representation of community types unique to the area such as prairies, Carolinian and boreal habitats (forests, swamps/bogs), habitats for area sensitive species;
- **high biodiversity areas**: focusing restoration and protection measures on expanding areas which already contain a high diversity of species by virtue of representing a broad cross section of vegetation community types;
- **stream and valley functions**: protection of stream and valley corridors to provide aquatic and terrestrial benefits, recognizing these corridors as the Abackbone@ on which the terrestrial system is built; and
- **hydrologic functions**: focusing protective and restorative measures for terrestrial system benefits on vegetation features and areas along watercourses and in important recharge/discharge areas where hydrologic/aquatic system benefits are also optimized.

Achieving this strategy requires changes to the existing pattern of features through the implementation of protective/enhancement/restorative measures. These changes are shown in Table 7.4.1. Revegetation of a number of areas is necessary to bring about these changes. The following priorities were used to select candidate areas for revegetation:

- lands within/adjacent to ESA=s and other large natural features;
- lands in stream riparian zones;
- lands in stream corridors;
- lands in valley corridors; and
- upland corridors linking large, natural features, lands within/adjacent to large woodlands (> 36 ha) with interior forest characteristics.

In addition, areas were also prioritized based on providing important recharge functions and hydrologic benefits (flood attenuation, stream protection).

The target vegetation community assemblage is to re-establish a regional, mixed forest with scattered representatives of boreal and Carolinian communities. While not as extensive as the presettlement forest, linkages across the landscape would be provided to encourage colonization and dispersal of plant and animal communities throughout the subwatershed. Open and edge communities would still dominate the terrestrial system, however the amount of interior forest habitat would be significantly increased and inter-linked. These reforested lands would also increase groundwater recharge capability.

Existing Terrestrial System Components

The distribution of the existing vegetation features by size class is as follows:

Site Class	No. of Features	Approx. Area (ha)
0-4 ha	118	130
4-16 ha	25	180
16-36 ha	6	120
36-100 ha	6	350
100-400 ha	2	400
Over 400 ha	0	0
TOTAL	157	1,180

This represents about 19% of the drainage area of the subwatershed, which overestimates the actual natural area, because some small areas of other land use types are included. The actual area of natural vegetation is 17%. Some of these areas represent the building blocks for the recommended terrestrial system as shown in Figure 7.1.

Existing terrestrial features, which form part of the recommended terrestrial system, are described below. A number of areas which are currently either naturally revegetating or currently in other land uses are also highlighted. These areas would be restored to form part of the recommended terrestrial system.

Several Core Natural Areas (>400 ha) exist on the boundaries of the subwatershed. The Caledon Lakes ANSI/ESA is located on the southwest boundary of the subwatershed covering an area of 693 ha. and the Rosehill Swamp (205 ha) forms part of a large Class 1 wetland (589 ha) known as Speersville Wetland Complex which also forms part of the headwaters of Caledon Creek and the Humber River. Immediately north of the subwatershed is the well forested Nottawasaga River valley (also known as Hockley valley) which is part of the Niagara Escarpment Planning Area. Immediately downstream along the Credit River valley is the Credit River at Alton ESA (323 ha), an area of significant discharge and high quality woodland and swamp features. These four large areas represent important nodes or refugia capable of harbouring populations of unique plant and animal communities that are highly sensitive to disturbance, eg. forest interior and range extensive species. Populations within these areas can recolonize areas within the subwatershed as they are rehabilitated and will also utilize smaller areas for nesting/feeding.

Important Secondary Core and Supporting Core Areas (36 - 400 ha) within the subwatershed include the Monora Park/Dufferin Hunters and Anglers properties, the Melville Marsh ESA, the Rosehill Swamp ESA and the Island Lake ESA. A large wetland feature on the Eastern Tributary and the Credit valley through the oxbow on the east side of Highway 10 are also considered as supporting core areas. Descriptions of the ESA's were provided in Section 3. These five features are predominantly wetland communities; however, the Island Lake and the Monora Park/Dufferin Anglers and Hunters properties include some medium sized upland forests.

Several Terrestrial Corridors are also shown as follows:

1. Monora Creek to Island Lake Valley Corridor, Island Lake to Melville Marsh Valley Corridor (including the Melville Marsh to Melville Pond Valley and Rail Corridor).
2. Melville Marsh ESA to Rosehill Swamp Valley Corridor (including the Credit Oxbow and Caledon Tributary Upland Forest).
3. Dufferin H&A to Caledon Lakes Upland Forest Corridor.
4. Island Lake to Eastern Tributary Wetland Corridor.
5. Rosehill Swamp to Tamarack Estates Wetland Corridor.

Within these corridors, there are many small existing wetland, bottomland forest and upland forest features and many idle/abandoned lands where revegetation may be required. Of these idle/abandoned lands, as much as 75% may already be naturally revegetating based on field inspections.

To be effective in promoting movement/dispersion of animals, birds and plants, a terrestrial corridor should be a minimum of 100 m in width and composed of predominantly forest habitat. A width of 100 m is considered to be the minimum required for forest interior species such as those listed in Tables 7.4.4 and 7.4.5 (City of London, 1995). In addition, the corridor would have to be at least 200 m wide before it could be used as habitat by these species. The forest community associations typical of a riparian or stream and valley corridor are different than those associated with an upland terrestrial corridor.

Typically, differences are as follows:

Riparian	Upland
wet to wet mesic soils	wet mesic to dry mesic
swamp, bottomland and slope forest communities	slope and upland forest communities

silver maple, red maple, elm, willow, black maple, spruce, cedar	sugar maple, white/red oak, hickories, American birch, white ash, white pine
linkages along topographic lows - wet microclimate	linkages along topographic highs - moist microclimate
connections between wetland core areas	connections between upland forested core areas
groundcover adapted to wetter, often periodically flooded, more acid soils	groundcover adapted to drier nutrient-rich, often neutral soils
hydrologic functions: sediment control, discharge, flood storage, stream temperature regulation	hydrologic functions: recharge, runoff attenuation, groundwater quality

These differences in soils, microclimate, vegetation and hydrologic function also contribute to differences in unique species of plants and animals that colonize these two corridor types.

Upland corridors, like upland forest habitats, are highly fragmented and rare now relative to their former dominance in pre-settlement times. One such corridor, the Dufferin Anglers and Hunters to Caledon Lakes Upland Forest Corridor, is proposed as part of the terrestrial system. As can be seen in Photo 7.7, a considerable portion of this corridor exists in the form of remnant vegetation in the headwaters of Mill and Monora Tributaries.

It is important to recognize that many of the existing features listed above are located in areas of important recharge, as are many of the idle/abandoned lands which are proposed to be enhanced/restored to a natural state. These naturally vegetated areas contribute a very important hydrologic function in recharging groundwater supplies (both quantity and quality of supplies) which support stream base flows and well water supplies. In addition to all existing features identified above, all remaining features which occur in high recharge areas are considered an integral part of the recommended terrestrial system because of their significant recharge function.

Vegetated and non-vegetated areas within Riparian Corridors adjacent to level 1 and 2 streams are also considered part of the recommended terrestrial system because of their hydrologic function and their value as general wildlife habitat. They also still provide a

limited terrestrial corridor function.

Recommended Terrestrial System

The recommended terrestrial system is shown in Figure 7.1 and described in Table 7.1. For the purposes of implementation, this recommended terrestrial system was prioritized into 3 classes based on the following criteria:

- **Class 1** areas are the fundamental building blocks which provide core natural areas and contribute the most to the biodiversity and integrity of the area. These areas are identified to be protected. They also have a significant hydrologic, specifically groundwater function. These areas perform important ecological processes and protect biological diversity and life-supporting systems that would be lost or degraded if such areas were permanently disturbed in any way. These areas must be protected from land use impacts.
- **Class 2** areas provide important secondary benefits in terms of wildlife habitat, linkages to the Class 1 areas, and act as seed sources or nuclei from which revegetation efforts can build upon. Class 2 areas should be protected through stewardship programs, particularly where they are adjacent to Class 1 areas. However, if land use change is proposed, these areas should be protected or replaced with equivalent features depending on the results of more detailed evaluation. These areas provide important ecological functions to the subwatershed and allow for the creation of new ecological features such as vegetative buffers, wetlands and linkages between vegetated areas and watercourses. If land use changes are proposed, subject to detailed studies in the form of an Environmental Impact Statement (EIS), some level of development may be permitted to alter the size and physical form of a Class 2 area provided that ecological functions including hydrologic and hydrogeologic functions are protected and maintained. This is discussed in more detail in Section 8.0.
- **Class 3** areas represent priorities for revegetation in a stewardship context or degraded streams which may be enhanced should development occur. Class 3 areas which are targeted for revegetation should be replanted with native species characteristic of the adjacent features or appropriate for the underlying soil/soil

moisture and flooding regime. Representative species typical of different terrestrial communities are provided in Table 7.4.2. For example, on mesic to dry mesic soils in upland locations, sugar maple - beech or sugar maple - mixed hardwood associations should be the target forest community (it may be appropriate to also plant species characteristic of upland successional forests as well). These lists are intended to provide a general indication of the species mix in each community type and were adapted from Hough *et al.* (1995) and Kavanagh and McKay-Kuja (1992). Species lists for other wetland associations are available in Hough *et al.* (1995).

As a further guide, Tables 7.4.3 to 7.4.5 show typical wildlife species of each broad vegetation community type and selected vegetation typical of forest edge and interior forest conditions. These species may be expected to recolonize vegetation communities which are re-established. Vegetation and wildlife typical of interior forest conditions are particularly limited within the subwatershed and should be the focus of revegetation efforts. It is expected that populations of these species exist in the core natural areas outside the subwatershed and would use restored natural areas as they become suitable.

Components of the recommended terrestrial system were prioritized for implementation as follows:

- Class 1:
  - all ESA=s, wetland features and contiguous woodland features
  - Monora Park and Dufferin Anglers and Hunters natural areas
  - all level 1 and 2 riparian (stream and valley) corridors
  - all woodlands in high recharge areas
  - all vegetation features within 100 m wide terrestrial corridors

- Class 2:
  - all natural features contiguous with terrestrial core areas and corridors
  - all natural features contiguous with level 1 and 2 riparian (stream and valley) corridors
  - all level 3 riparian (stream and valley) corridors

- all lands within a 50 m setback from the boundary of Class 1 areas (should land use change)
- all remaining features

- Class 3:
  - areas targeted for stewardship within terrestrial core areas and corridors
  - all remaining streams without a corridor designation

These areas are shown in Figure 7.1 and described in Table 7.1. In Figure 7.1, the brown line encircles the Class 1 areas (except for some features in high recharge) and those Class 3 areas targeted for stewardship. The actual width of the 100 m terrestrial corridor is shown only for the upland corridor along the headwaters of Monora/Mill Creeks and along the rail line. Field visits confirmed that up to 75% of these areas are already regenerating naturally. In this case, only an agreement with the landowner is necessary to continue to allow the process to occur uninterrupted.

In preparation for the revegetation program, naturalization plans are required for each of the core/supporting core areas (Class 1) and all of the areas targeted for revegetation (Class 3). These naturalization plans would assess the extent to which the natural regeneration process has already restored natural vegetation in these areas and identify other management actions that may be required to protect these areas and ensure that unique species and communities are sustained.

Finally, all lands within 50 m of the boundaries of all Class 1 areas has been added to Class 2. These lands, as well as all of the other Class 2 areas, would be subject to an EIS, should land use changes be proposed. Where no land use change is proposed, the protection of these areas would be pursued as a second priority in the implementation of a stewardship program.

In summary, the implementation of the recommended terrestrial system would increase the overall integrity and biodiversity of the terrestrial resources in the subwatershed, approximately double the coverage of subwatershed by natural vegetation and establish key linkages to core natural areas outside the subwatershed. In addition, by focusing

protection/enhancement/restoration efforts on natural features and areas in high recharge, an increase in groundwater infiltration capacity of over 200,000 m^3 would result. This would enhance the water budget within the watershed augmenting baseflows and municipal water supplies.

7.4.3 Recreational Trail System

A proposed hiking and walking trail which would follow the terrestrial and stream/valley corridors and provide passive recreational opportunities for subwatershed residents is shown in Figure 7.2. This trail would provide interpretive opportunities and linkages to Island Lake and other significant natural features in the area. Opportunities also exist to link this trail into the Hockley Valley Trail which is part of the Bruce trail system. In addition to providing an excellent recreational amenity to the community, the creation of a trail system would provide controlled access to sensitive features and help to educate residents about the benefits of maintaining healthy natural areas.

7.5 Tributary Factsheets

This section will describe the Tributary Factsheets that have been developed as part of this study. The Tributary Factsheets are to be used as a basis to establish the appropriate studies and measures to be undertaken, typically at the Official Plan Amendment or Secondary Plan stages, should land use changes occur.

Described in this section is an overview of the information provided within the factsheets, together with an example Factsheet for Mill Creek. Appendix A.6 provides further details with respect to the fact sheets, as well as the fact sheets for each of the 12 tributaries.

Section 8.5 provides further details as to the future study requirements at the Official Plan Amendment/Secondary Plan stage.

Each Factsheet includes the following information:

- Environmental Resources;
- Environmental Protection Targets;
- Key Best Management Practices; and
- Future Study Requirements.

The Factsheets are intended to serve as guidelines to be used at the Secondary Planning or Official Plan Amendment Phase for proposed land use change and/or for the completion of Environmental Management Plan (EMP). An EMP is required for each tributary to better define the site specific constraints and opportunities for land use change, and to confirm that proposed land use plans are consistent with the direction and targets of the overall study (see section 8.5 for further information relating to Environmental Management Plans).

Presented below is a brief overview of each of the Factsheet Components.

7.5.1 Environmental Resources

This section provides a summary and refinement of the key environmental resources within the tributary drainage area. The purpose of this summary is to provide the basis and an understanding of the need for specific Environmental Protection Targets, Best Management Practices and future studies. Groundwater, surface water, aquatic and terrestrial resources are listed as well as a description and condition of channel systems and current land uses.

7.5.2 Environmental Protection Targets

The overall recommended management plan for Subwatershed No. 19 is to Restore and Enhance Key Ecological Constraints. To achieve the goals and objectives of this management plan specific targets for the protection of existing environmental resources have been developed.

Environmental protection targets have been developed for each of the key environmental resources, groundwater, aquatic resources, terrestrial resources and stream morphology. The targets developed are sensitive to the types and conditions of environmental resources within each tributary, and as such vary for each tributary. They are intended to be used as minimum requirements and guidelines to assist in the land use planning process and in the selection and design of best management practices. These targets should be considered as the minimum levels required for environmental protection unless detailed analyses or investigations provide acceptable alternative targets. *These targets **do not** take precedence over the requirements under federal and provincial acts or municipal bylaws.*

7.5.3 Key Best Management Practices

The Tributary Factsheets summarize the key Best Management Practices (BMPs) from the subwatershed plan that are applicable to the tributary drainage area. They provided guidelines as to what types of measures should be considered in meeting the Environmental Protection Targets. The development and selection of more site specific BMPs and preliminary design considerations of the BMPs will be developed through the completion of the EMP.

7.5.4 Future Study Requirements

This section identifies the study components that will be required as part of the Environmental Management Plan. Further description of the study components is provided in Section 8.5.

8.0 IMPLEMENTATION

8.1 General

The study goal is defined as:

- to identify natural environmental resources and to establish appropriate strategies for the protection, enhancement and restoration of these important features under present land use conditions and as land use changes occur.

Chapter seven presented the technical components of the Recommended Plan. Collectively, the individual plans (e.g., Surface Water, Groundwater and Greenlands) when applied together, provide a holistic management strategy that will meet the study goal and associated objectives.

This chapter will describe the activities which must be undertaken if the Recommended Plan is to be successfully implemented. In preparing the Implementation Plan, the following points were considered:

- implementation must consider issues associated with both urban and rural land uses;
- consistent with the other components of the study, Implementation is based on existing and approved land uses;
- the Recommended Plan and associated Implementation considerations provide an environmental framework should land use changes occur including the setting of environmental targets, direction for future studies, and general designation of land uses;
- the Implementation Plan is flexible and realizes that the approach to subwatershed studies will change as the knowledge base advances, that future studies will refine the findings from this study and that the natural environment is not a static system;
- the success associated with implementing various steps will be strongly dependant upon the support of residents within the watershed; stewardship and

education are thus highlighted as key components to implementation;

- implementation of this plan, should, assuming the requirements as outlined herein are met, streamline the review and approval process for submissions relating to land use change;
- the implementation plan has been structured to facilitate the review and interpretation of material by the main user groups, these being: municipal staff and politicians, developers and consultants, technical agencies, and members of the public and special interest groups;
- the basis of implementing the plan is consistent with CVC's overall implementation concept for Subwatershed Plans which include:
  - planning and policy;
  - stewardship and education;
  - rehabilitation and retrofitting;
  - environmental monitoring; and
  - research and development;
- the Implementation Plan, as presented, is a starting point; it is fully expected that an Implementation Committee involving various stakeholder groups will be formed and that this group will ensure that the Plan is advanced, implemented, updated and revised as appropriate.

8.2 Subwatershed Plan Administration

The completion of the subwatershed study was a cooperative effort involving the area municipalities, the Region of Peel, CVC, provincial agencies, special interest groups and representatives from the public. The recommendations as described in this chapter were discussed with the above noted groups and, as such, do provide a framework for implementing the plan. An Implementation Committee will, however, be required to further define implementation mechanisms, ensure conformance with component strategies, assess the effectiveness of the plan and, in general, update and monitor plan implementation.

In terms of administration, it is recommended that an Implementation Committee be formed for the overall subwatershed to oversee plan implementation. The composition of

the Implementation Committee should include representation from the member municipalities, the Conservation Authority, special interest groups and members of the public.

Ultimately, the Implementation Committee may split into two or three subcommittees to deal with the following four topics:

- plan implementation;
- stewardship;
- environmental monitoring; and
- restoration and retrofitting.

It is expected that meetings of the Committee would occur on an annual basis. However, several meetings may be required early in the process to fully establish the proposed education/stewardship program. One of the tasks of the Implementation Committee should be to pursue alternative sources of funding (e.g., special interest groups, environmental foundations, corporations) to reduce municipal/provincial funding requirements.

8.3 Considerations for Proposed Measures

8.3.1 General

The individual components which comprise the Recommended Plan were presented in chapter 7. The objective of this section is to outline the implementation considerations for each plan component. The information, that is provided in this section is based on existing and approved land uses. Section 8.4 addresses proposed studies, approval mechanisms and triggers for initiating these studies should land use changes occur.

The proposed requirements and responsibilities for implementing the Recommended Plan are discussed below. These are itemized in Table 8.1 by action (or measure as described in chapters 6 and 7) and include the following:

Plan Component: *component (e.g., surface water, groundwater or greenland) under*

	which the action is described
Action:	*a description of the proposed measure*
Facilitator:	*the agency or group that will coordinate efforts to implement the measure*
Contributor:	*the agency(ies) or group(s) that will assist in implementing the measure by providing support in any of a number of ways, e.g., funding, labour, materials, technical expertise*
Official Plan Considerations:	*policy considerations relating directly to the Official Plan*
Other Implementation Mechanisms:	*mechanisms for implementation that are outside of the Official Plan*
Time Frame:	*three time frames; short (0-10 years), medium (11-20) years and long (21-30 years), which reflect general prioritization of the measures have been selected*
Cost:	*approximate cost of the measure assuming traditional funding sources (e.g., primarily municipal/provincial agency). It should be noted that the use of special interest groups and/or members of the public to implement the proposed measures and the pursuit of additional funding sources (e.g., special interest groups, environmental foundations) will reduce municipal/provincial funding requirements.*
Funding:	*these include traditional sources such as through direct municipal and provincial funding as well as other sources such as special interest groups, corporation and endowments*
Other Comments:	*any other information/considerations relevant to implementation*

In general, it is proposed that the municipalities will collectively be the facilitator of many of the proposed plan components. The Credit Valley Conservation has been listed as the facilitator for components involving stewardship (e.g., naturalization of significant natural features, naturalization plans for valleyland corridors) as they have historically provided this role (and indeed have completed several conservation plans with local residents). Furthermore, the initiatives involving stewardship and naturalization will transcend the subwatershed boundary and are therefore best addressed by an agency with responsibilities

on a watershed basis. Other agencies have been identified as contributors for specific plan components.

The overall time frame for implementing the plan has been selected to be 30 years; which reflects both budgetary considerations and the long term nature of several components (particularly naturalization plans). Three time periods have been selected. These are:

- 0 to 10 years: components to be implemented in this time frame are of high priority, may need to be implemented to protect existing natural resources, have reasonable costs associated with the construction/implementation and may not require additional policies to be written to implement the plan component;
- 11 to 20 years: within this category, selected measures are of moderate priority, generally enhance/restore existing resources, have moderate costs associated with the works, and may require policy change; and
- 21 to 30 years: components in this category are lower priority, may be relatively costly and only address enhancement/restoration of a single natural environmental resource (see Table 6.3), require policy change, and may impact existing uses by a landowner (e.g., removal/restoration of a private pond).

It should be noted for some of the plan components, more than one time frame has been given. For example, under stream restoration, reaches where works are required to protect existing conditions have been listed under the 0 to 10 year category; while restoration/enhancement works are under the 11 to 20 year category. With respect to the naturalization strategy, all components have been given a 0 to 30 year time frame as it is acknowledged that undertaking of these components is a long term commitment and that support and buy in by individual landowners is required. The proposed naturalization strategy was based on existing uses of the land and environmental considerations. However, until each landowner is contacted and support/buy in (see Section 8.6) is provided, prioritization cannot be provided.

In general, there are two key factors which will determine the success of the implementation plan:

- a strong community-based commitment to stewardship with active participation by all government levels; and
- a strong will within each municipality and CVC to accept responsibility for the protection, enhancement and restoration measures.

The environmental features within Subwatershed No. 19 have already benefitted from a long history of successful stewardship initiatives fostered by CVC, MNR, municipalities and interest groups. This has led to the replanting of many areas, restoration of a number of stream reaches and the retirement of lands which are now actively regenerating. This means that there are already many landowners who recognize the value of good land stewardship and who will hopefully continue these practices. A focused program of landowner contact and handshake agreements to manage lands for conservation is the first key step to be completed. This is discussed further in Section 8.6.

Further discussion of policies is provided in Section 8.4.

The recommended plan, from an implementation perspective, is described below under the following headings:

- **Surface Water Implementation Strategy**
- **Groundwater Implementation Strategy**
- **Greenlands Implementation Strategy**

8.3.2 Surface Water Implementation Strategy

The Surface Water Strategy focuses on the implementation of long term protection, enhancement and restoration measures to manage flood risk, sustain streams in a stable, natural state, and avoid impairment of surface water quality. Included are implementation considerations to address existing problems and those required to address future land use change. Presented below is a description of the implementation considerations.

8.3.2.1 Flood Control

Implementation of flood control measures requires two types of initiatives, those required to address problems associated with existing flood damage centres, and those required to protect existing developments and environmental resources from the potential impacts of future land use change (including redevelopment proposals).

Floodproofing works at First Street and Hansen Boulevard, and at Dawson Road and Mill Creek should be managed by the local municipality. The proposed works should be consistent with the CVC "Technical Guidelines for Floodproofing, October 1993", latest Ontario Building Code Regulations and local municipal bylaws. Prior to undertaking the works, further monitoring is required to confirm peak flows and thus the frequency and severity of flooding. Further public consultations may be required as part of the Environmental Assessment process. Findings from this study shall satisfy the first two Phases.

Timing considerations for the construction of flood proofing works should be planned when local improvements are proposed by the municipality or region, or when the land owner proposes to make changes to the structures on the property.

Implementation of existing floodplain management policies to address new and redeveloping land should be consistent with the existing Provincial Flood Plain Planning Policy Statement as issued under the authority of Section 3 of the Planning Act. Implementation must consider the following:

- CVC "Authority Policies on Flood Plain Management", April 21, 1994;
- CVC "Technical Guidelines for Floodproofing, October 1993";
- CVC "Watercourse and Valleyland Protection Policies, November 1992";
- the local Official Plan;
- Zoning Bylaws; and
- most current and up to date Regulatory Flood Plain mapping.

Should land use changes occur and should flood plain mapping of the Regulatory storm not be available, suitable mapping, which meets the approval of the CVC, should be prepared by the proponents of land use change. The required hydrologic and hydraulic studies, and

flood plain mapping components (see Section 8.5.1) should be implemented at the Secondary Planning phase and integrated with the preparation of the tributary Environmental Management Plan.

Funding of the required hydrologic and hydraulic studies, flood plain mapping and the design and construction of flood control measures should be the responsibility of the proponents of land use change.

Additional implementation information is also available in the following MNR documentation " Flood Plain Planning Policy Statement, Implementation Guidelines October 1988".

8.3.2.2 Stream Stability/Erosion Control

Implementation of recommendations to control channel erosion and maintain stable, natural channel systems requires three initiatives including:

- requirements to restore existing, or soon to become unstable streams;
- requirements to control the potential impacts of future land use change; and
- requirements to enhance existing environmental resources (terrestrial and aquatic communities).

Streams works recommended to stabilize existing or soon to become unstable streams are located on public property along Monora Creek and on private property on the Eastern Tributary and the Caledon Tributaries. Implementation of public property works on Monora Creek would be the responsibility of the local municipality (Town of Orangeville or Township of Mono) and would require the completion of technical studies to develop conceptual and detail design plans and funding for studies and construction works. The works would have to be completed under the Municipal Class Environmental Assessment process. CVC's role will be to provide technical support when required and the necessary work permits. Other permits may be required, and should be retained from the appropriate agencies.

Considerable cost savings and simplification of the implementation process including public consultation, and construction activities could be provided through the support of volunteers, public interest groups and or other local stewardship organizations.

Stream works to control livestock access and create buffer areas along the Eastern Tributary and the Caledon Tributaries require approval and implementation by the land owner. Considerable technical and construction support could be provided to the land owner from the CVC, public interest groups, volunteers or stewardship organizations. Funding alternatives include joint support from the CVC, OMAFRA, landowner and special interest groups.

Due to the existing unstable state of some stream reaches these works should be implemented in the near future (next 5 years). Extended delay in implementation could result in a further degradation of downstream reaches.

Recommendations to control the impact of future land use change requires the completion of the appropriate stream corridor study(s) to determine requirements for the protection of properties from valley slope erosion, and for maintaining stable natural channel systems; including area restrictions, land based controls and instream works. These recommendations would be implemented and funded by the proponents of land use change. The local municipality and/or the CVC would be responsible for review and approval of the proposed works. Implementation should be carried out at the Secondary Planning phase for land use change or at the time when the tributary environmental management plan is prepared.

Works to enhance stream corridors include the retrofit of three existing public stormwater management ponds, and the bypass or removal of other public and private ponds for the creation of natural channel systems and enhancement of existing aquatic community habitat. These initiatives would be jointly implemented by the local municipality and the CVC with support and consultation from the MNR, interest groups and general public.

Retrofit of the three existing public stormwater management ponds should be considered over the next 10 years. These works are best considered as components of stream

restoration works recommended upstream and downstream of these ponds. As such, the Milady Pond should be the first pond considered for retrofit, as it is located on a reach of Monora Creek which has the highest priority for stream restoration works. Furthermore, the Milady Pond retrofit should be considered as a pilot/demonstration project site from which the retrofit experience by the Town, CVC and public can be developed for the retrofit of other ponds.

All other pond removal or bypass works would require close consultation with private land owners and the public (Monora Park Pond only) as each of these ponds has a current use, function or value to the property which must be considered. Implementation should be considered over the long term, however early contact with the land owners is suggested to solicit their opinions an interest with respect to maintaining the existing ponds and proposals to bypass the ponds.

With respect to Melville Pond, the existing facility is a very old structure and may be in need of repair in the near future in which case an opportunity to examine the feasibility of removing or bypassing the pond could be considered. Since the Melville Pond site is also a flood damage centre and the facility may provide a flood control and aquatic habitat function, the cost for the works could be shared by the landowner, CVC and MNR. The cost for implementation could be reduced through the provision of volunteer services, equipment and donations.

8.3.3 Groundwater Implementation Strategy

Sections 3.4 and 7.3 outlined the hydrogeologic sensitivity with respect to groundwater withdrawal and the potential for baseflow impacts, and the contaminant susceptibility. The impact, from historical pumping, that well field 5/5A has had on the north tributary of Mill Creek is directly evident in the cessation of flow in this reach. The current or potential impacts of the other major existing wells (eg. Well No's 2,3,4,6,7,8 Cardinal Woods, Purple Hills, Coles) were not determined in detail within the scope of this study.

The first component of a groundwater management plan is a pumping well impact assessment study. A pumping well impact assessment study should be developed which

maximizes the pumping rates in the existing wells while minimizing the existing or potential baseflow impacts. The assessment of baseflow impacts can be carried out by the monitoring of water levels in water table wells in the vicinity of the well in question, water levels in streambed piezometers and stream flows in adjacent reaches. This data would be collected prior to, during and after the shutdown of the pump(s) (eg. recovery test) in the well field being assessed. Each well should be tested without a major change in pumping in nearby wells. The data must be assessed by taking into account precipitation. Ideally, average precipitation should occur over the duration of the monitoring. The tests would likely warrant the installation of streambed piezometers, flow monitoring stations (eg temporary weirs) and possibly some shallow water table wells.

The overall fine tuning of pumping rates would take into account the sensitivity of the potential baseflow impact (eg volumetric baseflow vs spawning upwellings) and the potential for seasonal variations in pumping. The assessment of potential baseflow impacts would require technical input from the CVC, MNR and OMOEE, as well as the municipalities.

The recovery test should also provide a preliminary assessment of the potential interference in adjacent wells in the event the pumping rates in the existing wells can be increased and, as such, individual drawdown cones should be estimated. An increase in a pumping rate beyond the current permitted value may require an additional pumping test as per MOEE guidelines.

In the event the overall pumping rate in the existing wells has to be reduced due to unacceptable baseflow impacts, or in the event additional water takings, beyond the current takings, are required for currently approved or future development, then future water supplies should be explored. High capacity water supplies, given the potential baseflow impacts, have a reduced potential in the western portion of the subwatershed along the Caledon tributaries and the main branch of the Credit between the Highway 10 Crossings. This does not rule out future water supplies in these areas, but the exact locations, depths and pumping rates may be restricted. Areas that have potential aquifers that are less sensitive to baseflow impacts include the northeast quadrant of the subwatershed and the south central portion. The first phase of a study for additional groundwater supplies should

include but not be limited to the detailed assessment of existing hydrogeological studies and test drilling and pumping tests. The overall assessment for locating additional groundwater supplies must follow the Class Environmental Assessment process.

A second component of a groundwater management plan would be to carry out a contaminant sources inventory study. Although the existing groundwater quality is excellent there is a significant potential for contamination. Replacement of lost water supplies and contaminant remediation is expensive. The prime objective of a contaminant sources inventory study would be to document the potential sources of groundwater contamination, both point source and non-point source, within the groundwater watershed and prioritize the potential impact based on such factors as the type of contaminant, locations in the groundwater flow system (e.g., upgradient of well fields), toxicity, mobility etc. The study would provide recommendations on contaminant sources (e.g., underground storage tanks) which may require early warning monitoring wells and Emergency Spills Response Programs.

The pumping well impact assessment study and the contaminant sources inventory study should be carried out, in both the facilitator and contributor role, by the local municipalities with a lead role taken by the Town of Orangeville, as the Town has significant information pertaining to well records, usage, etc. Technical input should be provided by MOEE, CVC and MNR, as well as the municipalities.

A third component to the groundwater management plan, which has been set out as a separate plan component and should be done in conjunction with the overall pumping well assessment study, is the replacement or pumping reduction at wells 5/5A. This well field has been singled out because baseflow impact has occurred to the point that streamflow has ceased in the upper reach of the north tributary of Mill Creek. This component should firstly assess the potential / viability to re-establish baseflow in this reach. Options for replacement of the lost volume of water if a reduction in pumping of Wells 5/5A is recommended, would be based on the results of the pumping well impact assessment study. The options could include: (1) utilizing existing wells, or (2) locating and installing a replacement well. This component would be carried out by the Town of Orangeville.

8.3.4 Greenlands Implementation Strategy

The Greenlands Plan consists of three components:

- **Terrestrial System**
- **Stream and Valley Corridor System**
- **Recreational System**

Implementation considerations for recommendations are discussed under each of the above components.

Terrestrial System

The recommended terrestrial system provides a mosaic of linked core natural areas and corridors and isolated, remnant woodlands/wetlands in high recharge areas. Once the non-vegetated areas within this system regenerate to a natural state, a two fold increase in coverage of the subwatershed by natural vegetation will result. The timeframe for this regeneration effort to occur, even with a focused stewardship effort is considered to be 30 years. The benefits include not only a dramatic increase in the biodiversity and integrity of the terrestrial system but an increase of 200,000 m^3 annually of additional groundwater recharge capacity which increases stream baseflows and municipal water supplies.

The successful implementation of initiatives to protect/enhance/restore the recommended terrestrial system will largely depend on support and buy in from private landowners.

Table 8.1.b, 8.1.d, 8.1.e and 8.1.f provide details of a number of measures to be implemented. These are briefly described below. Official Plan Considerations are described in Section 8.4.

The CVC have been identified as the facilitator as many of the proposed measures require coordination at a subwatershed wide (or larger) scale. Several contributors have been listed.

Details with respect to Official Plan Considerations and Other Implementation Mechanisms provided in Section 8.4. Generally, there are three items to be considered. These include:

- designation of the natural features into Official Plans;
- development of policies to control development adjacent to these areas; and
- development/implementation to protect existing features.

As outlined in Section 7 and Figure 7.1, the recommended terrestrial system was prioritized into 3 classes with respect to implementation.

Class 1 areas represent the core of the terrestrial system and any loss of function, size or physical condition represents an irreplaceable loss. These areas require protection.

Class 2 areas provide important functions and represent nuclei which provide opportunities to enhance linkages and increase the total area of general wildlife habitat. In a stewardship context, efforts should be made encouraging the protection of these features or their functions. If land use change occurs, an EIS should be completed to protect the areas function as development proceeds. This may result in: protection of the area; allowing compatible development within the area by mitigating a loss of function; or allowing development of the area to occur, while compensating for the areas function by an equitable compensation at another location.

Class 3 areas are targeted for revegetation through a stewardship program or should land use changes occur, be targeted for acquisition through land use process.

Other implementation mechanisms include the preparation of specific by-laws: Tree By-law, Fill By-law, Topsoil Removal By-law; the use of Fill Regulations and permits pursuant to the Conservation Authorities Act; and the development of public land acquisition policies in built up areas. These mechanisms would help to prevent a number of activities such as forest clearing, and excavation/filling of wetlands.

A general time frame (0-30 years) has been provided for all naturalization initiatives as the success of any initiative will depend on landowner support and buy in. The initial step, involving landowner contact (see Section 8.6) should be undertaken quickly.

The costs as provided are largely dependant upon the success of natural revegetation which, due to the retirement of agricultural properties, is presently occurring within the subwatershed.

Furthermore, cost sharing with landowners or alternative funding sources should be pursued.

Three naturalization programs (Tables 8.1.d, 8.1.e and 8.1.f) are proposed to

protect/enhance/restore the following Class 1 and Class 2 areas:

- significant natural features including the Rosehill Swamp, Melville Marshes, Island Lake, Monora Park and Dufferin Anglers and Hunters property;
- terrestrial valleyland corridors:
  - Rosehill Swamp to Melville Marshes
  - Dufferin Anglers and Hunters/Monora Park to Island Lake
  - Island Lake to Melville Marshes
  - Melville Marshes to adjacent Credit Valley; and
- upland forested corridors from:
  - Dufferin anglers and Hunters across the headwaters of Monora/Mill Creeks to Caledon Lakes Forest ESA; and
  - Melville Marsh to Caledon Lakes Forest ESA.

Approximately 900 ha of non-vegetated or naturally regenerating lands, split equally between the corridors (upland and valley) and the significant features, would be targeted for the preparation and implementation of naturalization plans. A naturalization plan would outline areas requiring revegetation (with appropriate species and recommended planting densities), areas which are naturally regenerating which require protection and management; and/or actions within existing vegetated areas necessary to restore ecological processes, maintain unique species and/or increase biodiversity.

Contacting and involving landowners in the preparation of management/naturalization plans for these areas and guidelines, including native species lists, for restoring vegetation and managing habitat for unique species is the first priority in protecting these areas.

An Urban Forestry Program is recommended to manage existing trees within the Town of Orangeville. This program would enhance an existing program which addresses removal of old or diseased trees. Many of the existing trees are quite old, diseased or encroached upon by utility and servicing corridors. This program would systematically look at measures improving the health of existing trees and plant replacements to ensure that these resources are not diminished or lost. Urban trees provide habitat for a variety of urban wildlife, provide a natural buffer and have considerable aesthetic value within the urban

landscape.

The Town of Orangeville would be responsible for implementing this program. CVC, landowners and special interest groups would also assist in this program through the provision of materials, promotion, labour and other in-kind support. Other implementation mechanisms include the preparation of a Tree By-law to protect existing trees. Some technical expertise and recommended native species lists for tree replacement may be also available through the County of Dufferin.

Since the majority of these areas are on private lands, a focused, coordinated stewardship program is required to solicit cooperation, support and participation by landowners in achieving the overall goal of a sustainable terrestrial system. During the subwatershed study, it was observed that up to 75% of the land in and adjacent to corridors and significant features were naturally regenerating. The degree by which natural revegetation occurs will impact the overall cost to undertake this measure. This is considered a long term effort to be completed over a 30 year time frame. CVC and/or the local municipality would be responsible for implementation. MNR, OMAFRA, special interest groups and landowners would also assist in these programs through the provision of funding, nursery stock, labour and equipment, technical advice and other in-kind support.

Stream and Valley Corridor System

The recommended stream and valley corridor system includes the protection of all existing coldwater streams, in particular within the Monora and Caledon tributaries (and a small section of Mill Creek). In addition, significant stream restoration works, livestock access control, stormwater pond retrofits and private pond bypasses are recommended to restore most of the reaches of Monora and Caledon tributaries to provide coldwater stream habitat. Finally, a reconstruction of Melville dam and associated stream works would provide fish passage throughout the upper Credit River thus moderating water temperatures and increasing habitat for coldwater species including brook trout. With the implementation of all 7 of these measures, the potential exists for the upper Credit River to support a much larger native brook trout population. All of the above measures are presented in Table 8.1.a through 8.1.h are described in Section 8.3 (Surface Water Management).

In addition, a naturalization program is recommended to revegetate stream riparian corridors along all Level 1 and 2 streams. Costs for this initiative are about $300 per linear metre of riparian corridor and are included in the costs for the naturalization plans for terrestrial corridors. The timeframe is considered to be long term, however, some of this work should be completed at the same time as the stream restoration and livestock access control work.

The last implementation measure recommended under the aquatic system component is to continue with the current program to reduce northern pike population in Island Lake and Credit River through promotional fish derbies.

Recreational System

The development of recreational trail system paralleling the terrestrial core areas and corridors is recommended as a means of controlling access to significant features and to promote the value of healthy terrestrial/aquatic systems through an education/interpretative program. Although components of the trail may be designed to municipal standards (i.e., within Orangeville), much of the trail is on private land and would likely be designed with more flexible standards based on landowner support and participation. This measure is outlined in Table 8.1.c and has not been costed as part of the implementation plan. Municipalities would act as facilitators for the design/development or the trail system.

8.4 Land Use Planning Considerations

8.4.1 General

The completion of this study is an important initial step which defines a technical framework for the preparation of formal implementing planning policy. Advancing to the next step of implementation through municipal planning documents is recommended as the Subwatershed No. 19 Recommended Plan lacks the legislative authority for government authorities to consistently and comprehensively implement its recommendations. Accordingly, the respective Councils of the constituent municipalities within Subwatershed

No. 19 should (by resolution[1]) endorse the Subwatershed No. 19 Recommended Plan as the basis for proceeding with future municipal planning initiatives, as well as in the development review process.

The Subwatershed No. 19 Recommended Plan assumed, as its land use basis, all existing and planned[2] land uses and therefore, the technical analysis reflects the potential impacts from the existing/future development of such lands. In many instances planned land uses reflect a continuation of the existing agricultural and rural land use base. Subwatershed No. 19 Recommended Plan provides a long-term environmental framework which, if no development occurs, provides an emphasis for the Plan's implementation through public and private stewardship initiatives. However, the Plan also provides an appropriate framework for the evaluation of potential changes in land uses through establishing environmental targets; the framework for more detailed tributary based studies; implementation mechanisms; and, specific identification of the principal matters to be assessed in the preparation of other municipal planning documents (such as growth management strategies and secondary plans) or, in the review of a development application. This framework is also relevant in the "streamlining" of future land use planning initiatives through its clear articulation of these environmental objectives.

This section will address how Official Plan policy documents, and other related implementation tools, are available to carry forward the recommendations of the Subwatershed No. 19 Recommended Plan. Because of the scope of its recommendations and the limitations to some types of documents, it is appropriate to utilize a series of documents and tools, where appropriate, at different stages of the planning process. A discussion of other land use planning implementation mechanisms is also provided.

8.4.1.1 Official Plan

The Official Plan of both Regional and local municipalities is the principal land use planning document for those jurisdictions. With the Planning Act as its legislative authority, the Official Plan guides the land use decisions of both the private and public

[1] Such endorsement should proceed expeditiously upon completion (ie. three to six months) of the Subwatershed No. 19 *Management Plan*.

[2] "Planned" land uses include all lands designated in the existing Official Plans of the constituent municipalities.

sectors. It is both a strategic and a land use control document.

In its strategic function, the Official Plan can establish municipal strategic initiatives or targets which may be of a short term or a long term nature. Goals, objectives, and policies of an Official Plan can direct certain matters to be studied and/or programs to be initiated, or they can set targets for various environmental or engineering related works. By establishing these matters in an Official Plan, an important basis is established to guide the future decision making concerning the allocation of municipal finance and resources related to these matters[3].

In its land use control function, the Official Plan establishes the policies related to various land use designations to guide more detailed land use decisions. In particular, the Official Plan can direct what standards and criteria are to be addressed, and at what stage in the planning process. The stage(s) that a piece of land must follow can include one (1) or more of the following:

- Official Plan Amendment
- Secondary Plan
- Draft Plan of Subdivision (Condominium)
- Zoning By-law Amendment
- Consent to Sever
- Site Plan
- Minor Variance
- Building Permit

The information concerning significant natural features identified through the Subwatershed No. 19 Recommended Plan can, at each stage of the planning process, be further developed and refined.

Related to the foregoing stages of planning are other tools which lend assistance in

[3] In relation to Subwatershed 19, some specific matters the Official Plan can address in its strategic function are discussed in Section 8.4.3 of this Report.

securing a desired commitment or requirement of one nature or another, from a planning applicant. These other tools include the following:

- The application forms for each type of land use application can list the information and documentation that must accompany the application to support the application as being "complete";
- Subdivision/Condominium agreements;
- Site plan agreements;
- Conditions of municipal approval (e.g., subdivision, rezoning, site plan, consent);
- Design and performance guidelines;
- Restrictive covenants;
- Public acquisition of rights to environmental areas by purchase, easement and parks dedication; and
- Environmental fact sheets or warnings to landowners, occupants, or future purchasers.

Therefore, the use of the foregoing procedures[4], as directed by approved Official Plan policy, can considerably strengthen and focus the implementation of the Subwatershed No. 19 Recommended Plan recommendations.

The constituent municipalities should move expeditiously to review their respective Official Plan documents and determine what amendments are required to implement the objectives and recommendations of the Subwatershed No. 19 Recommended Plan. The timing of such a review will, of course, be dependent upon municipal resources and the priority that this matter may have relative to other municipal initiatives. However, it is recommended that, where possible, the municipality seek, within six to twelve months after the endorsement of the Plan by their respective Councils, to implement the results of this Study through their Official Plans.

[4] Further discussion of the role of these various implementation mechanisms can be found in Section 8.4.4.

Given the variety and diversity of existing Official Plans within Subwatershed No. 19, there are a number of approaches that may be used in combination, including: utilization of the Subwatershed No. 19 Recommended Plan as a background document for other detailed land use studies (such as a growth management strategy or secondary plan); a comprehensive Official Plan review, which uses the recommendations of the Subwatershed No. 19 Recommended Plan; an Official Plan Amendment establishing environmental land use policies and/or associated designations which are identified/implemented within those portions of the municipality affected by the Subwatershed No. 19 Recommended Plan.

8.4.1.2 Transitional Measures

Incorporating the recommendations of the Subwatershed No. 19 Recommended Plan into approved Official Plan documents will involve, for each municipality in Subwatershed No. 19, a considerable amount of time to process and consider the approval of such a document. This is particularly true in Subwatershed No. 19 where (portions of) five local municipalities and one Regional municipality exist within its boundaries. Before this is done, various interim measures can be employed to ensure, where appropriate, the implementation of its recommendations. The following interim measures are therefore recommended:

- As an initial step of implementation, the Subwatershed No. 19 Recommended Plan should be endorsed as the guiding subwatershed planning framework document by each local municipal Council, the Regional Municipality of Peel, and the CVC. In this regard, its recommendations can be employed by the various government authorities and the private sector during the consideration of planning matters other than the general Official Plan. This could apply to a planning exercise as large as a Secondary Plan or as small as a Consent.

- The recommendations of Subwatershed No. 19 Recommended Plan that relate to

planning policy or guidelines should be published in a brief, summary form, and made available to the public and land development industry through the offices at each municipality, the Region of Peel, and the CVC.

- All municipal application forms should specify information and documentation requirements as they relate to Subwatershed No. 19 and more specifically, the Subwatershed No. 19 Recommended Plan should be mentioned as a guiding framework document.

- All review agencies should utilize the [municipally-endorsed] Subwatershed No. 19 Recommended Plan as the basis for the review of development applications and the preparation of comments relating thereto.

From a planning perspective, during the interim period, the Subwatershed No. 19 Recommended Plan should be regarded as Council-endorsed guidelines, and utilized as such during the consideration of various land use applications. In this way, the Subwatershed No. 19 Recommended Plan can remain as a functional implementation tool, in advance of its formal implementation into Official Plan Policy.

8.4.2 Official Plan Considerations

An important product of the Subwatershed No. 19 Recommended Plan is the identification and mapping of different natural environmental resources which possess varying degrees of significance. In carrying forward the Subwatershed No. 19 mapping into Official Plan policy, there should be policy recognition of the varying degrees of significance of the different natural environmental resources. In this way, the most significant resource(s) can be protected by the most restrictive and proscriptive policies, using the appropriate legislative framework as the basis for those policies. Conversely, where there is little policy basis to establish highly restrictive policy for less significant resource(s), then less proscriptive and more permissive policy language can be utilized to implement the recommendations of the Subwatershed No. 19 Recommended Plan.

In this regard, Figure 7.1 identifies three (3) classes of natural environmental resources. It is appropriate to utilize these three classes and adopt them as "Environmental Constraint Areas" in Official Plan policy by defining them in the following manner:

- Class 1 areas are the fundamental building blocks which provide core natural areas and contribute the most to the biodiversity and integrity of the area. These areas are identified to be protected. They may also have a significant hydrologic, specifically groundwater function. These areas perform important ecological processes and protect biological diversity and life-supporting systems that would be lost or degraded if such areas were permanently disturbed in any way. These areas must be protected from land use impacts.

  Class 1 areas include:

  - all ESAs, wetland features and contiguous woodland features;
  - Monora Park and Dufferin Anglers and Hunters natural areas;
  - all level 1 and 2 riparian (stream and valley) corridors;
  - all woodlands in high recharge areas; and
  - all vegetation features within 100 m wide terrestrial corridors.

  To ensure the protection of these areas, the areas should be incorporated as a separate land use designation.

- Class 2 areas provide important secondary benefits in terms of wildlife habitat, linkages to the Class 1 areas, and act as seed sources or nuclei from which revegetation efforts can build upon. Class 2 areas should be protected through stewardship programs, however if land use change is proposed, these areas should be protected or replaced with equivalent features depending on the results of more detailed evaluation. These areas provide important ecological functions to the subwatershed and allow for the creation of new ecological features such as

vegetative buffers, wetlands and linkages between vegetated areas and watercourses. If land use changes are proposed, subject to detailed studies in the form of an Environmental Impact Statement (EIS), some level of development may be permitted to alter the size and physical form of a Class 2 area provided that ecological functions including hydrologic and hydrogeologic functions are protected and maintained. This is discussed in more detail in Section 8.0.

Class 2 areas include:

- all natural features contiguous with terrestrial corridors;
- all natural features contiguous with level 1 and 2 riparian (stream and valley) corridors;
- all level 3 riparian (stream and valley) corridors;
- all lands within a 50 m setback from the boundary of Class 1 areas (should land use change); and
- all remaining features.

These areas can be incorporated as either a separate land use designation, or a "constraint" or "overlay" to a underlying land use designation (which, in many instances, will be an open space, rural or agricultural designation).

- Class 3 areas represent priorities for revegetation in a stewardship context or degraded streams which may be enhanced should development occur. Class 3 areas which are targeted for revegetation should be replanted with native species characteristic of the adjacent features or appropriate for the underlying soil/soil moisture and flooding regime. Representative species typical of different terrestrial communities are provided in Table 7.2.2. For example, on mesic to dry mesic soils in upland locations, sugar maple - beech or sugar maple - mixed hardwood associations should be the target forest community (it may be appropriate to also plant species characteristic of upland successional forests as well). These lists are intended to provide a general indication of the species mix in each community type and were adapted from Hough *et al.* (1995) and Kavanagh and McKay-Kuja (1992). Species lists for other wetland associations are available in Hough *et al.* (1995).

Class 3 areas include:

- areas targeted for stewardship within terrestrial core areas and corridors.

These areas are appropriate to show in an Appendix Map of an Official Plan for information purposes but not on (an approved) Land Use Schedule(s).

Approval of Official Plan policy tailored to the three foregoing Classes or Constraint Areas will appropriately assign formal policy priority to the respective Constraint Areas (or Classes) and facilitate the protection of these areas.

However, it must be noted that the accuracy of the mapping of these Environmental Constraint Areas reflects the scale at which the inventory/mapping of the Subwatershed No. 19 Recommended Plan was undertaken (ie. 1:10,000). Therefore, inclusion of these identified Areas within Official Plan must be accompanied with a "caution", indicating that this mapping should not be interpreted as being "accurate" beyond a certain degree and that more detailed identification of the extent of on-site natural features will be undertaken through subsequent environmental studies and the development review process. Further, the Official Plan should note that the boundaries shown on the Official Plan schedule/ appendix may be used as a general basis for the identification of designation boundaries, and that a more precise delineation of the limits of environmental features will be undertaken through subsequent studies, EIS, and/or the development review/approvals process.

8.4.3 Official Plan Policy Framework

As previously noted, Subwatershed No. 19 comprises (portions of) five local municipalities which undertake long-range planning, together with the Region of Peel (which has recently completed a Regional Plan)[5]. The Official Plans for these municipalities reflect a range of

[5] The County of Dufferin, at present, does not administer planning services.

approach, content and contemporariness ranging from a very recent and comprehensive review of environmental management policies (Town of Caledon), to a predominantly urban-oriented approach (Town of Orangeville).

Notwithstanding, all existing Official Plan documents do contain one or more "environmental" land use designations (e.g., Environmental Resource, Hazard Lands, Environmental Constraint Policy Area, Environmental Protection, Open Space Conservation), with associated land use policies. Therefore, a framework for addressing environmental matters during the land use planning and development process does exist in all current Official Plan documents, to varying degrees[6]. As previously discussed, it is advised that the objectives and recommendations be implemented through the inclusion of Official Plan policy which is appropriate to, and reflective of each constituent municipality.

In addition to the diversity of these local planning documents, the Provincial context of planning is currently undergoing a significant evolution. In March, 1995, the Provincial government adopted the Comprehensive Set of Policy Statements ("CSPS"), pursuant to Section 3 of the Land Use Policy and Protection Act (i.e., addressing matters of Provincial interest). However since that time, Bill 20 which addresses further modifications to the Land Use Policy and Protection Act has been advanced, together with a proposed Provincial Policy Statement ("PPS") which will replace the former CSPS. While the PPS is still in draft form at this time, it is intended that, with the proclamation of Bill 20, this PPS (as may be modified) will become the declaration of matters of Provincial interest.

In particular, the focus of the proposed PPS with regards to natural heritage and environmental matters can be briefly summarized as follows:

Natural Heritage [Section 2.3]

- Development is not permitted in significant portions of endangered/threatened species habitat

* development is not permitted in significant wetlands.

[6] The implementation of changes to these Official Plans is further discussed in Section 8.4.2.

- Development may be permitted in:
  - fish habitat
  - significant woodlands
  - significant valleylands
  - significant wildlife habitat,

  where it has been demonstrated that it will not negatively impact natural features/ecological functions
- Development may be permitted on "adjacent lands" to the above, where it has been demonstrated that it will not negatively impact natural features/ecological functions
- A diversity of natural features, and connections between them, should be maintained/improved, where possible

Water Quality and Quantity [Section 2.4]

- Maintain the quality/quantity of ground water and surface water
- Maintain/enhance sensitive ground water recharge/discharge areas, aquifers and headwaters

Public Health and Safety [Section 3]

- Development will generally be directed outside of hazardous lands adjacent to river/stream corridors effected by flooding and/or erosion hazards, and areas of unstable soils and bedrock
- Development will not be permitted within the floodway portion of a floodplain
- Development may be permitted in these areas, subject to the following:
  - the hazard can be safely addressed
  - new hazards are not created
  - existing hazards are not aggravated
  - no adverse environmental impacts will result
  - there is safe vehicular/pedestrian access during emergencies
  - development is carried out in accordance with established standards/procedures

- no institutional uses, emergency service uses, or uses dealing with hazardous substances will be permitted

The recommendations for Official Plan initiatives to implement the objectives and recommendations of the Recommended Plan for Subwatershed No. 19 have been formulated within the currently-enunciated framework of Provincial interests. In addition, the Provincial government has also stated its intent to vest greater decision-making responsibilities at the municipal levels and certain Provincial Ministries will be removing themselves from the development review process.

Therefore, there is the opportunity for the local municipalities within Subwatershed No. 19 to play a greater role in the implementation of this comprehensive strategy for the subwatershed, through their respective planning initiatives. Subsequent to the endorsement of the final Recommended Plan, each municipality should consider a review of its Official Plan to incorporate appropriate policies which reflect the recommendations of the Subwatershed No. 19 Study and provides a context for both long-range planning, as well as a basis for the review of specific development applications.

The suggested policy framework begins first with an overall planning goal and related objectives, for the subwatershed, appropriate for inclusion in local Official Plans:

Goals:

- To endorse the objectives of the Subwatershed No. 19 Recommended Plan as a guide to manage existing and future development, in order to protect, enhance and restore the natural environmental resources of the subwatershed.

Objectives:

- To protect, conserve, manage and enhance natural resources, including land, environmentally sensitive areas, natural areas, corridors, surface water, groundwater, floodplains, valleys, wetlands, woodlands and their linkages and significant fish and wildlife habitats.

- To integrate subwatershed planning into the municipal land use planning process.
- To achieve integrated subwatershed management through partnerships with all stakeholders within the Subwatershed No. 19 area.
- To minimize potential hazards to public safety from flooding.
- To preserve, or re-establish, natural hydrologic functions within the subwatershed in order to maintain the headwater functions of the Credit River and to ensure an ongoing supply of potable water.
- To establish consistent and "streamlined" review procedures with relevant agencies, to ensure that development proceeds in accordance with the objectives of the Subwatershed No. 19 Recommended Plan.
- To increase public awareness of the importance and values of a sustainable environment.
- To develop stewardship and other partnership initiatives which support the objectives of subwatershed management.

The table which follows (Table 8.2) provides a framework for appropriate Official Plan policies, based on the proposed measures recommended in the Subwatershed No. 19 Recommended Plan (Chapter 7, Figure 7.1).

A general description of the purpose of the policy, together with further details of specific matters to be addressed have been provided. These generic policy recommendations can then be refined for inclusion into any one of the municipal Official Plans within the subwatershed. Where relevant, the proposed Provincial Policy Statement germane to each topic is also identified. As previously noted, the prevailing Official Plan documents within Subwatershed No. 19 are diverse in their scope and content. The generic policies identified in this chart can be "tailored" to reflect each municipality's Official Plan composition, while still reflecting the intent and objectives of the Subwatershed No. 19 Recommended Plan.

8.4.4 Implementation Mechanisms

As previously noted, there are a variety of land use planning mechanisms that may assist in the implementation of the Subwatershed No. 19 Recommended Plan. Inclusion of the land use policy-related recommendations of the Subwatershed No. 19 Recommended Plan in Official Plan documents is an important first step in establishing a municipal policy framework formally adopted by the respective municipal Councils and ultimately approved by the Province. However, protection of these natural environmental resources may be further achieved through regulatory approvals processes and other planning mechanisms.

Zoning:

Natural environmental resources should be zoned in an open space, conservation or hazard lands zone category that protects the characteristics and/or functions of the area/feature by restricting the land uses to be permitted and imposing restrictions on buildings and structures (where permitted) and other standards for development. The boundaries of the Environmental Constraint Areas identified in the Subwatershed No. 19 Recommended Plan can be used as a general basis for establishing zone boundaries. However, subject to the cautionary observations noted in Section 8.4.2, these zone boundaries can be refined through a further study process, or in conjunction with the review of a specific development application.

In addition, the objectives of the Subwatershed No. 19 Recommended Plan may also be addressed through restrictions on development adjacent to a particular natural resource. Accordingly, municipalities may wish to consider identifying specific setbacks for other zone categories where they abut an open space, conservation or hazard lands zone. For instance, a typical rear yard setback for a single-detached residential zone category may be 7.5 metres. However, where such a lot abutting an open space zone associated with an Environmental Constraint Area 1, that rear yard may need to be increased to, for example, 12 metres with associated prohibitions on swimming pools or other accessory buildings/structures within a certain distance of the rear lot line.

Accordingly, zoning can implement the objectives and recommendations of the Subwatershed No. 19 Recommended Plan not only by regulating the zoning of the natural environmental resources themselves, but also by controlling activities on immediately

adjacent lands. Therefore, it is recommended that all local municipalities within the Subwatershed No. 19 area review their existing zoning by-laws with respect to: "environmental" zone categories; permitted uses and regulations; and the mapping of natural environmental resources.

Environmental Impact Studies (EIS):

An EIS is a procedure in which natural environmental resources can be more fully assessed prior to development proceeding. These studies can better define the limits of the area/resource, and any adjacent setbacks or buffers required thereto and consequently, establish the restrictions to development. An EIS may be undertaken as part of an area-specific Secondary Plan, or for a specific development proposal (where a secondary plan was not prepared or did not include an EIS to the level of detail necessary to assess the impacts of a particular land use).

It is recommended that the requirements for an EIS be incorporated into the Official Plan so that requirements for such an analysis are clearly indicated to any development proponent and this will streamline the development review process. Such EIS documents should be reviewed by the municipality, the CVC and other relevant agencies.

Development Charges:

Certain Ontario municipalities have been exploring the inclusion in their municipal Development Charges by-law, a cost factor associated with the acquisition of natural resources (such as woodlots). The factor establishes a specific price per acre for the land and enables the municipality to purchase (at this set price) the lands from a landowner.

However, at present the Provincial government has indicated its intent to conduct a comprehensive review of the Development Charges Act legislation, with a view towards limiting the scope of the costs to be included in a development charge to specific "capital costs", as opposed to "soft costs". Therefore, this approach to municipal acquisition of natural environmental resources through establishing a fund from development charges may be limited/eliminated by the results of this legislative review.

Fill Regulations/By-laws:

Regulations to prohibit the placing/dumping of fill on defined lands; regulating grading; requiring plans to be submitted; and, compelling approvals/permits (subject to conditions) to be secured can be achieved through the Conservation Authorities Act (within prescribed fill regulations areas), or through the Municipal Act[7] (by by-law). The Dufferin County has the authority to pass a tree by-law under the Trees Act.

These regulations can have significant effect in the grading and/or alterations that may effect the form or function of natural resources. Municipalities should consider the enactment of fill by-laws pursuant to the Municipal Act; particularly in the Environmental Constraint Areas as identified in the Subwatershed No. 19 Recommended Plan. Such by-laws may only be imposed on lands not otherwise subject to Conservation Authority fill regulations. These regulations also apply to control the removal of organic soils and peat for commercial reasons.

Tree Preservation:

Tree preservation regulations may be secured by either by-laws enacted pursuant to the Trees Act, or the Municipal Act.

Under the Municipal Act, those local municipalities with populations greater than 10,000 persons (ie. Towns of Caledon and Orangeville), can enact by-laws to regulate the destruction of trees in defined areas and require permits (subject to conditions) to be issued to permit tree removal. The Act also identifies situations in which the by-law does not apply (for example, highway road allowances, lands where site plan/building permits have been issued, and Christmas tree farms).

Under the Trees Act, upper tier municipalities may pass by-laws to restrict tree removal.

[7] The Provincial government has indicated its intent to review the Municipal Act; however, there are no specific indications as to whether these provisions will be amended.

Typically, such by-laws include a definition of the "areas" or "woodlots" to which the by-law would apply (ie. geographic size).

Therefore, each constituent municipality should consider the enactment of a tree preservation by-law, with particular emphasis on the significant woodlot and forestry resources identified in the Subwatershed No. 19 Recommended Plan.

However, the Townships of Mono, Amaranth and East Garafraxa do not have the legislative jurisdiction to enact such by-laws.

Topsoil By-law:

A topsoil by-law may be enacted pursuant to the Topsoil Preservation Act, which permits a municipality to regulate the removal of topsoil for defined areas; require the issuance of permit to allow topsoil removal; and, prescribe required rehabilitation measures.

Each local municipality within the Subwatershed No. 19 area should, if they have not already done so, enact a topsoil by-law with particular emphasis on the natural resources identified in the Subwatershed No. 19 Recommended Plan. Where municipalities currently have such a by-law in force, an evaluation of its operational effectiveness should be undertaken so that all departments having responsibility in the development review process (and by-law enforcement) are aware of its standards. In addition, information regarding these regulations should be made available to the general public (through the other educational efforts associated with this Plan) and specifically, to landowners in planned development areas and development proponents.

Development Guidelines:

Development proponents should be able, early in the development review and approvals process, to be able to understand the more detailed implementation measures related to specific recommendations of the Subwatershed No. 19 Recommended Plan. A manual(s) containing standards or guidelines dealing with environmental issues should be available to residents, landowners and development proponents to assist in both the ongoing

maintenance and management of lands, and to assist in the preparation of development proposals. For example, such guidelines may address specific environmental issues, such as woodland/forestry management, soil conservation practices or development design matters (such as landscaping materials, municipal standards, or stormwater management practices). These guidelines should also include a description of the content requirements for an EIS, or any other required assessment and analysis (for example, a stormwater management analysis).

The local municipalities and CVC may jointly prepare such Development Guidelines in order to achieve consistent application throughout the Subwatershed No. 19 area.

Development Bonusing:

Pursuant to the Planning Act, a municipality may provide for an increase in density or height of a development, in exchange for certain "facilities, services or other matters". In the context of the Subwatershed No. 19 Recommended Plan, bonusing may be utilized as a means to encourage the retention and preservation of natural environmental resources. In order to utilize such provisions as an "incentive" to development proponents, a municipality must first have general policies in its Official Plan indicating its intent to use development bonusing and, specify in the zoning by-law which "facilities, services or other matters" are to be achieved in return for such bonusing.

Each local municipality should review the merits of establishing Official Plan policies to establish a framework for the implementation of bonusing in the context of environmental objectives, and enact density bonusing by-laws on the basis of a site-specific zoning application associated with a specific development application.

Alternative Development Standards:

Certain development standards for public infrastructure (for example, road rights-of-way, servicing easements, boulevard widths, sight triangles) are very land extensive, in that they require substantive physical areas to accommodate the facility. Where such infrastructure

must be located within or adjacent to natural environmental resources, municipalities should consider reduced standards in order to minimize potential impacts on these areas/features.

Land Acquisition:

Public ownership and management of significant natural heritage areas/features is commonly accepted as providing the preferable opportunity for long-term preservation, management, security and public access opportunities (where appropriate). Such public ownership can be vested in a municipality or the CVC. However, financial resources for acquisition may be limited.

One means of acquisition is dedication through the development approvals process and in particular, parkland dedication pursuant to the Planning Act which permits a municipality to secure a specific percentage of land area for public park purposes. Traditionally, municipalities have sought to acquire tableland suitable for active recreational activities through the parkland dedication process. However, as an alternative, a municipality may consider acquisition of natural environmental resources through this statutory process. This option should be evaluated in the context of a municipality's overall open space, park and recreational needs to determine the appropriate municipal priorities.

Development proponents may strongly resist the dedication of both tableland and other natural environmental resources and the municipality should consider a "credit" process, wherein the calculation of tableland parkland dedication requirements is based on a "net" developable land area (i.e., the net area remaining after the other natural resources to be preserved and perhaps, transferred to public ownership) have been deducted. In some circumstances, the amount of lands deducted from the parkland calculation, provide a sufficient incentive to the development proponent while, at the same time, allowing the public to acquire a natural resource that would otherwise be unavailable.

Therefore, the municipalities and CVC should establish criteria and program for acquisition or assumption of certain lands within the Subwatershed No. 19 area, including a prioritization of the most significant properties that should be secured.

8.5 Future Studies/Initiatives

8.5.1 General

In Section 8.3, the implementation considerations for the proposed measures were described. Implementation considerations were based on existing and approved land uses. This section will discuss the study requirements and approval process should land use changes occur within the subwatershed. Triggers as to what should initiate a study will also be provided.

Figure 8.1 illustrates the proposed approval process from a land use and environmental perspective. Also provided is the agency involvement at each stage of the environmental planning process. The intent (from a regulatory perspective) is to streamline the review and approval process. This would be achieved by reducing the number of agencies involved at a given stage (e.g., Environmental Management Plan) and by limiting the number of agencies involved in the review/approval of a given task/component (e.g., review of hydrology).

The goals of the Credit River Water Management Strategy (Phases I and II) were:

- to develop a practical, comprehensive and environmentally sound management strategy for the natural environmental resources of the Credit River watershed; and
- to provide direction for subsequent subwatershed plan.

The level of detail provided is generally suitable to develop environmental goals/objectives at the Official Plan stage.

The Subwatershed No. 19 study, in turn, provides a more definitive environmental strategy of suitable detail for Growth Management Strategies, Environmental Assessments and other municipal based (e.g., Community Development) studies. This study also provides a framework for smaller tributary-based studies (see Section 7.5) should land use changes

occur.

Environmental Management Plans (EMPs) will be required in the future, should land use changes occur. The EMPs will be completed at a tributary scale, at the Secondary Plan or Official Plan amendment stage. They will generally be carried out concurrently with other studies which are necessary at this stage in the land use process, e.g., master open space, transportation, servicing and economic assessment studies. It is suggested that only the municipalities, CVC and public participate in the approval process at this phase.

The intent of the EMP is to provide sufficient detail such that, upon acceptance, relatively straightforward Stormwater Implementation Reports (reference should be made to the document entitled Stormwater Management Guidelines, CVC in cooperation with the member municipalities, December 1995) for individual plans of subdivision or sites, be required.

Approvals from only the resident municipality would be required at this phase.

A description of the component studies necessary to complete the EMP is provided in the next section. Key deliverables from the EMP will include:

- field assessments, as necessary, to better define the functions, linkages and limits of the natural environmental resources;
- a protection/restoration/enhancement strategy for the study area;
- location, sizing and preliminary design of all Best Management Practices;
- integration of the study findings and recommendations with other studies (e.g., servicing, transportation) that may be carried out concurrently; and
- framework for the compatible integration of land use, recreational and environmental requirements.

Initiation of an EMP and integration of proposed land uses with the environmental resources should, as discussed, occur at the onset of a Secondary Plan or Official Plan amendment process. An EMP should be carried out for each tributary where proposed

development of large blocks of land, a major watercourse or valleyland crossing, infringement into a sensitive area, and/or if the tributary in question has unstable or sensitive reaches that could be adversely affected by any land use change.

8.5.2 Environmental Management Plans

Outlined below is the general intent of each component that may be required as part of the Environmental Management Plan. Each component will not necessarily be required for each tributary. Further description of the necessary component studies is provided on the fact sheets for each tributary located in Appendix D.

8.5.2.1 Surface Water Resources

The intent of the Environmental Management Plan is to complete the necessary hydrologic and hydraulic analyses, and conceptual design of surface water management facilities on a tributary basis. The goal of this study is to define existing conditions, the potential impacts of land use change, and requirements for the management of the surface water resource to meet the goals, objectives and specific targets set for each tributary. Management of surface waters resources includes requirements for defining restricted land use areas or defined by flood plains, channel erosion/natural stream stability requirements, base flow and surface water quality. Presented below is a general description of the scope of work and deliverables to be completed by the study. Specific requirements for a given tributary area are provided in each of the tributary Factsheets.

The scope of work and deliverables of the surface water resource study may include, but is not limited to the following:

- Calculation of peak flow rates under existing and future land uses conditions for the purpose of defining the existing Regulatory Storm flood plain, where suitable mapping is not available, and to determine the potential impacts of land use change on existing flood elevations.

- Preparation of approved flood plain mapping to identify development

restrictions and requirements as defined by CVC's "Authority Policies on Flood Plain Management". This would be required only for those tributaries and locations where suitable flood plain mapping is not currently available, see Figure ??.

- The proposed approach to flood flow control, and the location and size of proposed flow control storage facilities to maintain existing peak flow conditions on a tributary and subwatershed basis.

- The proposed surface water management strategy for maintaining the existing surface water budget, baseflow conditions and surface water quality. This would include proposed site planning and design considerations, and locations and preliminary sizing of proposed stormwater management BMPs including source controls, conveyance systems and end of pipe facilities. Preliminary sizing of facilities should include retention (permanent pool) and detention/extended detention storage volumes to be used for infiltration, wetpond, wetland or other stormwater BMP facilities.

- The proposed approach for integrating surface water management facilities required for flood control, baseflow and water budget management, quality control and erosion control/channel stability management. Further details and requirements for flow control requirements for maintaining stable, natural channel systems is provided in Section 8.5.2.5.

- The proposed approach for integrating the tributary surface water management strategy with other proposed works and environmental management components for the tributary and Subwatershed 19.

8.5.2.2 Groundwater Resources

As previously discussed in Section 7.3 a more detailed groundwater characterization of the recharge and discharge areas, and the linkage between them has to be carried out on the tributary and reach scale to assess potential impacts and assign appropriate BMP's for

future land use changes.

The major purpose of the future studies would be to quantify in more detail, within the tributary catchment or subcatchment area, the following:

(1) the recharge;
(2) the delineation of the flow system; and
(3) the baseflow contribution.

The recharge component is the most significant hydrogeological aspect within the subwatershed when assessing land use changes that do not include groundwater withdrawal. By emulating or enhancing the quality and quantity of infiltrating water, the groundwater flow system and its linkages will be maintained.

A general range of recharge values relating to surficial geology / soil type was presented in Section 7.3. This range was used to provide a general subwatershed groundwater budget (Sections 3.4.7 and 7.3). Groundwater budgets would be carried out in more detail on the tributary catchment or subcatchment scale, utilizing a more detailed assessment of the areal distribution of surficial geology / soil type. An assessment of the recharge values must factor in vegetation and topography. As such it is still recognized that the recharge values obtained are estimates.

The assessment of recharge combined with the more local delineation of the groundwater flow system (eg locating local groundwater divides) will provide significant input into the type and location of stormwater BMP's. The local delineation of groundwater divides will involve the installation of a number of water table monitoring wells and mapping of the respective water levels.

Further delineation of the flow system may include the installation of multi-level piezometers, measurements of water levels and water quality, so as to predict the impacts from potential contaminants in cases where stormwater infiltration facilities or septic systems are proposed. A more localized and detailed understanding of the groundwater flow direction, ultimate receptor and subsurface attenuative capabilities are necessary for

contaminant impact assessment. Various existing agency policies provide more detail in this respect and are outlined in Appendix A.1 and A.2 of the Natural Heritage, Environmental Protection and Hazards Policy.

A more detailed assessment of baseflow contribution is a necessary component to a full understanding of the tributary and reach groundwater flow system, particularly from the linkage perspective. This linkage is very significant for impact assessment in dealing with groundwater withdrawals and to a much lesser extent for stormwater infiltration.

In either case an assessment of baseflow contribution is critical in an overall definition of the flow system. On a more local scale the impact from major groundwater withdrawals is far more significant than the potential for reductions in recharge given the above discussion on recharge.

The baseflow component should include but not be limited to the following assessment:

- Detailed spot streamflow measurements representing baseflow, on 50 metre reaches to indicate localized contributions and possible upwellings;

- Streambed temperature survey and spawning survey to assess potential upwellings; and

- Installation of streambed piezometers to obtain water levels in areas of high baseflow and upwellings.

This data is critical to assess the potential impacts of a major groundwater withdrawal from communal or municipal wells. In assessing the impacts, a pumping test on the proposed well would be carried out. The assessment and methodology must address the following considerations:

(1) A sufficient understanding of the groundwater / surface water flow system so that monitoring locations are strategically placed (e.g., in areas of significant baseflow or upwellings).

(2) Natural trends (e.g., precipitation and water levels) pre and post pumping are determined to put the pumping test data in a temporal perspective.

(3) Anthropogenic trends, such as changes in local pumping from existing wells is taken into account.

(4) The discharge of water during the pumping test must not affect the monitoring.

(5) Greater frequency of streamflow and water level measurements during the pumping test.

8.5.2.3 Terrestrial Resources

All Class 1 lands are protected and are therefore not developable.

For any land use change proposed within 50 m of Class 1 areas (or 120 m of a Class 1-3 wetland) or within any Class 2 areas, an Environmental Impact Statement (EIS) is required. The EIS will describe the physical form and function of the ecological features of the area, any functional relationships to adjacent Class 1 areas, and demonstrate how the proposed development will maintain or compensate for the area's existing ecological/hydrological functions. The EIS should include:

- a description and rationale for the development proposal showing building envelopes, property boundaries, open spaces and utility corridors;
- maps illustrating the existing environmental features/communities within and adjacent to the study area, landownership, land use zoning and existing/approved landownership;
- a description of the physical form (species, size, state of maturity) and ecological/hydrological function of the area's environmental features, and a summary of the features/functions which may be affected by the development proposal in/adjacent to the area or downstream;
- a description of any alternatives which would offset any impacts by

maintaining/ enhancing/restoring the area's hydrological/ecological function either on- or off-site (including replacing the area's function with an equivalent function);

- a comparative evaluation of management alternatives based on environmental merits, of each alternative, leading to a preferred alternative; and
- a summary of the expected impacts, recommended mitigative measures and suggested environmental monitoring.

The recommended plan identifies the need to prepare naturalization plans for Class 1 areas and areas targeted for stewardship plans (Class 3, in part). These naturalization plans represent a revegetation and natural area management plan for each ecological unit, which could be implemented on a property-by-property basis. A naturalization plan should include the following:

- a detailed inventory and map of existing natural features showing vegetation communities present, areas which are naturally regenerating, areas which are disturbed by existing land uses, forest management, agriculture or invasion of non-native species;
- a map showing soil types, general terrain/topographic characteristics, drainage features, floodplains;
- a list of native species common to each vegetation community; and
- a vegetation management plan identifying areas to be replanted and appropriate species, areas which should be allowed to revegetate naturally, and areas which may require special actions in order to accomplish the following:
  - maintain habitat for a unique species,
  - remove/reduce non-native species, and
  - encourage natural processes to be self-sustaining.

Examples of some typical vegetation communities suited to a range of soils and soil moisture types was provided in Chapter 7.0.

8.5.2.4 Aquatic Resources

There are two general types of studies necessary for Levels 1 and 2 streams:

- the development of natural channel designs to restore stream stability as discussed in Section 8.5.2.5, and
- revegetation plans within the riparian zone along each streambank.

For the purposes of stream protection and habitat enhancement, the riparian zone should consist of about 50% woody species (trees and shrubs) to provide stream shading, a local cool microclimate, intercept precipitation and create wildlife habitat. The canopy created should be partly open, allowing a groundcover of grasses and forbes to develop which intercepts sediment in runoff and contributes terrestrial vegetation and insects to the stream. Where conditions (soil type and moisture) are suitable, species typical of coniferous or broadleaved swamps (as outlined in Section 7.0) may also be suitable for planting. Creating a species mix with at least 50% woody species also will provide a supply of woody debris to the stream, an important fish habitat element.

8.5.2.5 Stream and Valley Morphology Study

The intent of this study is complete the necessary investigations and analyses required to define development restrictions and measures required to maintain stable, natural channel systems and to protect properties from natural stream and valley erosion processes in areas where land use changes are proposed. In areas where land use changes have already occurred and stream stabilization works are recommended these studies may not require identification of development restrictions. With respect to the stream corridors, the goal is to maintain, and in some locations restore and enhance, channel systems to either their existing or previous state of natural channel stability as defined by the specific Subwatershed No. 19 goals and objectives and tributary targets. With respect to valley systems, the goal is to restrict development to acceptable limits for the protection of private and public properties from the natural erosion of valley slopes and migration of channel systems.

Management requirements may include the definition of the top of bank (between valley and tableland), set backs or buffers from the top of bank, fill limits, floodplain widths, set-

backs required for maintaining channel migration in undefined valley systems, BMPs required to maintain channel stability, and the possible need for instream works.

The scope of work and deliverables of the steam morphology and valley studies may include but are not limited to the following:

- Completion of a supplementary geomorphic field survey which builds upon the base line information obtained in the Subwatershed No. 19 study. This includes assessments of both the channel and valley systems (see Appendix A.6).

- Determination of the critical geomorphic threshold or the ability of a channel to absorb or resist change.

- Determination of the valley and stream corridor boundaries, as defined by the CVC "Watercourse and Valley Land Protection Policies" for defined and undefined valley systems, to maintain the dynamics of naturally stable streams and to protect against the natural erosion/widening of valleys.

- Selection of possible retention and/or detention BMP techniques to control channel stability to erosion targets as defined by the tributary Factsheets, field surveys and technical analyses of the critical geomorphic threshold.

- Preliminary design of proposed instream works.

8.5.2.6 Headwater Tributary Assessment

When development is proposed on lands within headwaters, the conveyance of flows may be dealt with as a function of subdivision design without necessarily maintaining a natural channel. The natural channel should be maintained if it has any of the following characteristics:

- a continuous baseflow;
- a source of food production for aquatic resources;

- a well-defined valley;
- native woody or wetland vegetation; or
- fish spawning/nursery habitat (Level 1).

A site inventory of each drainage feature should be completed to identify whether the feature should be maintained, based on the above criteria, or allowed to be incorporated into development plans. In either case, the functions of the feature in contributing to the quality and quantity of downstream reaches will be maintained/enhanced/restored.

8.5.2.7 Preparation of an Environmental Management Plan

- The tasks as described in Sections 8.5.2.1 through 8.5.2.6 will provide the basis for the Environmental Management Plan.

The EMP, in a general sense, would define/provide:

- a summary of the technical findings/recommendations;
- appropriate boundaries of areas to be protected, e.g., stream corridors, woodlots, wetlands;
- preliminary design of restoration/enhancement measures, e.g., proposed cross-section of terrestrial/aquatic/recreational corridor; and
- location, sizing and preliminary design of all Best Management Practices.

As importantly, the report would be used in conjunction with other studies (e.g., servicing, transportation, master open space) at the Secondary Plan or Official Plan amendment stage to ensure that land use and environmental requirements have been considered in a cooperative manner. This, for example, could include the placing of passive land uses (e.g., parks, schools) adjacent to sensitive environmental features, the planning/design of corridors such that recreational and environmental requirements are met and the siting of stormwater management facilities in a manner that is consistent with educational, recreational and economic considerations.

The EMP should also discuss phasing of proposed Best Management Practices, cost

sharing arrangements, and operation and maintenance requirements.

The level of detail, particularly with respect to the pre-design of restoration/enhancement measures and Best Management Practices should be sufficient that all subsequent works can be carried out at a draft plan or site plan level.

8.5.3 Stormwater Management Report

A stormwater management report (SWMR) will be required for each plan of subdivision or site plan. This report will generally accompany the submission of detail engineering drawings. The primary intent of this report will be to provide the appropriate details, at a draft or site plan level, to ensure that the recommendations, as provided in the EMP, have been carried out. Further details with respect to the requirements of a SWMR are provided in Stormwater Management Guidelines Credit Valley Conservation, May 1996.

8.5.4 General Studies

Over time, a variety of studies, e.g., municipal servicing, transportation, master open space, environmental assessment, will be undertaken within the Subwatershed. This study provides both baseline information relating to *existing* natural environmental resources as well as a framework for the protection, enhancement and restoration of *existing* and *potential* natural environmental resources.

In order to ensure that the resources are protected, proponents of future studies should therefore:

- critically review and assess each general alternative and summarize the impacts (positive and negative) of each alternative on the natural environmental resources; and
- for the preferred alternative, provide site specific information with respect to environmental inventory construction techniques, use of appropriate materials, restoration plans and associated monitoring to ensure that restoration is successful.

8.5.5 Groundwater Management Strategy

Sections 7.3, 3.4.7 and 3.4.8 outlined the hydrogeologic sensitivity with respect to groundwater withdrawal and the potential for baseflow impacts. The impact from historical pumping of well field 5/5A has had on the north tributary of Mill Creek is directly evident in the complete cessation of flow in this reach. This impact is addressed directly through the replacement of Wells 5/5A or a significant reduction in pumping.

The current or potential impacts of the other major existing wells (e.g., Well No.'s 2, 3, 4, 6, 8 Cardinal Woods, Purple Hills, Coles) were not determined in detail within the scope of this study.

A groundwater management plan should be developed which maximizes the pumping rates in the existing wells while preventing unacceptable existing or potential baseflow impacts.

The assessment of baseflow impacts can be carried out by the monitoring of water levels in water table wells in the vicinity of the well in question, water levels in streambed piezometers and stream flows in adjacent reaches. This data would be collected prior to, during and after the shutdown of the pump(s) (e.g., recover test) in the well field being assessed. Each well should be tested without a major change in pumping in nearby wells. The data must be assessed by taking into account precipitation. Ideally, average precipitation should occur over the duration of the monitoring. The tests would likely warrant the installation of streambed piezometers and flow monitoring stations (e.g., temporary weirs) and possibly some shallow water table wells.

The overall fine tuning of pumping rates would take into account the sensitivity of the potential baseflow impact (e.g., volumetric baseflow vs. spawning upwellings) and the potential for seasonal variations in pumping.

The recovery test should also provide a preliminary assessment of the potential interference in adjacent wells in the event the pumping rates in the existing wells can be increased. An increase in a pumping rate beyond the current permitted value may require an additional

pumping test as required by the MOEE.

In the event the overall pumping rate in the existing wells has to be reduced due to assessed, unacceptable impacts or in the event additional water takings, beyond the current takings, are required for currently approved or future development than, future water supplies should be explored. High capacity water supplies, given the potential baseflow impacts, have a reduced potential in the western portion of the subwatershed along the Caledon tributaries and the main branch of the Credit between the Highway 10 crossings. This does not rule out future water supplies in these areas, it just may be the case that the exact locations, depths and pumping rates are restricted. Areas that have potential aquifers that are less sensitive to baseflow impacts include the northeast quadrant of the subwatershed and the south central portion. The first phase of a study for additional groundwater supplies should include but not be limited to the following:

- detailed assessment of existing hydrogeological studies; and
- test drilling and pumping tests.

A contaminant sources inventory should be carried out to document the existing and potential sources for groundwater contamination in order to protect the high quality groundwater resources within the watershed and prevent the costs associated with groundwater clean-up and well replacement. This study is basically a paper survey of the following types of records for potential point source contamination:

- existing land uses (e.g., gas station, etc.);
- local archives on previous land uses;
- local archives on spills, complaints, etc., and
- MOEE files, etc.

Non-point source contamination can be inventoried based on a more general land use survey (e.g., type of agriculture, developments with private septic systems).

The study would assess the potential contaminant materials (e.g., petroleum products, pesticides, septic effluent, etc.), consider their characteristics such as toxicity, mobility, etc.

in relation to the hydrogeological setting (e.g., location in groundwater flow system, subsurface attenuative capability, etc.) and prioritize the risk or potential for groundwater contamination.

Based on the above assessment, recommendations can be made regarding the following proactive measures:

- installation of early warning monitoring;
- Emergency Spills Response Program; and
- consideration for the exclusion of future land uses in sensitive hydrogeologic settings.

8.6 Education/Stewardship

A majority of the lands within the subwatershed are privately owned. Furthermore, many of the proposed measures outlined as part of the Recommended Plan would be undertaken on private lands. Success of this plan will therefore depend on the support and buy in of the individual landowners. This will involve an education process whereby the importance of the existing natural environmental resources on a landowners property are clearly explained as are the proposed benefits of undertaking a specific measure (e.g., reforestation) on their lands. It will also require targeted programs which involve private landowners in conservation through voluntary choice (i.e., stewardship).

Several stewardship programs (e.g., reforestation, stream restoration, habitat enhancement) have been undertaken within this subwatershed. It is recommended that a committee be established to oversee stewardship programs which will build on those already underway. In this regard, a stewardship committee should be formed. The committee should be comprised of agency staff, special interest groups and the public.

The objectives of the committee would be to:

- oversee the proposed stewardship program;
- develop guidelines (e.g., woodland conservation, valleyland naturalization) for

the protection, restoration and enhancement of the natural environmental resources on private property; and

- develop a stewardship manual.

Further discussion of each of the items is provided below.

Stewardship Program

Several approaches for the development of a stewardship program do exist. The general approach, as outlined below, has been based on discussions with the Steering Committee and Public Advisory Group. Existing programs within Canada were also reviewed (reference, B.C., Hilts, Caroline Mach, Hamilton CA). The approach, as recommended, is based on the following points:

- a joint agency/community partnership will be essential in developing community support programs for encouraging private stewardship;
- education is important, i.e., most landowners are very interested in obtaining more information on their land to inform them why their land is important (i.e., presence of significant habitat, functions of woodlots) and how they might better manage their lands;
- straightforward, voluntary agreements with landowners are the easiest to obtain;
- acknowledgements of good stewardship efforts, through the issuance of plaques, certificates are beneficial;
- the importance of gaining landowner trust and using this opportunity to develop long term partnerships to improve land stewardship cannot be underestimated; and
- successful stewardship programs require "one-window" stewardship offices which serve as the contact point for local landowners (otherwise, landowners are more likely to become confused and disinterested).

The following general approach for undertaking a stewardship program is recommended.

- **initiate landowner contact via letter**; a description of the stewardship

committee's role should be provided as should an overview as to the types of projects which could be undertaken;

- **phone call and follow up**;
- **site visit of property**; aerial photos and maps of the property could be used to provide information relating to known environmental resources and their importance as well as potential projects. A copy of the stewardship manual (see below) could be left with the landowner;
- **request for guidance and support of landowner**; landowner input, e.g., existing/proposed uses of land, preferences for types of conservation projects should be received; support, in principle, for development of conservation measures on the property would also be provided by the landowner;
- **enter into verbal agreement**; a verbal agreement, to undertake certain conservation measures would be received; participation by agencies, volunteer groups, landowners in undertaking proposed measures would also be discussed;
- **inventory of property**; a more detailed inventory of the property, in order to best establish the types of conservation measures which are appropriate, would be undertaken;
- **undertaking of conservation measures**; the proposed conservation measures, as discussed and agreed to by the landowner and committee member, would be undertaken; and
- **follow-up meetings**; meetings, as required, to ensure the proposed measures were successful and to update the landowner should be held; plaques/certificates acknowledging that the landowner is a "friend of nature" could also be provided.

Guidelines

The committee could prepare guidelines which relate to the stewardship program. Topics to be addressed could include:

- the form of the stewardship agreement, e.g., if reforestation of the property is undertaken, what type of agreement would be required to ensure that the lands remain in a natural state;

- development of policy related to private land ownership and stewardship, i.e., the development of woodlot conservation policy, naturalization guidelines; and
- land ownership, ensuring that the requirements/rights of the individual landowner and general public are met.

Stewardship Manual

The development of a stewardship manual outlining actions which are typically the focus of a stewardship program should be undertaken. Typical measures include:

- rural Best Management Practices, in particular, practices which reduce overland sediment delivery to streams and which take environmentally sensitive lands out of production;
- reforestation programs to revegetate valleylands and streamsides, naturalize idle lands or provide linkages (terrestrial corridors) between natural areas;
- stream rehabilitation and aquatic habitat enhancement including creation of wetlands;
- other types of habitat creation or natural area planning; and
- recreational trail development.

A review of existing stewardship programs found that successful stewardship programs require "one-window" stewardship offices which serve as the contact point for local landowners - otherwise, landowners are more likely to become confused and disinterested. Presently, three different agencies, i.e., the municipalities, Conservation Authority and Ontario Ministry of Natural Resources provide stewardship programs. It is recommended that the Credit Valley Conservation undertake the role as lead proponent for stewardship, as:

- CVC have already undertaken conservation plans for various landowners; and
- many of the stewardship initiatives will require and understanding of environmental benefits (or impacts) on a watershed basis.

Funding for stewardship programs will ultimately be worked out by the committee.

Funding from the following should be considered:

- agencies/municipalities (monetary, or services in kind);
- endowments;
- special interest groups;
- corporations;
- environmental foundations; and
- other sources (e.g., reinvest funds that are currently collected for fishing licences).

8.7 Environmental Monitoring

8.7.1 General

Development of an environmental monitoring program is required to ensure that the study goal and environmental targets are achieved. Development of the program must be responsive to several items including:

- the environmental resources to be monitored;
- available funding;
- staffing;
- availability of volunteer groups;
- existing monitoring databases;
- proposed measures to be undertaken; and
- rate of change of development within the subwatershed.

Provided in this section is the proposed monitoring program. The primary objectives of the monitoring program are to:

- evaluate the effectiveness of the measures as described in Chapter 7 in order to protect, enhance and restore the natural environmental resources; and
- establish the impacts of potential land use changes and ensure that the environmental targets (Section 7.5) for each tributary and the subwatershed as a

whole, are met.

It should be noted that in order to meet each of these objectives, a different type of monitoring program may be required. For example, monitoring the effectiveness of stream restoration works to restore a coldwater fishery may entail localized monitoring along the stream reach which was restored and may be focused primarily on indicators which impact aquatic resources. Conversely, monitoring the impact of proposed development would require that a range of indicators be selected and may require that different scales (e.g., local, tributary and subwatershed) be used.

The primary focus of the monitoring program will be to evaluate the effectiveness of the proposed measures which are proposed to protect, enhance and restore the natural environmental resources. The reasons for this focus are as follows:

- The premise of the study was to use existing and approved land uses as a basis. As such, it is not known whether land use changes will occur, or the extent and location, should changes occur.

- An approach which involves defining environmental resources, outlining future study requirements and setting of environmental targets has been provided (Section 7.5 and Appendix A.6). This approach, together with what has been provided below, could be used as a basis for establishing a monitoring program should land use changes occur.

As stated in Section 8.2, it is recommended that an Environmental Monitoring Committee be established to initiate and oversee the proposed monitoring program. The committee would be comprised of municipal staff, CVC staff and members of the public. It is recommended that CVC act as the facilitator as they currently have in-house staff to oversee the program and much of the monitoring will be carried throughout the subwatershed.

It is also recommended that, where possible, volunteer groups, individual landowners or

local residents participate in the monitoring program. This is consistent with the stewardship approach as outlined in Section 8.6 and will be cost effective. Training of individuals or groups will be necessary to ensure reliability of the results.

The proposed monitoring components are outlined below. For the purpose of discussing monitoring each of the natural environmental resources, the following components have been used:

- surface water quantity (Section 8.7.2);
- groundwater (Section 8.7.3);
- surface water quality (Section 8.7.4);
- fluvial geomorphology (Section 8.7.5);
- terrestrial resources (Section 8.7.6); and
- aquatic resources (Section 8.7.7).

Environmental monitoring generally requires defining baseline conditions from which change or effectiveness can be monitored.

It should be noted that, with the exception of surface water and terrestrial resources, suitable baseline information exists (either through this study or ongoing monitoring efforts, e.g., WSC, PWQMN). Additional monitoring of surface water flows to establish baseline conditions is recommended. Further enhancement of the terrestrial resource inventory through field surveys is required to fully define environmental baseline conditions.

8.7.2 Surface Water Quantity

The monitoring of the water budget (e.g., peak flows, flow volumes and baseflows) is an integral component of the program as many items (e.g., flooding, erosion, aquatics, terrestrial and surface water/groundwater interactions) rely on accurate assessments of flows being attained.

There is currently only one flow gauge (located at Melville Pond) which provides

continuous flow results. It is recommended that flow monitoring at two additional sites be undertaken. The monitoring locations would vary (likely on annual basis) and information would be used as input to establishing baseline conditions and monitoring effectiveness of various measures as they are undertaken.

Initially, monitoring could be undertaken at the downstream limits of Mill and Monora Creeks. Monitoring over the past two years was carried out in an effort to better define peak flows and thus ascertain the frequency and severity at the five flood damage centres. Further information is required. Monitoring at these sites could also be used to help assess potential impacts associated with pending developments in the headwaters of these two tributaries.

The estimated cost to purchase two level recorders and one portable velocity meter (to establish stage/flow curves) is approximately $10,000. Monitoring could be undertaken by agency staff or by volunteer groups.

8.7.3 Groundwater

The major components of a groundwater monitoring program include:

- regular water level monitoring in the pumping wells, observation wells and streambed piezometers;
- pumping volumes in all municipal and communal wells;
- water quality monitoring in pumping wells, selected observation wells and selected low flow baseflow grab samples; and
- spot flow baseflow measurements in select reaches.

Some of the components of this monitoring program may overlap with the finalized surface water quantity and surface water quality monitoring program.

The current Town of Orangeville water level monitoring program is quite extensive and covers all the municipal wells including the newly installed MacArthur Well. The Cardinal Woods well, the Coles well and the Purple Hill Wells should be included. The

current water level monitoring program for monitoring wells is quite extensive and includes a substantial number of wells added on recent permits. At some future point the permits should be reviewed to reduce some of the more extensive monitoring programs that were recently, or are about to be set. Multi-level monitoring well SW19 should be included in the regular water level monitoring program.

A limited water level monitoring program could be developed utilizing streambed piezometers. This monitoring program should be developed, to a greater extent, in conjunction with and utilizing instrumentation incorporated in the Groundwater Management Plan (Section 8.3.2). A regular streambed piezometer monitoring program is limited by the susceptibility of a streambed piezometer to be destroyed. The frequency of all water level measurements, as a minimum, should be seasonal.

Water quality samples are currently being obtained from the pumping wells and should continue. In addition monitoring well SW19 should be sampled. Water quality analyses should include as a minimum, inorganic species, metal species and nitrogen species.

The location of spot flow baseflow measurements should be done in conjunction with the Groundwater Management Plan but, in the current absence of the Plan, strategic locations coincide with reaches that show substantive baseflow including Upper Monora Creek, Lower Monora Creek (eg. both tributaries) the Upper reach of Mill Creek including the main branch and the north tributary, the Caledon Tributaries and the upper reach of the Eastern Tributary. Spot baseflow measurements should be taken during a low flow period (eg. June - September), no less than 2-3 days subsequent to a precipitation event. An attempt should be made to gather all data within a 2-3 day window. These same reaches could be sampled for water quality (inorganic species, metals, nitrogen species) at the same time as the spot flow measurements.

8.7.4 Surface Water Quality

Surface water quality was generally not found to be a limiting factor to environmental health. Furthermore, the existing PWQMN and the sampling that is carried out as part of

the Certificate of Approval for the Town of Orangeville STP is more than adequate to define water quality conditions. As such, additional monitoring efforts under existing conditions are not required unless existing monitoring practices are discontinued. Should this occur, limited water quality monitoring could be undertaken, or, the collection of water quality samples could be replaced by biological indicators (e.g., benthic invertebrates). Monitoring protocol and assessment would be required should land use changes occur, or if infrastructure (e.g., STP expansion) changes occurred. In this regard, the report, particularly through the Fact Sheets, outlines environmental targets to be met in order to protect, enhance or restore the natural environmental resources.

8.7.5 Fluvial Geomorphology

Stream morphology is dependent on the ability of the stream to convey the water and sediment inputs from upland regions. Changes in water discharge, sediment discharge bed and bank material may cause adjustments of width, depth slope, velocity and planform. By monitoring changes in these variables the effectiveness of the measures described in chapter 7 to protect, enhance and restore the channel system can be evaluated.

Periodic sampling of stream morphology should be conducted to detect improvements in the stream stability and diversity. At-a-station information should be collected at the five detailed survey stations used to establish baseline conditions for this study. The data collected through these surveys (see Appendix A.6, Fluvial Geomorphologic Section for Details) should include:

- the longitudinal profile;
- cross-sectional profiles;
- the planform; and
- particle size distribution of substrate.

Downstream trends and the nature of the remediation project upstream of the survey sites can be collected using a video camera by interest groups. The purpose of this video survey is to document localized impacts not detectable at the five detailed monitoring sites.

Analysis of the video tapes would require a qualitative assessment of changes in stream morphology to document localized impacts/improvements and downstream trends.

Monitoring on a subwatershed scale can be done in association with the fisheries survey on a five year sampling frequency. The purpose of this survey is to continue monitoring baseline conditions. This period is considered short enough to detect long term trends in morphological adjustment and long enough to reduce unnecessary surveying effort. The five baseline survey stations should be surveyed in detail and video taped. Video tape of the additional 15 survey stations proposed for fisheries monitoring should also be conducted (Section 8.7.7).

More frequent monitoring is appropriate when specific works are undertaken such as stream restoration, riparian plantings and pond retrofits. Morphological changes can occur more quickly after such measures are imposed and should be monitored after the spring freshet for the first two years and fifth year after the project is completed. A detailed survey site should be established at the site of the remedial measures such that changes in the stream morphological diversity can be monitored. Video footage of the project site and areas upstream and downstream where impacts/improvements are anticipated. Sampling frequencies can be lengthened to five years if the rate of change decreases.

The continued monitoring of baseline conditions could be undertaken by students and take approximately three days for the detailed survey (5 stations at $75/station by students or $4000 for a professional engineering survey) and one week for the video survey (5 days at $150 a day by students). Motoring of remedial sites would take 2 days for the detailed survey and video survey (2 days at 150/day). Analysis of the detailed survey data, the video tapes and the historical data will require a moderate level of training and may be accomplished through undergraduate level research (free if completed for an honours thesis or $6000 professionally).

8.7.6 Terrestrial Resources

Out of more than 150 vegetation features identified as part of the terrestrial system, only eight occupy an area in excess of 36 ha, and five of these are represented by the three

ESAs, Monora Park and the Dufferin Anglers and Hunters lands. The majority of the remaining features are associated with stream and valley corridors, wetlands and plantations. Features consisting of remnant upland forests represent a minor component of the existing system. In addition, there are many areas which are naturally regenerating since their former use has been abandoned or discontinued. These areas were not field inventoried as part of the subwatershed study.

Before a monitoring program to assess the effectiveness of subwatershed plan recommendations can be undertaken, a systematic inventory of the smaller remnant features and the regenerating lands is required. This inventory would focus on a community level assessment and an accurate identification of the boundaries of existing features in order to prepare an accurate baseline. Since this inventory could not be completed without landowner permission, this would be one of the first steps in the stewardship program.

The terrestrial system of Subwatershed No. 19 forms a link in an inter-regional terrestrial system that includes the Hockley Valley and Niagara Escarpment to the northeast, the Forks of the Credit area to the south and important links to the west (Caledon Lakes Forest ESA) and west (Rosehill Swamp ESA - Speersville wetland). Environmental monitoring will focus on how well the protection/enhancement/restoration measures in the subwatershed establish these linkages. Monitoring will also link into other monitoring efforts such as the proposed cumulative effects monitoring program for the Niagara Escarpment (1995).

Monitoring will focus on collecting and interpreting information at two scales: the subwatershed scale and the plot or property level scale. The frequency of this monitoring effort should be, on average, every five years. At the subwatershed scale, there is an opportunity to take advantage of remote sensing satellite imagery which is readily available on an annual basis. Although resolution varies, the imagery can differentiate between areas in the order of 30 m x 30 m or 0.09 ha. With limited groundtruthing, major vegetation types and different land uses can be differentiated. This information can be used in a GIS system to provide the following information:

- the total area covered by natural vegetation and plantations;
- the size distribution of individual features, e.g., number of features <3 ha, 3 to 10 ha, 10 to 40 ha, >40 ha;
- the proportion of vegetation in major community types, e.g., wetland, upland broadleaf forest, mixed/coniferous forest; and
- the number of features with interior forest conditions, e.g., features with an area of at least 40 ha and an edge to area ratio of less than 5:1.

Most municipalities have GIS systems and can readily undertake this type of analysis, (e.g., Region of Peel, CVC, is doing this type of work in support of Subwatershed 15). Other subwatershed scale information to be collected could include:

- number of lands revegetated;
- number of lands retired from agricultural use; and
- number of landowners participating in stewardship programs.

At the plot or property level, volunteers (including landowners) could be used to undertake simplified terrestrial inventories of a number of vegetation features representing different community types. Community types might include:

- an old field/meadow community;
- a non-treed wetland;
- a treed wetland;
- a bottomland/slope forest;
- an upland forest; and
- a forest with forest interior habitat (>40 ha).

On a five-year interval, a standardized transect in each community type would be walked in each season, and the characteristics/species of vegetation and wildlife would be recorded. Information to be recorded could include:

- species lists of vegetation and wildlife;
- size/distribution of unique vegetation;

- presence of forest interior species;
- age/succession stage of vegetation;
- vertical structure development, e.g., coverage by canopy/understorey/ground cover;
- condition of soil/litter layer - poorly/well developed; and
- presence of specialized habitats/habitat diversity, e.g., dead trees for hole ....., brush piles/fallen logs, etc.

Representative photographs and audio recording could also be taken as a permanent record of each site inventory.

8.7.7 Aquatic Resources

Fish and aquatic invertebrates are a product of the environment in which they live. In other words, the health, abundance and diversity of aquatic life in a stream is influenced by a number of factors, namely:

- streamflow characteristics, particularly baseflow;
- water quality conditions, particularly oxygen and temperature;
- riparian vegetation;
- stream morphology and sediment regime (i.e., stability);
- in-stream habitat diversity; and
- biological interactions.

Periodic sampling of fish and aquatic invertebrates can serve as an inexpensive indicator of the condition of streams and provide information on what specific components of habitat may be limiting or degrading the stream environment. They serve equally well as an indicator of improvements in the stream environment. Benthic invertebrates, because they are unable to move out of an area (like fish), are often better indicators of water quality degradation. On the other hand, fish are an indicator of a larger portion of the stream environment because individuals use more stream area than benthic invertebrates. Fish also are at the top of the aquatic food chain and thus reflect any potential contaminants

which may become toxic through bioaccumulation or pose a threat to human health. Table 3.17, which was originally presented in Section 3.0, describe the species associations typical of four stream habitat conditions in the watercourses of Subwatershed No. 19.

Monitoring of streams can also be undertaken at a subwatershed and a tributary scale. The frequency of monitoring should be in the order of five years; however, more frequent monitoring is appropriate when specific works are undertaken such as stream restoration, riparian plantings and pond retrofits.

At the subwatershed scale, monitoring could include:

- number of metres of stream restoration;
- number of metres of riparian plantings;
- number of metres of streamside fencing to control livestock; and
- number of on-line ponds retrofitted.

In addition, a subwatershed-wide fish and benthic invertebrate survey should also be undertaken on a five-year basis. This could be a cooperative effort and employ several crews of summer students to undertake surveys in several subwatersheds. Based on work by MNR (Steinfield, pers. comm.), a two-person crew can complete two stations per day at a cost of about $15,000 for 20 weeks or $75.00 per stations. About 20 stations would need to be sampled within Subwatershed No. 19.

On a tributary basis, volunteers could undertake simple surveys on representative reaches on five-year intervals. Representative reaches would be about 100 to 150 m in length, and the following information would be collected in each of three seasons:

- stream temperature (particularly summer maximum temperature);
- observations of fish spawning sites (particularly brook trout);
- estimates of streamflow (particularly low flow);
- stream width and depth;
- number of riffles and condition (particle size, presence of silt/algae/aquatic plants);

- average particle size of substrate (pebble count);
- percent stream shaded by trees/shrubs;
- percent of in-stream cover (large boulders, logs, undercut banks); and
- observations of fish and benthic invertebrates (use of dipnet or minnow seine).

Photographs could be taken at reference locations to illustrate changes in stream condition.

The location of the representative reaches should coincide with stream morphology monitoring sites. One reference location should be established on each tributary and on the Credit River.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Outlined below are the conclusions from this study.

1. The study goal is defined as

   "to identify natural environmental resources and to establish appropriate strategies for the protection, enhancement and restoration of these important features under present conditions and as land use changes occur."

   In this regard, a majority of the work for this study has been undertaken using existing and approved land uses[1] as a basis. In all cases, however, a framework has been developed for addressing future land use changes and measures to protect, enhance and restore the natural environmental resources should the land use changes occur.

2. In general, the environmental health of Subwatershed No. 19 is quite good. Existing resources include:

   - considerable groundwater recharge and discharge;
   - high quality surface water which is not limiting to environmental health;
   - strong linkage between woodlots/wetlands, high recharge areas and coldwater fisheries;
   - stable streams; and
   - a moderate level of terrestrial resources, including three woodlots and three Environmental Significant Areas which provide habitat for plants and animals and serve a significant recharge function.

[1] Approved land uses include all lands designated in the existing Official Plans of the constituent municipalities which are not yet developed.

3. There are several constraints which presently limit present or potential environmental health. These include:

- lack of a contiguous terrestrial system capable of supporting abundant and diverse plant and animal life which are native to this area;
- localized potential for property damage due to flooding;
- localized stream degradation; and
- localized impacts attributable to existing wells.

4. A public participation process involving meetings with local interest groups, formation of a Public Advisory Group and two Public Meetings/Open Houses were held. Key impacts may be summarized as follows:

- the most important natural environmental resource is the groundwater supply, followed by terrestrial resources, aquatic resources and water quality;
- the public were primarily interested in the development/implementation of:
  - a groundwater management plan;
  - naturalization plans for valleyland and upland corridors;
  - restoration of streams; and
  - development of a recreational trail system;
- the public showed an equal interest in participating in community awareness (e.g., stream clean-up days) and special projects (e.g., tree planting, stream restoration works); and
- there was a significant preference for an ecologic level involving restoration and enhancement.

5. Two alternative ecologic levels were presented. The first essentially maintained existing environmental health while the second involved measures to enhance/restore the environment thereby improving, in the long term, the present and potential environmental health. The second level was selected as the recommended alternative as:

- this alternative, with the appropriate mechanisms as well as public support, is implementable;
- there was general consensus by all groups that environmental health of the subwatershed is very important and that restoration/enhancement of the natural environmental resources, is desired; and

- the restoration/enhancement alternative, as presented meets the requirements, objectives and goals as expressed by the various stakeholders within the subwatershed.

6. The key measures to be undertaken (see Chapter 7 for details) include:

   - protection of the existing groundwater regime; through the implementation of a subwatershed wide Groundwater Management Strategy;
   - restoration of a fragmented terrestrial system to a level capable of supporting abundant and diverse plant and animal species as well as increase groundwater recharge;
   - restoration of stream reaches which presently limit aquatic health and degrade water quality;
   - protection of buildings located within two flood damage centres; and
   - integration of environmental requirements with recreational needs.

7. A streamlined approval process for future development is proposed (Section 8.5.1). A series of fact sheets which summarize, on a tributary by tributary basis the environmental resources, environmental protection targets, key best management practices and future studies requirements are also provided. Lastly, implementation mechanisms that address potential land use changes are discussed.

8. An implementation plan which builds on existing stewardship efforts and requires a commitment from municipalities and the CVC to support protection/enhancement and restoration initiatives is presented. In summary, the implementation plan includes:

   - direction for administration of the plan;
   - implementation considerations for each of the proposed measures;
   - land use planning considerations;
   - direction for future studies relating to land use change;
   - direction for continuing and intensifying stewardship efforts; and
   - a framework for environmental monitoring.

   It should be noted this document provides a starting point for implementing the Recommended Plan. Further efforts by the public sector, special interest groups and individual landowners will be required to ensure the plan's success.

9.2 Recommendations

The recommendations necessary to protect, enhance and restore the natural environmental resources of Subwatershed No. 19 and, to a lesser degree, the Credit River as a whole (approximately 60 percent of the baseflow in the Credit River originates from headwater areas of the Credit) are as follows.

1. An Implementation Committee to deal with

   - plan implementation;
   - stewardship;
   - environmental monitoring; and
   - restoration and retrofitting.

   should be formed. The composition of the committee should include representation from member municipalities, the CVC, special interest groups and members of the public.

   One of the tasks of the committee would be to pursue alternative sources of funding.

2. The measures as outlined in Chapter 7 and Section 8.3 should be implemented. Several measures (see Tables 8.1.a through 8.1.l) are necessary to protect existing resources and should therefore be implemented in the near term. Others will require a longer term (up to 30 years) to complete.

3. This report has presented a classification system (Section 7.4) for the protection, enhancement and restoration of the natural environmental resources.

   Class 1 areas are the fundamental building blocks which provide core natural areas and contribute the most to the biodiversity and integrity of the area. They may also have a significant hydrologic, specifically groundwater function. These areas must be protected from land use impacts.

   Class 2 areas provide important secondary benefits in terms of wildlife habitat, linkages to the Class 1 areas, and act as seed sources or nuclei from which

revegetation efforts can build upon. Class 2 areas should be protected through stewardship programs, however if land use change is proposed, these areas should be protected or replaced with equivalent features depending on the results of more detailed evaluation.

Class 3 areas represent priorities for revegetation in a stewardship context or degraded streams which may be enhanced should development occur.

4. A process for incorporating the proposed classification system into Municipal Documents is described in Section 8.4. The process, which includes incorporation of the proposed classification system into municipal Official Plans and the description of mechanisms to be implemented at other phases of the land use process is described in a general sense as the present status of Municipal Documents varies considerably. Some of the key recommendations include:

- endorsement (within six months) of the Subwatershed Recommended Plan as:
  - the guiding subwatershed planning framework document by each local municipality, the Regional Municipality of Peel, and the CVC; and
  - as the basis for proceeding with future planning initiatives, as well as in the development review process; and
- the constituent municipalities should move expeditiously to review their respective Official Plan documents and determine what amendments are required to implement the objectives and recommendations of the Subwatershed No. 19 Management Plan. The timing of such a review will, of course, be dependent upon municipal resources and the priority that this matter may have relative to other municipal initiatives. However, it is recommended that, where possible, the municipality seek, within six to twelve months after the endorsement of the Plan by their respective Councils, to implement the results of this Study through their Official Plans.

5. The success of the proposed plan will be dependant upon the support and buy in of local landowners and the commitment of the municipalities and CVC to undertake measures which will restore/enhance the environment. Several stewardship programs have been undertaken within this subwatershed. It is recommended that a committee be established to oversee stewardship programs which will build and intensify on those already underway.

6. An environmental monitoring program to ensure the study goal and environmental targets are achieved should be set up. Where possible, use of existing public sector staff, special interest groups and volunteers should be used to undertake the monitoring.

REFERENCES

Beak Consultants Limited. 1985. Orangeville Marsh Monitoring Program.

Beak Consultants Limited. 1989. Orangeville Marsh Monitoring Program.

Beak Consultants Limited. 1990. Orangeville Marsh Monitoring Program.

Beak Consultants Limited. 1992. Orangeville Marsh Monitoring Program.

Beak Consultants Limited. 1994. Orangeville Marsh Monitoring Program.

Beak Consultants Limited and Credit Valley Conservation Authority. 1988. Feasibility of Aquatic Plant Harvesting in Water Quality Amelioration and Nutrient Management in a Shallow Impoundment, the Orangeville Reservoir.

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario. Ont. Geol. Survey, Special Vol. 2, Min. of Nat. Res., 270 pp.

City of London. 1995. City of London Subwatershed Studies - Terrestrial Biology Supporting Documentation.

DFO. 1994. Habitat Conservation and Protection Guidelines - Developed from the Policy for the Management of Fish Habitat (1986). Department of Fisheries and Oceans.

IEC International Environmental Consultants Ltd. 1982. Stormwater Quality Management Study Town of Orangeville.

IEC Beak Limited. 1984. Annual Benthic Community Monitoring in the Upper Credit River (Orangeville Marsh).

IEC Beak Limited. 1982. Orangeville Marsh Monitoring Programme 1982.

Kavanagh, K. and S. McKay-Kuja. 1992. A classification of natural communities occurring in Ontario. A report for the Carolinian, Canada and Great Lakes Conservation Data Centre Projects.

MacRae, C.R. 1991. A Procedure for the Design of Storage Facilities for Instream Erosion Control in Urban Streams. Unpublished Ph.D. Thesis, University of Ottawa, Ottawa, Ont.

Ministry of the Environment. 1991. Report on the 1990 Discharges From Sewage Treatment Plants in Ontario.

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

Ministry of Environment and Energy. 1994. Revised Tables of Objectives For MOEE's Publication Water Management.

MNR. 1994. Natural Channel Systems: An Approach to Management and Design.

MTRCA. 1993. Stream and Valley Corridor Management Program.

Noss, R.F. and L.D. Harris. 1986. Nodes, networks and MUMS: preserving diversity at all scales. Env. Man. 10: 299-309.

Osterkamp, W.R. 1980. Sediment - Morphology Relations Of Alluvial Channels. Symp. on Watershed Management, Boise, Idaho, ASCE, Vol. 1, July 21-23, pp. 188-199.

Riley, J. and P. Mohr. 1994. The Natural Heritage of Southern Ontario's Settled Landscapes. A review of conservation and restoration ecology for land-use and landscape planning. Ontario Ministry of Natural Resources, Southern Region, Aurora.

Rosgen, D. 1993. A Classification of Natural Rivers. Wildland Hydrology, Catena (in review).

Rosgen, D.L. 1994. A Classification of Natural Rivers CATENA (in press).

Rowney, A.C. and C.R. MacRae. 1991. QUALHYMO User's Manual Version 2.1: A Language For Continuous Hydrologic Simulation. Dept. of Civil Eng., Royal Military College of Canada.

Schumm, S.A. 1977. The Fluvial System. John Wiley and Sons, Inc., N.Y., 338 pp.

Triton Engineering Services Limited and Beak Engineering Limited. 1990. Town of Orangeville Report on the Performance Evaluation of the Water Pollution Control Plant.

Wolman, M.G. 1967. A Cycle of Sedimentation and Erosion in Urban River Channels. Geogr. Ann., Vol. 49A, pp. 385-395.

APPENDIX 1

Technical Index

INDEX

Topic	Section
Surface Water Resource Features (Hydrology, Flood Flows, Flood Risk)	
Existing Subwatershed Conditions	3.3
Goals and Objectives	4.1
Best Management Practices (BMPs)	5.3.1, 5.4.1
Recommended Management Plan	7.2
Implementation Strategy	8.3.2
Future Study	8.5.2.1
Environmental Monitoring	8.7.2
Hydrogeology (Baseflows, recharge/discharge areas, groundwater, aquifers)	
Existing Subwatershed Conditions	3.4
Goals and Objectives	4.1
Best Management Practices (BMPs)	5.3.14, 5.4.10
Recommended Management Strategy	7.3
Implementation Strategy	8.3.3
Future Study	8.5.2.2, 8.5.5
Environmental Monitoring	8.7.3
Surface Water Quality	
Existing Subwatershed Conditions	3.5
Goals and Objectives	4.1
Best Management Practices (BMPs)	5.3.1, 5.4.1
Recommended Management Strategy	7.2.3
Future Study	8.5.2.7
Environmental Monitoring	8.7.4
Fluvial Geomorphology (erosion, sediment control)	
Existing Subwatershed Conditions	3.6
Goals and Objectives	4.1
Best Management Practices (BMPs)	5.3.10, 5.3.11, 5.4.6
Recommended Management Strategy	7.2.2.1
Implementation Strategy	8.3.2.2
Future Study	8.5.2.5
Environmental Monitoring	8.7.5

Topic	Section
Terrestrial Features	
Existing Subwatershed Conditions	3.7
Goals and Objectives	4.1
Best Management Practices (BMPs)	5.3.5, 5.4.9
Recommended Management Strategy	7.4
Implementation Strategy	8.3.4
Future Study	8.5.2.4
Environmental Monitoring	8.7.6
Aquatic Features	
Existing Subwatershed Conditions	3.8
Goals and Objectives	4.1
Best Management Practices (BMPs)	5.3.4
Future Study	8.5.2.4
Environmental Monitoring	8.7.7

EXPLANATORY NOTES: FIGURE 7.1
RECOMMENDED PLAN FOR SUBWATERSHED NO. 19

A series of recommendations which are necessary to achieve the Recommended Plan are presented in Table 7.1. Where feasible, the recommendations are illustrated in Figure 7.1 which is located in the map pocket. These notes assist in briefly explaining the:

- basis of the Recommended Plan; and
- key recommendations which comprise the Recommended Plan.

The Recommended Plan consists of the following plan components:

- **Surface Water Management Plan** which describes protection, enhancement and restoration measures to sustain streams in a stable, natural, state, manage flood and erosion risks and avoid future water quality problems.
- **Groundwater Management Plan** which identifies key measures necessary to enhance recharge, avoid natural resource and water supply conflicts and protect groundwater quality.
- **Greenlands Plan** which describes the terrestrial, stream and valleyland corridor and recreational systems and outlines required protection, enhancement and restoration measures.

While each recommendation is highlighted separately on Figure 7.1, it is important to recognize that most recommendations represent integrated solutions to problems that address each of the component systems: greenlands, groundwater and surface water. For example, restoration of an unstable stream will reduce excessive sediment supplies which, in turn, will protect sensitive spawning areas, protect stream morphology (e.g., pool/riffle habitat), improve water quality and protect sensitive plant species in wetlands which are susceptible to turbid waters.

These recommendations, when implemented over the long term, will achieve the goal of the study, which is to develop a plan for the protection, enhancement and restoration of the natural environmental resources under present conditions and as land use changes occur. Two recommendations which form part of the Groundwater Management Plan are not shown on Figure 7.1. These include:

- developing a water supply management strategy on a subwatershed basis to confirm potential sources and quantities of groundwater and associated requirements for environmental protection; and
- undertaking a contaminant source inventory study to document potential sources of groundwater quality impact.

In addition, floodlines and fill lines have not been shown as they are not available for the entire subwatershed.

There are three general subheadings shown in the legend of Figure 7.1. These are:

- terrestrial system,
- stream and valleyland corridor system, and
- restoration/enhancement projects.

Collectively, the terrestrial and stream and valleyland corridor systems form part of the overall Greenlands Plan. Outlined below is a further description of each of the terrestrial system, the stream and valley corridor system, and the restoration/enhancement projects.

GREENLANDS PLAN

The Greenlands Plan consists of three components - a stream and valleyland corridor system, a terrestrial system and a recreational trail system. The components of the greenlands plan are categorized into three classes of AEnvironmental Constraint Areas@ for consideration in official plan policy.

Terrestrial System

Components of the recommended terrestrial system were prioritized as follows:

- Class 1 areas are the fundamental building blocks which provide core natural areas and corridors and contribute the most to the biodiversity and integrity of the area. These areas are identified to be protected. They may also have a significant hydrologic, specifically groundwater function. These areas perform important ecological processes and protect biological diversity and life-supporting systems that would be lost or degraded if such areas were permanently disturbed in any way. These areas must be protected from land use impacts.

  Class 1 areas include:

  - all ESAs, wetland features and contiguous woodland features;
  - Monora Park and Dufferin Anglers and Hunters natural areas;
  - all level 1 and 2 riparian (stream and valley) corridors;
  - all natural features in high recharge areas; and
  - all vegetation features within 100 m wide terrestrial corridors.

  To ensure the protection of these areas, the areas should be incorporated as a separate land use designation in official plans.

- Class 2 areas provide important secondary benefits in terms of wildlife habitat, linkages to the Class 1 areas, and act as seed sources or nuclei from which revegetation efforts can build upon. Class 2 areas should be protected through stewardship programs, particularly where they are located adjacent to Class 1 lands. However, if land use change is proposed, these areas should be protected or replaced with equivalent features depending on the results of more detailed evaluation. These areas provide important ecological functions to the subwatershed and allow for the creation of new ecological features such as vegetative buffers, wetlands and linkages between vegetated areas and watercourses. If land use changes are proposed, subject to detailed studies in the form of an Environmental Impact Statement (EIS), some level of development may be permitted to alter the size and physical form of a Class 2 area provided that ecological functions, including hydrologic and hydrogeologic functions, are protected and maintained.

Class 2 areas include:

- all natural features contiguous with terrestrial core areas and corridors;
- all natural features contiguous with level 1 and 2 riparian (stream and valley) corridors;
- all level 3 riparian (stream and valley) corridors;
- all lands within a 50 m setback from the boundary of Class 1 areas (should land use change); and
- all remaining features.

These areas can be incorporated as either a separate land use designation or a Aconstraint@ or Aoverlay@ to an underlying land use designation (which, in many instances, will be an open space, rural or agricultural designation).

- Class 3 areas represent priorities for revegetation in a stewardship context or degraded streams which may be enhanced should development occur. Class 3 areas which are targeted for revegetation should be replanted with native species characteristic of the adjacent features or appropriate for the underlying soil/soil moisture and flooding regime.

  Class 3 areas include:

  - targeted areas for stewardship within terrestrial core areas and corridors.

  These areas are appropriate to show in an Appendix Map of an Official Plan for information purposes but not on (an approved) Land Use Schedule(s).

<u>Stream and Valley Corridor System</u>

The width of this vegetated corridor for streams and valleys should provide a variety of functions necessary to protect aquatic species, including shading, sediment control, food supply and woody debris, and create a cool microclimate around the stream. In addition, this zone should support other aquatic/hydrologic functions, such as maintain sufficient room for natural morphologic changes, protecting wetlands and discharge areas adjacent to the stream and valley. As a minimum, the setback criteria as outlined in the CVC Watercourse and Valleyland Protection Policies should be applied to define stream and valley widths. In addition, the following additional criteria may be used to assist in

determining the corridor width:

- **Level 1**: the greater of any of the following: the valley or floodplain width, a multiple of 16 to 20 times the bankfull width, a multiple of three times the natural meander width of the stream, a multiple of 10 times the average bank slope, the edge of a discharge area or riverine wetland, a 60 m corridor as defined by MNR policy, the criteria as outlined in CVC Watercourse and Valleyland Protection Policies, a corridor equal to the valley width intersected by a horizontal drawn at two times bankfull depth, a setback from the valley wall equal to the 100-year erosion recession limit.

- **Level 2**: the greater of any of the following: the valley or floodplain width, a multiple of 16 to 20 times the bankfull width, a 30 or 60 m corridor as defined by MNR policy, the criteria as outlined in the CVC Watercourse and Valleyland Protection Policies, a corridor equal to the valley width intersected by a horizontal drawn at two times bankfull depth.

- **Level 3**: generally defined by the floodplain width; however, the size of the corridor may be adjusted to accommodate development provided that the requirement to convey flows and maintain water quality is preserved.

Further details are provided in Section 7.4.1 of the report.

Restoration/Enhancement Projects

Restoration/enhancement projects, with the exception of relocation of Well 5/5A, are listed under the Surface Water Management Plan in Table 7.1. The recommendations include undertaking flood protection works, agricultural stewardship fencing and buffer programs, stream restoration projects, and retrofitting/removal of man-made ponds or stormwater management facilities. As stated above, implementation of several of these recommendations will benefit the community in many ways, including improvement of the aquatic and terrestrial habitat, reduction in water quality levels, as well as improvement in neighbourhood aesthetics and educational opportunities.

TABLE 7:1 RECOMMENDED SUBWATERSHED 19 MANAGEMENT PLAN

Recommendation	CRITERIA			
	Technical Consideration	Environmental Benefits	Land Requirements/Impacts	Cost
GREENLAND PLAN - TERRESTRIAL				
Protect all Classification 1 features - ESAs, large natural areas, features in high recharge, wetlands, terrestrial corridors	• protect unique species/habitats • protect areas serving as core habitat for plants and animals • maintain hydrologic/water quality function • increase linkages between natural areas for plant/animal dispersion	• increases biodiversity (# of species/communities) • increases integrity of terrestrial system (linkages, functions) • provides recharge/water quality function	• ?	NIL
Conduct EIS on all Classification 2 features - woodlands contiguous with Level 1/2 riparian corridors, features in low/moderate recharge	• evaluate function of feature w.r.t. habitat for plants/animals, unique species, wetland and stream function	• adds to overall terrestrial habitat • source of seeds/plant material to replace last biodiversity or cores and corridors • may have stream/wetland function	• ?	NIL
Undertake a stewardship/education program to promote regeneration of Classification 3 areas to a natural state	• evaluate current state of Classification 3 levels to determine degree to which regeneration has occurred • develop planting schemes, native species lists for use	• adds to overall terrestrial system - increased habitat particularly in core areas • increased width of corridors allows use by more sensitive species, increases habitat value	• 900.ha	$1,000,000 to $4,000,000
Urban forestry program	• assess health of existing trees in Orangeville • develop planting program to replace unhealthy/over-mature trees	• maintain aesthetic and habitat value of trees on public and private urban lands	NIL	$100,000
GREENLANDS PLAN - AQUATIC				
Protect Level 1 and 2 valley and stream corridors	• protect critical aquatic habitats, spawning areas, discharge areas • provide space to allow natural morphological processes to continue unrestricted • maintain natural floodplain characteristics	• protect critical spawning habitats, discharge areas • protect floodplain functions: - fish spawning habitat - amphibian habitat - discharge - sediment control - flood conveyance - flood production • maintain natural morphological/channel forming processes	N/A	N/A
Maintain key functions of Level 3 valley and stream corridors	• define minimum criteria for channel/floodplain width • width based on conveyance of flows, sediment control and water quality considerations	• conveyance of flows • maintenance of water quality • sediment control • aquatic food production	N/A	N/A
GREENLANDS PLAN - RECREATION				
Recreational trail system	• identify appropriate routes • identify sensitive natural areas to be avoided	• recreational amenity • link communities/neighbourhoods • control access to sensitive features • provide education/interpretive opportunities	• combination of public/private lands	Not listed

TABLE 7:1 RECOMMENDED SUBWATERSHED 19 MANAGEMENT PLAN

Recommendation	CRITERIA			
	Technical Consideration	Environmental Benefits	Land Requirements/Impacts	Cost
SURFACE WATER MANAGEMENT PLAN - EXISTING INLINE POND WORKS				
Retrofit existing stormwater management ponds including, Milady Pond and North Credit Estates Pond and the existing old farm pond (Cook Pond)	• remove existing barriers/restrictions to fish passage • improve surface water treatment function • landscape with native plant communities • create natural channel system through ponds • reduce permanent pool volume	• enhances fish access potential to alternate habitat • enhances aquatic community habitat conditions through a reduction in maximum water temperatures and improved surface water quality • enhances the quality of the terrestrial community and improves neighbourhood aesthetics	NA	$900,000 (3 ponds @ $300,000/pond)
Remove/bypass existing Quarry pond south east of Blind Line and County Road 16 and Monora Creek Park Pond	• abandon existing flow control structure and permeant pools • landscape with native plant communities • control sediment impacts during the removal/bypass process • restore upper and lower reaches with natural channel design works	• enhances downstream aquatic community habitat conditions through a reduction in maximum water temperatures • integrates pond for an enhanced terrestrial community • restores fish access to alternate habitat (Monora Creek Park Pond only)	• each pond is located on private property • possible conflict with existing uses	$300,000 (2 ponds @$150,000/pond)
Remove /bypass of Melville pond on the Credit River	• abandon existing flow control structure and permeant pools • landscape with native plant communities • control sediment impacts during the removal/bypass process • restore upper and lower reaches with natural channel design works	• enhance downstream aquatic community habitat conditions through a reduction in maximum water temperatures • integrates pond for an enhanced terrestrial community • restores fish access to alternate habitat • restores indigenous fish habitat	• pond is located on private property • possible conflict with existing uses	$1,100,000 (pond bypass/removal and natural channel design works)
Remove /bypass of existing online ponds on the lower Monora Creek at Townline (Pond I), on the upper Caledon Tributary (Pond L) and on the lower Caledon tributary (Pond M)	• abandon existing flow control structure and permeant pools • landscape with native plant communities • control sediment impacts during the removal/bypass process • restore upper and lower reaches with natural channel design works	• enhance downstream aquatic community habitat conditions through a reduction in maximum water temperatures • integrates pond for an enhanced terrestrial community • restores fish access to alternate habitat • restores indigenous fish habitat	• pond is located on private property • possible conflict with existing uses	$450,000 (3 ponds @ $150,000/pond)
GROUNDWATER MANAGEMENT PLAN				
Develop a water supply management strategy on a subwatershed wide basis to confirm potential sources and quantities of groundwater and associated requirements for environmental protection	• recovery test • installation of monitoring wells • temporary loss of localized water supply	• potential reduction in baseflow impact	NA	$100,000 to 150,000
Removal of well 5/5A or significant reduction in pumping capacity	• water supply reduction would have to be made up through existing wells (if possible) or additional well • potential aquatic health of revitalized stream unknown	• potential revitalization of cold water community	• area necessary for well house and right of way for supply	$500,000 for replacement well
Undertake a contaminant source inventory study to document potential sources of groundwater quality impact.	• historic land uses (e.g., archive search) must be considered	• protection of groundwater quality • prevention and/or early warning of spills	NA	$25,000

TABLE 7:1 RECOMMENDED SUBWATERSHED 19 MANAGEMENT PLAN

Recommendation	CRITERIA			
	Technical Consideration	Environmental Benefits	Land Requirements/Impacts	Cost
SURFACE WATER MANAGEMENT PLAN - FLOOD CONTROL WORKS				
Carry out flood protection works for 2 flood damage centres, Dawson Road on Mill Creek and First Street and Hansen Boulevard on Monora Creek	• floodproof affected structures	• reduces flood risk and annual flood damage costs	NA	$75,000 Dawson Road on Mill Creek $10,000 First Street and Hansen Boulevard on Monora Creek
Implement flood control measures for approved development	• Stormwater management pond required (Ponds 4, 3, E, A2, A1, B) to provided post-development flow control to less than pre-development conditions for the 100 storm to maintain existing levels of flood protection	• maintains existing level of flood risk on Monora and Mill Creek	8.5 ha total for all ponds	$ 2,500,000 (82,500m^3 @ $30/m^3)
SURFACE WATER MANAGEMENT PLAN - NATURAL STREAM WORKS				
Restore middle Monora Creek, lower branch, from Blind Line to Cemetery Road	• remove excess sediments • improve channel stability using natural channel design • coordinated with Milady Pond retrofit	• control downstream sediment supply • restores aquatic habitat • restores long term stream stability • link aquatic communities in the upper and lower reaches	NA	$1,260,000 (2.1 km @ $600/m)
Control livestock access on middle Caledon Tributary, both branches from 1st Line East to the Credit River	• fencing • riparian plantings • alternative livestock water supply	• reduces channel erosion and excess sediment supply • provides long term channel stability • enhances surface water quality • protects existing aquatic community	• works required on private property	$24,000 (2 km @ $12/m)
Restore degraded lower channel reach on the upper and lower Caledon Tributaries	• remove excess sediments • improve channel stability using natural channel design • coordinated with pond removals on upper and lower Caledon tributaries	• restores aquatic habitat • restores long term stream stability	NA	$40,000 (0.40 km @ 100/m)
Restore lower Monora Creek tributary, lower branch, from Blind Line to confluence with upper branch	• improve channel stability using natural channel design	• restores aquatic habitat • restores long term stream stability • link aquatic communities in the upper and lower reaches	NA	$ 960,000 (1.6 km @ $600/m)
Restore and enhance degrading channel on Upper Monora Creek tributary Highway 10 to Cemetery Road	• improve channel stability using natural channel design	• reduces downstream sediment supply • restores aquatic habitat • restores long term stream stability	NA	$76,000 (0.38 km @ $200/m)
Replace hard unnatural channel with a natural channel system on Middle Monora Creek tributary Starview Road to First Street	• create a natural channel system to replace the existing gabion channel	• restores ("Net Gain") in fish habitat	• may require lands from adjacent properties (Orangeville Mall)	$225,000 (0.38 km @ $600/m)
Create an natural channel section of the roadside ditch along Second Avenue in Lions Park	• improve channel stability using natural channel design	• restores ("Net Gain") in fish habitat	• may require lands from adjacent properties (Lions Park)	$240,000 (0.40 km @ $600/m)
Control livestock access on the Eastern Tributary upstream of 3rd Line	• fencing • riparian plantings • offline water supply	• reduces channel erosion and excess sediment supply • provides long term channel stability • enhances surface water quality • protects existing aquatic community	• works would be required on private property	$4,800 (0.4 km @ $12/m)

TABLE 8.1.G
IMPLEMENTATION CONSIDERATIONS FOR RETROFITTING OF EXISTING STORMWATER MANAGEMENT FACILITIES AND PONDS

Plan Component: *Surface Water*

Action: *Regenerate (retrofit) three Stormwater Management Facilities pond; remove or bypass one public and private pond to provide water quality, fish passage and temperature regulation benefits as well as educational and restoration of indigenous fish habitat opportunities*

Facilitator: *Municipality/CVC*

Contributor: *MNR, special interest groups*

Official Plan Considerations: *None*

Other Implementation Mechanisms:

Time Frame:

short term (0 - 10 yr)	•	*Milady Pond*
medium term (11 - 20 yr)	•	*Cook Pond, North Credit Estates Pond,*
long term (21 - 30 yr)	•	*Monora Park Pond, Monora Creek, Private ponds on Monora Creek and Caledon Tributaries*

Cost:

short term (0 - 10 yr)	•	*$300,000*
medium term (11 - 20 yr)	•	*$600,000*
long term (21 - 30 yr)	•	*$750,000*

Funding: *Funding through municipal and/or Conservation Authority initiatives, special interest groups, corporations, or environmental foundations.*

Other Comments: *Regeneration of the Milady Pond should be coordinated with instream works on Monora Creek with special interest groups, local homeowners and schools as considerable education and environmental enhancement opportunities exist. Removal/bypass of the private ponds will require agreement from existing landowners*

TABLE 8.1.H
IMPLEMENTATION CONSIDERATIONS FOR DEVELOPMENT OF A GROUNDWATER MANAGEMENT PLAN

Plan Component: *Groundwater*

Action: *Undertake a pumping well impact assessment study and a contaminant sources inventory study*

Facilitator: *Municipalities*

Contributor: *MOEE, CVC*

Official Plan Considerations: *Review and revise policies to ensure protection of the quality and quantity of aquifers, surface and groundwater. Review and revise permitted uses in Official Plans to ensure certain uses with the potential adverse impacts from discharge of substances are not permitted in sensitive recharge areas. Implementation of a Water Conservation Strategy.*

Other Implementation Mechanisms: *n/a*

Time Frame:

short term (0 - 10 yr) • *undertake study*

Cost:

short term (0 - 10 yr) • *$100,000 - $150,000*

Funding: *Funding to be provided by municipalities*

Other Comments: *The Official Plan considerations are in addition to existing permit requirements (e.g., OMOEE) and municipal policy that are in place for new developments.*

TABLE 8.1.I
IMPLEMENTATION CONSIDERATIONS FOR DEVELOPMENT OF A RECREATIONAL TRAIL SYSTEM

Plan Component: *Greenland*

Action: *Develop and implement a community-based recreational trail system to increase public awareness of the natural environment and control access to sensitive resource features*

Facilitator: *Municipality*

Contributor: *CVC, interest groups*

Official Plan Considerations: *Identify the intent to establish a recreational trail system in Official Plans (either by map and/or text)*

Other Implementation Mechanisms:

Time Frame:

short term (0 - 10 yr)	• *Undertake study*
medium term (11 - 20 yr)	• *Develop trail system*

Cost:

see Other Comments

Funding: *see Other Comments*

Other Comments: *The development of a recreational trail system was not directly considered in this study. Costs are therefore not provided. Figure A.B in the report does identify, at a conceptual trail system, which is consistent with the Recommended Subwatershed Plan*

TABLE 8.1.J
IMPLEMENTATION CONSIDERATIONS FOR REPLACEMENT OF WELLS 5/5A

Plan Component: *Groundwater*

Action: *Undertake a hydrogeological study to assess the potential to re-establish baseflow into the upper reach of the north tributary of Mill Creek and locate additional water supply, if necessary, to replace the reduction in pumping rates at Wells 5/5A.*

Facilitator: *Municipalities*

Contributor: *MOEE, MNR, CVC*

Official Plan Considerations: *N/A*

Other Implementation Mechanisms: *N/A*

Time Frame:

medium term (11 - 20 yr) • *undertake study*

Cost:

medium term (11 - 20 yr) • *$20,000 - $500,000*

Funding:

Other Comments: *This study should be done in conjunction with the Groundwater Management Plan. The range of costs reflects potential options to replace water loss by (1) utilizing existing wells or (2) locating and installing a replacement well.*

TABLE 8.1.K
IMPLEMENTATION CONSIDERATIONS FOR
MELVILLE POND DAM

Plan Component: *Surface Water*

Action: *Seek landowner cooperation to repair/modify/reconstruct Melville Dam to facilitate fish passage and moderate stream temperatures. Prepare design drawings.*

Facilitator: *CVC*

Contributor: *Landowner, special interest groups*

Official Plan Considerations: *N/A*

Other Implementation Mechanisms: *N/A*

Time Frame:
short - medium term (0 - 20 yr)

Cost:
short - medium term (0 - 20 yr) • *$1,100,000*

Funding: *Funding through municipal and/or Conservation Authority initiatives, special interest groups, corporations, or environmental foundations.*

Other Comments: *Due to the poor condition of the dam, structurally, there may be an opportunity to consider bypass or retrofit actions in the short term. Furthermore, some action may be necessary in the short term to assess the current condition.*

TABLE 8.1.L
IMPLEMENTATION CONSIDERATIONS FOR FLOOD CONTROL

Plan Component: *Surface Water*

Action: *Floodproof buildings at First Street and Hansen Blvd. and at Dawson Road and Mill Creek. Restrict development from floodplain. Control existing levels of flooding.*

Facilitator: *Municipalities, CVC*

Contributor: *Municipalities, CVC, proponents of land use change*

Official Plan Considerations: *Designate and zone hazard lands/floodplains as areas where development is to be restricted or prohibited within areas defined by the regulatory storm. (Provincial Floodplain Planning Policy Statement).*

Other Implementation Mechanisms:
Ontario Building Code Regulations
Municipal Zoning By-laws
CVC Authority Policies on Flood Plain Management

Time Frame:
short to medium term (0 - 20 years)

- *Floodproof buildings at times when local improvements by the municipality are proposed or when land ownership changes or when landowner proposes building changes.*
- *Flood control planning as required at the secondary planning phase.*

Cost:
Flood Proofing/Flood Control: $85,000

Funding: *Landowner*

Other Comments: *Further monitoring of peak flows is required to validate flood frequency and flood proofing requirements.*

TABLE 8.2:
OFFICIAL PLAN POLICY FRAMEWORK

Plan Component	Purpose	Recommended Official Plan Initiatives	Municipality
Stream Restoration	Study recommendations focus on the restoration of identified, unstable stream areas. Official Plan policy should support natural stream channel design within all future development and for the restoration of existing streams.	• Stormwater management practices shall incorporate natural channel design and maintain existing watercourses in their natural condition, where appropriate. • Stream bed disturbance should be minimized to prevent erosion during pre- and post-development periods. • Stream banks which are subject to significant erosion, should be restored to a natural or stable condition. • Maintain slope stability in order to avoid erosion, slope failure and resultant sedimentation of watercourses • *PPS 3* (proposed)	All
Develop Urban Forestry Program	To identify support for the establishment of an urban forestry program within the Town.	• The Town will implement a regular program of tree rehabilitation and replacement in order to restore, maintain and enhance forest cover within the urban area.	Orangeville
Agricultural Stewardship, Fencing and Buffers	Official Plan policy may be used to administer a program to identify other rural land use, stewardship and best management objectives.	• Support initiatives of the Ministry of Agriculture, Food and Rural Affairs, farming organizations, and other agencies which encourage sound agricultural land and livestock management and soil conservation practices. • Promote environmentally sound and sustainable agriculture that will support both the agricultural economy and protect significant environmental features • Encourage other rural uses to develop in manner sensitive to the environment • Promote the maintenance/enhancement of woodlots/hedgerows on farms • Restrict agricultural activities within Environmental Constraint Area 1 • Establish rural stewardship initiatives/committees which promote education and assistance directed towards improving farm management practices. • Direct farm-related consents away from identified natural features. • Promote agricultural practices that minimize the amount of pesticides and nutrients entering water bodies. • *PPS 2.1.5* (proposed)	Town of Caledon, Townships of Amaranth, East Garafraxa and Mono

Plan Component	Purpose	Recommended Official Plan Initiatives	Municipality
Natural Environmental Resources (including Environmentally Significant Areas)	To protect significant natural heritage areas through their designation in the Official Plan. **To promote an interconnected system of natural areas and open spaces that will preserve features of significant environmental value.**	• Recognition of subwatershed planning as the basis for the protection, enhancement and rehabilitation of significant natural features • Preservation of the aesthetic character of natural features • Designation of significant natural features as (one or more) separate land use categories in the Official Plan, based on the recommendations of the Subwatershed Recommended Plan • Environmental Constraint Area 1 natural features should be identified as "preservation" (ie. non-development) areas intended to preserve, enhance and protect the most important environmental features from land use impacts • Environmental Constraint Area 2 natural features should be identified as "conservation" (ie. limited development) areas (of low to moderate importance) intended to allow a certain level of development to occur providing the function of the feature is protected or replaced • Environmental Constraint Area 3 natural features should be identified (in an appendix to the Official Plan) as areas with opportunities for enhancement of natural features • Notation cautioning that the mapping is general in nature only, and that further refinement of the precise boundaries will occur at the further Official Plan Amendment and/or development review stage, subject to an Environmental Impact Statement • Identify that where Environmental Constraint Areas are in private ownership, that such identification does not imply that they are open to the public, nor that they will necessarily be purchased by a public agency • Prohibit development within endangered/threatened species habitat, in accordance with the Provincial Policy Statement • To require that the physical form, size (in general) and ecological functions of Environmental Constraint Areas 1 features are protected/enhanced/restored • To control the crossing of Environmental Constraint Area 1 natural features by underground and above ground utilities/services and roads, unless it can be demonstrated that no adverse environmental impacts will occur • As additional areas become enhanced/naturalized, similarly designate/identify these areas • To require Environmental Impact Studies (EIS) to determine the potential for adverse impacts from development on lands adjacent to Constraint Area 1 and within Constraint Area 2 (EIS will determine detailed boundaries of the significant natural features and required mitigation measures) • To establish that more specific measures for the protection of such significant natural features (including the delineation of buffer areas) will be undertaken on the basis of an EIS/site-specific review • Identify whether the municipality/CVC will establish guidelines for the preparation of EIS documents • Indicate whether a program of municipal acquisition of these features is contemplated • Identify if/where tableland natural features may be acceptable as the statutory parkland dedication requirements • An EIS for significant natural features will include on-site staking and/or site assessment by CVC	All

Plan Component	Purpose	Recommended Official Plan Initiatives	Municipality
Groundwater Management Plan	To identify/protect significant groundwater recharge and aquifer areas (including the 6 km^2 area outside of the Subwatershed and within the Township of Amaranth) for their long-term benefits in maintaining municipal/private water supply requirements, and protecting natural resources.	• Prohibit or control development, as appropriate, within groundwater recharge and aquifer areas • Maintain the quality and quantity of surface water entering all water bodies • Protect, maintain and enhance the quality and quantity of groundwater recharge and discharge • Encourage use of best management practices in all stormwater management facilities, and in erosion/sedimentation management • Establish municipal fill by-laws to protect significant groundwater recharge/discharge areas (not subject to the Conservation Authorities Act) • Promote water conservation efforts in order to protect significant groundwater resources (including water-saving fixtures and appliances in all new development) • Protect water quality in water bodies receiving treated effluent from wastewater treatment plants • Ensure private servicing systems meet required standards • Establish early warning groundwater monitoring and Emergency Spills Response Programs at significant potential contaminant source locations • Consideration for exclusion of high risk land uses, related to groundwater contamination, from significant recharge areas • *PPS 2.4* (proposed)	All
Development of Recreational Trail System	To identify the potential for an inter-connected recreational trail system.	• Establish a linear trail system consistent and compatible with parks and natural heritage areas • Recreational trails shall be limited to those areas where there is no adverse impact on natural features/functions • Impacts from the location, installation, use and maintenance of recreational trails shall be minimized • Proper regard is given to issues of trespassing and liability, particularly where private property is involved • Recreational trail system identified/designated within the Official Plan - optional.	All
Relocation of Well No. 5	A municipal capital works matter that does not require Official Plan policy.		
Removal of Melville Dam	This matter does not require Official Plan policy.		

Plan Component	Purpose	Recommended Official Plan Initiatives	Municipality
Other Issues	Policy issues not covered under other plan components	• Encourage soil conservation and protection practices and minimize soil erosion • Encourage the enactment of by-laws which regulate topsoil removal • Minimize alterations to existing topography, particularly in areas of steep or unstable slopes • Encourage the enactment of fill by-laws which regulate the grading and filling of lands • Control the establishment of new "water taking uses" (eg. municipal wells) to minimize the potential adverse impact on the subwatershed • Protect existing, or establish additional, linkages between the key elements of the Subwatershed 19 Recommended Plan to promote ecological integrity • Establish a policy framework for the application of bonus by-laws (pursuant to Section 37 of the Planning Act) in order to achieve specific environmental objectives such as preservation of significant natural heritage areas/features	

Implementation Measures	Identify what land use planning mechanisms will be used by the municipality in implementing these policies.	• Utilize the recommendations of the Subwatershed 19 Recommended Plan in the preparation of relevant land use planning documents (ie. Official Plans, Secondary Plans), and through the development review process.
		• Implementation through such mechanisms as:
		  • comprehensive and/or site-specific zoning by-laws
		  [policy notation that the boundaries shown on the Official Plan schedules may be used as a general basis for zone boundaries, and that a more precise delineation of the limits of environmental features will be undertaken through subsequent studies, EIS, and/or development review/approvals process]
		  • subdivision/condominium approvals/agreements (including conditions of approval)
		  • site plan approvals/agreements (including conditions of approval)
		  • design and performance guidelines
		  • restrictive covenants and/or easements
		  • public acquisition of lands (including a review of parkland dedication requirements, pursuant to the Planning Act)
		  • stewardship programs	

Plan Component	Purpose	Recommended Official Plan Initiatives	Municipality
Implementation Measures (continued)		• Require Environmental Constraint Areas 1 and/or 2 to be identified/zoned in a separate Zone category • Identify the intent to streamline the development review process through the application of the Subwatershed 19 Recommended Plan recommendations and the clear integration of various municipal/agency roles and responsibilities • Encourage the enactment of other available regulatory mechanisms which will support the implementation of the Subwatershed 19 Recommended Plan (such as tree, topsoil, and fill by-laws) • Establish the determination of "gross" versus "net" density for the purposes of development review, including parkland dedication calculations • Evaluate the opportunities for utilizing alternative development standards for roads, services and utilities as a means of achieving preservation/conservation of significant natural features • Ongoing consultation with Credit Valley Conservation, Provincial ministries and other public agencies • Jointly establish public education and awareness initiatives • Promote the active participation of landowners/residents in the identification, protection, enhancement and maintenance of significant natural features • Participation in public and private stewardship initiatives which support the protection, enhancement and/or restoration of significant natural features • Establish monitoring programs (criteria, measures, and reporting structures)	All

Notes:
1. "All" refers to the Towns of Caledon and Orangeville and the Townships of Amaranth, East Garafraxa and Mono.

TABLE 3.17: BIOPHYSICAL PERFORMANCE STANDARDS FOR AQUATIC ECOSYSTEM OBJECTIVES - SUBWATERSHED NO. 19

	AQUATIC ECOSYSTEM OBJECTIVE			
Aquatic Performance Standard	Type I	Type II	Type III	Type IV
HYDROLOGY				
• baseflow	• minimum 30% of average annual daily flow	• minimum 10-20% of average annual daily flow	• minimum 5% of average annual daily flow or sufficient to maintain isolated pools	• minimum to maintain isolated pools, may be <5% of average annual daily flow
• bankfull frequency	• 1-2 times per year	• 1-2 times per year	• as required to protect downstream aquatic communities	• as required to protect downstream aquatic communities
CHANNEL MORPHOLOGY	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features
• average pool area as % of total surface area at low flow	• >12%	• >4%	• >4%	• >4%
• average riffle area as % of total surface area at low flow	• >12%	• >10%	• generally >5%	• may be <5%
• average minimum summer pool depth	• 0.5 m	• 0.3 m	• 0.2 m	• 0.2 m
• bankfull width to depth ratio	• generally <10	• generally 5-10	• generally 5-10	• no requirement
IN-STREAM COVER	• minimum total in-stream cover 30-40% by surface area • woody debris present up to 10% of surface area • minimum 15% of surface area with overhead cover • minimum 5% of surface area with overhead cover	• minimum 10% of stream area during low flow • 10-20% of bottom of pool/backwater habitats covered by logs, vegetation, woody debris and boulder • cover at stream margins critical for juvenile fish	• minimum 5% of stream area during low flow • 10% of bottom of pools/breakwaters covered by logs, vegetation, woody debris and boulder	• minimum 5% of stream area during low flow • 5% of bottom of pools/ backwaters covered by logs, vegetation, woody debris and boulders

TABLE 3.17: BIOPHYSICAL PERFORMANCE STANDARDS FOR AQUATIC ECOSYSTEM OBJECTIVES - SUBWATERSHED NO. 19

	AQUATIC ECOSYSTEM OBJECTIVE			
Aquatic Performance Standard	Type I	Type II	Type III	Type IV
SUBSTRATE	• well-sorted riffle zones • maximum 25% fines in spawning substrates • maximum 30% fines in riffle zones • upwelling conditions required • minimum 50% of riffles composed of cobble, rubble, small boulder	• D5O in pools generally <80 mm • fines in riffle zones moderate to low (<50%)	• D5O in pools generally <40 mm • more fines in riffle zones,generally >50%	• no requirement
RIPARIAN HABITAT				
• shaded during 1000-1400 hr	• minimum 35%	• minimum 0% • maximum 50-75%	• minimum 0% • maximum 75%	• minimum 0% • maximum 100%
• woody debris	• important component of in-stream cover and roughness	• important for roughness and refuge during peak flows	• woody debris less important	• less important
WATER QUALITY				
• maximum annual water temperature	22°C	30°C	31-35°C	31-35°C
• average annual total suspended solids (ppm)	<20	<150	<200	<400
• dissolved oxygen (ppm)	>5	>3-4	>2	<2
• spills	none	none	none	none
BARRIERS	• remove as feasible	• removal as feasible	• minimize as feasible	• minimize as feasible

TABLE 3.1 - CLIMATE AND PRECIPITATION CHARACTERISTICS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
ORANGEVILLE													
DAILY MAXIMUM TEMPERATURE (C)	-4.6	-3.5	1.2	9.8	16.8	22.3	24.9	24.0	19.5	12.9	5.1	-1.8	10.6
DAILY MINIMUM TEMPERATURE (C)	-12.9	-13.0	-8.2	-1.0	4.3	9.5	11.8	11.0	7.5	2.3	-2.2	-9.5	0.0
DAILY TEMPERATURE (C)	-8.8	-8.3	-3.5	4.4	10.6	15.9	18.4	17.5	13.5	7.6	1.4	-5.7	5.3
RAINFALL (mm)	16.3	17.1	24.3	61.7	74.0	66.7	77.3	75.4	69.5	67.5	60.0	32.9	642.7
SNOWFALL (cm)	35.9	28.2	24.8	6.7	1.5	0.0	0.0	0.0	0.1	3.0	12.1	35.0	147.3
TOTAL PRECIPITATION (mm)	49.1	43.9	51.9	68.5	75.1	66.7	77.3	75.4	69.6	70.3	73.5	67.2	788.5
DAYS WITH PRECIPITATION	12	11	12	10	10	9	8	10	10	11	13	13	129

NOTE: DATA BASED ON ADJUSTED NORMALS FOR LESS THAN 19 YEARS OF RECORD, AES STATION, 43o 55' N , 80o 3' W , ELEVATION 405 m

TABLE 3.2: EXISTING STORMWATER MANAGEMENT FACILITIES - SUBWATERSHED NO. 19 STUDY

Pond Name	Water Course	Flood Storage (m^3)	Total Storage (m^3)
ON-LINE PONDS			
Brucedale Pond	North Branch of Monora Creek Tributary	14,700	14,700
Milady Subdivision Pond	North Trib. of South Branch of Monora Creek Tributary	NA	15,686
North Credit Estates Pond	South Trib. of South Branch of Monora Creek Tributary	NA	NA
Cook Pond	South Trib. of South Branch of Monora Creek Tributary	0	NA
Monora Park Pond	Monora Creek (Main Branch)	0	15,400
Hunter's and Angler's Pond	Monora Creek (Main Branch)	800	40,000
Orangeville Reservoir	Credit River	5,882,107*	6,412,916
OFF-LINE PONDS			
Palu/Milady Pond	North Branch of Monora Creek Tributary	5,370	5,370
Edgewood Pond 3	South Trib. of South Branch of Monora Creek Tributary	155	155
Edgewood Pond 2	South Trib. of South Branch of Monora Creek Tributary	262	262
Mono Meadows I / Edgewood Pond	South Trib. of South Branch of Monora Creek Tributary	4,695	4,695
Mono Meadows (Phase III) Pond	Mill Creek	10,000	10,000
Lakeview Crescent Pond	Credit River	440	440

* Based on June - November Reservoir level.
NA - not available.

TABLE 3.3: PEAK FLOW RATES AT VARIOUS LOCATIONS WITHIN SUBWATERSHED NO. 19

Flow Rates (cms)								
Hydrograph Number	Description of Hydrograph Location	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional
525	Cook Pond	0.43	0.51	0.72	0.98	1.18	1.38	5.83
526	North Credit Estates Pond	0.54	1.53	2.08	2.74	3.24	3.74	11.00
227		1.02	1.80	2.51	3.41	4.04	4.73	13.00
523	Milady Subdivision Pond	0.17	0.42	0.68	0.99	1.24	1.49	5.63
224		0.42	0.73	0.93	1.18	1.37	1.56	6.00
827		1.43	2.33	2.91	3.91	4.66	5.44	18.90
228		1.68	2.52	3.29	4.47	5.16	5.83	20.20
521	Brucedale Pond	0.11	0.27	0.39	0.53	0.64	0.82	3.43
222		0.17	0.36	0.50	0.67	0.80	1.01	4.00
828	Confluence of North and South Branches of Monora Creek Tributary	1.80	2.74	3.56	4.81	5.56	6.42	24.10
229		1.77	2.77	3.57	4.76	5.55	6.48	24.20
511	Hunter's and Angler's Pond	0.43	0.55	0.77	1.06	1.27	1.54	5.94
512	Monora Park Pond	0.46	0.96	1.33	1.91	2.28	2.63	11.40
213		0.51	1.10	1.52	2.20	2.64	3.05	13.00
829	Confluence of Monora Creek and Monora Creek Tributary	2.08	3.43	4.61	6.15	7.59	9.00	36.80
200		2.02	3.46	4.66	6.22	7.68	9.12	37.20
331		0.73	1.43	1.90	2.53	3.01	3.49	12.30

TABLE 3.3: cont'd...

		Flow Rates (cms)						
332		0.33	0.68	0.92	1.24	1.48	1.72	5.59
333		2.59	3.85	4.68	5.78	6.59	7.39	18.70
800	Inflow to Orangeville Reservoir	5.52	9.25	12.00	15.60	18.40	21.40	73.50
501	Outflow from Orangeville Reservoir	0.62	0.75	0.82	0.88	0.92	0.96	16.60
304	Downtown Orangeville Sewer System	3.75	6.13	7.71	9.72	11.30	12.80	20.00
204		4.10	6.51	8.10	10.10	11.70	13.20	20.80
351	Upper Mill Creek	0.69	1.56	2.16	2.92	3.51	4.09	13.80
252	Middle Mill Creek	1.15	2.55	3.54	4.77	5.73	6.69	22.40
253	Mill Creek u/s of Confluence with Credit River	1.92	3.78	5.21	6.85	8.20	9.49	26.10
804	Credit River d/s of Confluence with Mill Creek	5.68	9.13	11.50	14.70	17.30	19.80	44.10
261		6.92	11.50	14.90	19.20	22.60	25.70	59.50
262		7.14	12.30	16.00	20.60	24.10	27.60	70.10
263		7.70	13.40	17.50	22.60	26.60	30.40	80.10
264		7.71	13.40	17.50	22.60	26.50	30.50	80.50
265		8.19	14.40	18.70	24.20	28.50	32.70	88.50
266		8.19	14.40	18.80	24.40	28.60	32.90	89.10
267		8.52	15.00	19.60	25.50	30.00	34.40	94.40
268	Melville Gauge	8.55	15.10	19.60	25.40	29.90	34.40	96.70

TABLE 3.4: FLOOD DAMAGE CENTRES

Buildings in the Floodplain
Under Regulatory Storm Conditions

Flood Damage Centre	Buildings in Floodplain
1. Monora Creek - First St. and Hansen Blvd.	6
2. Monora Creek - Cemetary Rd. to Highway 10	2
3. Mill Creek at Credit River - East Broadway/Townline	16
4. Mill Creek - Dawson Road	5
5. Mill Creek - West Broadway - Diane to C-Line	4
6. Mill Creek - Centre St. to East Broadway	19
7. Credit River - Melville	3

The total average annual flood damages in 1982 dollars are $160,000 (1982 FDR Study). This is the total yearly damages, due to flooding, that are expected to occur, on average, over time.

TABLE 3.5: Orangeville Sewage Treatment Plant Effluent Summary

Treatment : Convential Activated Sludge, Phosphorus Removal - continuous, Effluent Polishing
Design Capacity : 14.4 (1000 m3/day)
Operating Authority : Ontario Ministry of the Environment and Energy

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC	Annual Average	Annual Average Influent	Efficiency
Average Daily Flow (1000 m3/day)															
1990	8.89	9.12	10.86	9.97	9.51	8.40	7.54	7.53	8.04	10.55	11.63	12.71	9.56		
1991	10.55	10.76	14.14	16.52	10.79	9.24	9.17	8.93	8.64	9.65	9.37	10.62	10.70		
1992	9.25	9.08	12.28	13.62	11.61	9.40	9.45	11.42	11.45	10.48	16.19	12.49	11.39		
1993	12.97	9.72	11.26	15.93	10.98	11.05	9.69	9.16	9.58	10.02	10.56	10.37	10.94		
BOD															
1990	1.1	0.7	0.9	0.8	2.1	1.6	1.0	0.9	1.2	0.7	0.5	1.2	1.1	163.8	99.4
1991	1.2	1.2	2.4	3.6	1.2	1.3	1.0	0.9	1.4	1.0	1.1	0.9	1.4	149.3	99.0
1992	1.2	1.4	1.5	1.6	1.1	1.1	0.9	0.7	1.3	1.1	1.8	1.1	1.2	172.0	99.3
1993	0.9	1.6	1.6	1.1	1.1	0.9	1.6	1.3	1.3	1.2	1.5	1.1	1.3	182.0	99.3
SUSPENDED SOLIDS															
1990	2.1	2.6	2.5	3.6	3.0	2.4	2.9	2.1	2.1	1.6	1.9	2.1	2.4	154.2	98.4
1991	2.9	2.9	3.1	3.8	2.8	2.4	2.0	1.9	2.1	1.9	1.7	2.0	2.5	150.5	98.4
1992	2.3	2.5	2.7	2.8	2.5	1.8	1.8	1.5	1.9	2.2	2.8	2.5	2.3	143.0	98.4
1993	2.2	3.3	3.7	3.5	2.3	ND	2.3	1.9	2.0	2.1	2.1	2.4	2.3	190.0	98.8
TOTAL PHOSPHOROUS															
1990	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.2	5.2	97.1
1991	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.2	5.1	97.1
1992	0.15	0.18	0.15	0.14	0.14	0.11	0.13	0.14	0.18	0.20	0.20	0.23	0.16	5.60	97.10
1993	0.19	0.19	0.18	0.18	0.17	0.17	0.21	0.24	0.24	0.17	0.20	0.17	0.19	6.50	97.04

TABLE 3.6: Water Quality Sampling Results of Urban Drainage

Parameter	Units	Wet Weather					Dry Weather		Mean	
		April 24	May 31	July 20	Sept 28	Oct. 19	May 04	June 20	Wet Weather	Dry Weather
Total Suspended Solids	mg/L	316	275	77	151	100	3	12	159	6
Turbidity	NTU	153	68	48	95	65	4	15	79	8
Total Dissolved Solids	mg/L	100	120	214	231	57	979	613	128	775
BOD	mg/L	ND	11	6	12	6	<4	<4	8	<4
pH	pH units	8.6	7.3	7.9	7.3	7.9	7.9	7.6	7.8	7.8
Sodium	mg/L	16.6	10.4	19.2	19.3	95.0	145.0	69.8	22.7	100.6
Chloride	mg/L	33.9	13.7	39.3	34.9	5.2	273	177	20	220
Potassium	mg/L	1.81	2.97	4.70	4.56	31.70	2.46	4.12	5.16	3.18
Phophorus	mg/L	0.404	0.344	0.264	0.330	0.213	0.048	0.122	0.304	0.077
Ammonia as N	mg/L	0.60	0.57	0.26	0.46	0.12	0.60	0.85	0.35	0.72
Nitrate as N	mg/L	0.6	0.7	0.8	0.4	<0.1	2.5	0.2	0.4	0.7
Nitrite as N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<.01
TKN	mg/L	2.94	1.83	1.34	1.20	<0.1	0.80	1.30	0.85	1.02
Lead	mg/L	0.062	0.036	0.049	<0.025	0.074	<0.025	<0.025	0.040	<.025
Cadmium	mg/L	<0.003	<0.003	<0.003	<0.003	0.024	<0.003	<0.003	<0.003	<0.003
Nickel	mg/L	<0.01	<0.01	<0.01	<0.01	0.015	<0.01	<0.01	<.01	<.01
Iron	mg/L	5.87	5.08	2.90	3.96	11.30	1.59	3.28	5.218	2.28
Aluminum	mg/L	3.90	4.78	2.28	3.16	0.42	0.03	0.03	2.23	0.03
Zinc	mg/L	0.187	0.138	0.187	0.187	0.439	0.036	0.014	0.209	0.022
Copper	mg/L	0.040	0.026	0.036	0.044	0.271	0.004	0.004	0.054	0.004
Fecal Coliforms	counts/100mL	46	1600	1600	1600	1600	12	920	787	105
Escherichia Coli	counts/100mL	17	1600	1600	1600	1600	12	540	645	80

Notes: 1. ND - no data
2. Sampling location, drainage ditch on Second Street
3. Mean = Log normal mean

TABLE 3.7: ANNUAL POLLUTANT CONCENTRATION AND LOADINGS SUMMARY

PARAMETER	UNITS	OBSERVED CONCENTRATIONS					TYPICAL CONCENTRATION (from literature sources)		
		URBAN DRY	URBAN WET	RURAL	RESERVOIR	STP	URBAN DRY	URBAN WET	RURAL/AGRICULTURAL
ANNUAL VOLUME @STATION 023	1000 m3	175	1518	3036	9000	4015			
TOTAL PHOSPHORUS	mg/l	0.077	0.304	0.01	0.028	0.200	0.15	0.33-0.82	0.14-0.85
NITRITE+NITRATE	mg/l	0.7	0.4	2.5	0.3	5.2	2.6	0.68-1.96	0.66-1.28
TKN	mg/l	1.02	1.70	0.5	0.72	0.71	0.66	1.5-4.11	0.54-0.75
COPPER	mg/l	0.004	0.054	0.002	0.001	0.110	0.036	.034-.045	0.002-0.004
FECAL COLIFORM	cnts/100ml	105	1600	100	175	0	500	1,000-100,000	34-9,300
TSS	mg/l	6	40	5	4	2	15	100-200	6-170
		LOADINGS @ STATION 023, MELVILLE POND							
TOTAL PHOSPHORUS	kg/year	13	462	30	252	803			
NITRITE+NITRATE	kg/year	122	607	7591	2790	20878			
TKN	kg/year	178	2581	1518	6480	2851			
COPPER	kg/year	1	82	6	9	442			
FECAL COLIFORM	10 ^ 6counts/yr	18359	2428992	303649	1575000	0			
TSS	kg/year	1049	60725	15182	31500	8030			

* Estimated/Calibrated Value

TABLE 3.8 Results of the Phase 1 survey

RIVER	REACH	SEC.NO	B_{TOE} / $B_{W/L}$ (cm)	$D_{W/L}$ (cm)	W_{BFL} (cm)	D_{BFL} (cm)	W_{FPL}	COMMENTS
Credit R.	B1	1	700/700	35	790	65	>5W_{BFL}	meadow, tall grass
		2	665/665	33	695	91	>5W_{BFL}	meadow, very tall grass
Caledon	B2	1	–/116	4	174	48	366	
Tributary #3		2	–/64	4.5	250	40	395	
		3	–/80	3.5	252	40	375	
		4	–/88	4.5	300	30	435	
		5	–/97	8.0	196	53	282	
		6	–/113	11.0	233	58	>5.5W_{BFL}	
		7	–/210	4.0	260	51	1390	
		8	156/89	8.0	130	46	1050	shady, white cedar
		9	180/90	4.5	247	55	350	incised
Caledon	B3	1	195/118	9.0	256	29	≈2W_{BFL}	confined on right side
Tributary #2		2	115/115	11.0	211	31	484	dense vegetation
		3	194/194	11.0	244	36	–	
	B4	1	145/145	10.5	215	33	≈9W_{BFL}	cedar, clearing just d/s of por??
		2	178/78	13.5	293	26	≈3W_{BFL}	
	B5	1	630/630	42.0	850	73	>10W_{BFL}	meadow,grass
		2	540/540	28.0	620	55	>10W_{BFL}	meadow
		3	490/490	38.0	610	63	3W_{BFL}	cedar, no canopy
Mill Creek	B6	1	202/202	7.7	259	29.5	>10W_{BFL}	meadow
		2	126/126	8.1	173	19.0	≈5W_{BFL}	chute on left bank
		3	454/149	8.8	560	64.0	≈6W_{BFL}	seepage face left bank,tree canopy,bedrock
		4	321/321	5.9	376	36.0	615	
		5	278/220	10.5	460	44.0	1010	willow/spruce/maple
		6	116/116	8.3	214	21.5	405	open to sun

TABLE 3.8 Results of the Phase 1 survey (Cont'd)

RIVER	REACH	SEC.NO	B_{TOE} / $B_{W/L}$ (cm)	$D_{W/L}$ (cm)	W_{BFL} (cm)	D_{BFL} (cm)	W_{FPL}	COMMENTS
Monora	B9	1	386/87	5.4	440	49.5	>5W_{BFL}	tall grasses with cedar canopy
S. Branch		2	71/71	3.9	126	32.0	490	entrenched meadow
S.Tributary		3	134/59	4.8	132	20.5	233	bedrock,poplar tree cover
		4	276/208	3.7	323	48.5	>5W_{BFL}	cobble,gravel, sand, boulders
		5	143/83	6.0	212	72.5	≈4W_{BFL}	
Monora	B10	1	144/144	4.8	239	57.0	?	tall grass, dogwood shrubs
N. Branch		2	176/89	7.0	257	42.0	>7W_{BFL}	gravel, small boulders
S.Tributary		3	295/295	9.0	423	42.0	>5W_{BFL}	wooded terrace
		4	320/227	8.0	360	35.0	≥1940	wooded?
		5	134/134	9.0	460	39.0	≈3W_{BFL}	wooded?
		6	217/150	1.1	242	45.0	≈5W_{BFL}	?
Monora	B11	1	–/107	34	157	70	>10W_{BFL}	fast flowing
Near		2	–/100	28	144	80	>10W_{BFL}	
Reservoir		3	–/53	32	114	74	>10W_{BFL}	
Monora	B12	1(4)	–/180	–	370	10	>10W_{BFL}	gravel cobble, cedar cover, high flow velocity
N. Branch		2(5)	93	15.0	180	43	>10W_{BFL}	no canopy
		3(6)	131	9.5	173	30	>10W_{BFL}	no canopy
		4(7)	275	11.0	500*	30.4*		cedar cover, terraced
		5(8)	323	10.0	495	55/48		cedar cover, numerous debris jams

* Not well defined.

Table 7.2:

Summary of Recommendations for Flood Damage Centres

Total Average Annual Damages within Subwatershed 19 is $231,125. This figure is from the 1982 *Credit River Flood Damage Reduction Study* by Philips, increased to account for an average annual inflation rate of 3.4%.					
Flood Damage Centre	**# Buildings in Regional Floodplain**	**Most Frequent Flooding Event**	**Average Annual Damages ($)**	**Recommended Strategy**	**Estimated Cost ($)**
1. Monora Creek Tributary: First St. and Hansen Blvd.	6	10 Year[1]	118,105[1]	Floodproof affected commercial structures	$7500
2. Monora Creek: Cemetery Rd. to Hwy 10	2	Regional	0	Do nothing	Nil
3. Mill Cr. at the Credit R.: East Broadway / Townline	16	10 Year	11,325	Do nothing. Floodproofing has already been implemented as part of the 1984 WPCP expansions. Since the plant is the only structure affected by events more frequent than the regional, no further measures are warranted.	Nil
4. Mill Creek: Dawson Road	5	10 Year[2]	79,507[2]	Floodproof affected structures	$50,000 - $75,000
5. Mill Creek: West Broadway: Diane Dr - C-Line	4	Regional	0	Do nothing	Nil
6. Mill Creek: Centre St. to East Broadway	19	10 Year	21,957	Purchase and remove structures that are most at risk	$1,000,000 +
7. Credit River: Melville	3	10 Year	231	Do nothing	Nil

[1] The flood elevations used to compute the average annual damage figures in the 1982 Flood Damage Reduction Study were based on flowrates for both the north and south branches of the Monora Creek Tributary (only the south branch affects this flood damage centre) and are therefore somewhat higher than they should be. The 1982 study notes that both the *Tim Horton's* and the *Midas Muffler* will be flooded by events as frequent as the 5 year flow. Long time local residents cannot remember flooding at either of these buildings at any time in the past.

[2] The flood elevations used to compute the average annual damages at this site were computed using the flowrate at the outlet of Mill Creek. Since this flood damage

TABLE 3.16: FRAMEWORK FOR CHARACTERIZING ENVIRONMENTAL QUALITY IN SUBWATERSHED NO. 19

RESTORATION/REHABILITATION/ENHANCEMENT/MITIGATION PROTECTION

Type I Pristine Aquatic Community	Type II Slightly Degraded Aquatic Community	Type III Moderately Degraded Aquatic Community	Type IV Severely Degraded Aquatic Community
FISHERIES			
IBI >36 • brook trout	IBI <36 • brook trout	IBI <30 • pike • darters • sunfish • suckers • mimic shiner • common shiner	• longnose dace • central mudminnows • brown bullhead • brook stickleback
MACROINVERTEBRATES			
WQI >13 At least four of the following: • *Leuctra* • *Ectopria* • *Diplectrona* • *Promoresia* • *Glossosoma* • *Parapsyche*	WQI = 11 - 13 At least eight of the following: • *Isoperla* • *Baetis* • *Paraleptophlebia* • *Amphinemura* • *Leuctra* • *Taeniopteryx* • *Hydroptila* • *Rhyacophila* • *Diplectrona* • *Neophylax* • *Diamesa*	WQI = 9 - 10 At least ten of the following: • *Turbellaria* • *Nais pardalis/bretscheri* • *Tubifex tubifex* • *Erpobdella dubia* • *Baetis* • *Palaleptophlebia* • *Stenonema vicarium* • *Optioservus* • *Cheumatopsyche* • *Hydropsyche* • *Micropsectra* • *Polypedilum* • *Simulidae* • *Pseudolimnophila* • *Ferrissia*	WQI < 8 At least seven of the following: • *Nais pardalis/bretscheri* • *Limnodrilus hoffmeisteri* • *Tubifex tubifex* • *Cheumatopsyche* • *Hydropsyche* • *Optioservus* • *Erpobdella dubia* • *Probezzia* • *Ceratopogon* • *Rheotanytarsus* • *Chaetocladius* • *Diplocladius* • *Parametriocnemus* • *Physella*
STATION LOCATION			
Monora Creek • upper reaches of northern and southern tributaries **Mill Creek** • short section in upper reaches between Hwy 9 and B Line **Caledon Tributaries** • lower reaches of tributaries 2 and 3	**Monora Creek** • middle and lower reaches of northern tributary • upper and lower reaches of southern tributary **Mill Creek** • small sections in upper reaches **Eastern Tributaries** • small section of lower and middle reaches **Caledon Tributaries** • lower reaches of tributary 1 **Credit River** • between Hwy 10 crossings	**Monora Creek** • middle reaches of southern tributary **Mill Creek** • small section of upper reaches north of Hwy 9 • lower reaches **Eastern Tributaries** • sections of lower reaches **Caledon Tributaries** • section of middle and upper reaches, tributaries 2 and 3 **Credit River** • south of Reservoir above northernmost Hwy 10 crossing • Orangeville Reservoir • Melville Marshes	**Monora Creek** • middle tributary **Mill Creek** • middle reaches **Eastern Tributaries** • majority of upper and middle reaches **Caledon Tributaries** • majority of upper reaches and sections of middle reaches for all tributaries

TABLE 3.17: BIOPHYSICAL PERFORMANCE STANDARDS FOR AQUATIC ECOSYSTEM OBJECTIVES - SUBWATERSHED NO. 19

	AQUATIC ECOSYSTEM OBJECTIVE			
Aquatic Performance Standard	Type I	Type II	Type III	Type IV
HYDROLOGY				
• baseflow	• minimum 30% of average annual daily flow	• minimum 10-20% of average annual daily flow	• minimum 5% of average annual daily flow or sufficient to maintain isolated pools	• minimum to maintain isolated pools, may be <5% of average annual daily flow
• bankfull frequency	• 1-2 times per year	• 1-2 times per year	• as required to protect downstream aquatic communities	• as required to protect downstream aquatic communities
CHANNEL MORPHOLOGY	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features
• average pool area as % of total surface area at low flow	• >12%	• >4%	• >4%	• >4%
• average riffle area as % of total surface area at low flow	• >12%	• >10%	• generally >5%	• may be <5%
• average minimum summer pool depth	• 0.5 m	• 0.3 m	• 0.2 m	• 0.2 m
• bankfull width to depth ratio	• generally <10	• generally 5-10	• generally 5-10	• no requirement
IN-STREAM COVER	• minimum total in-stream cover 30-40% by surface area • woody debris present up to 10% of surface area • minimum 15% of surface area with overhead cover • minimum 5% of surface area with overhead cover	• minimum 10% of stream area during low flow • 10-20% of bottom of pool/backwater habitats covered by logs, vegetation, woody debris and boulder • cover at stream margins critical for juvenile fish	• minimum 5% of stream area during low flow • 10% of bottom of pools/breakwaters covered by logs, vegetation, woody debris and boulder	• minimum 5% of stream area during low flow • 5% of bottom of pools/ backwaters covered by logs, vegetation, woody debris and boulders

TABLE 3.17: BIOPHYSICAL PERFORMANCE STANDARDS FOR AQUATIC ECOSYSTEM OBJECTIVES - SUBWATERSHED NO. 19

	AQUATIC ECOSYSTEM OBJECTIVE			
Aquatic Performance Standard	Type I	Type II	Type III	Type IV
SUBSTRATE	• well-sorted riffle zones • maximum 25% fines in spawning substrates • maximum 30% fines in riffle zones • upwelling conditions required • minimum 50% of riffles composed of cobble, rubble, small boulder	• D5O in pools generally <80 mm • fines in riffle zones moderate to low (<50%)	• D5O in pools generally <40 mm • more fines in riffle zones,generally >50%	• no requirement
RIPARIAN HABITAT				
• shaded during 1000-1400 hr	• minimum 35%	• minimum 0% • maximum 50-75%	• minimum 0% • maximum 75%	• minimum 0% • maximum 100%
• woody debris	• important component of in-stream cover and roughness	• important for roughness and refuge during peak flows	• woody debris less important	• less important
WATER QUALITY				
• maximum annual water temperature	22°C	30°C	31-35°C	31-35°C
• average annual total suspended solids (ppm)	<20	<150	<200	<400
• dissolved oxygen (ppm)	>5	>3-4	>2	<2
• spills	none	none	none	none
BARRIERS	• remove as feasible	• removal as feasible	• minimize as feasible	• minimize as feasible

TABLE 7.4.1: CHARACTERISTICS OF THE EXISTING VERSUS REHABILITATED TERRESTRIAL SYSTEM

Existing System	Rehabilitated System
dominance of wetland and bottomland communities	equal representation of upland, wetland and bottomland communities
numerous small features (< 16 ha)	fewer, but larger features (> 36 ha)
< 50% of natural vegetation in large features (> 36 ha)	> 50% of natural vegetation in large features
most features early to mid-successional	most features mid-successional to mature
most corridors through valley, stream and shoreline features	more corridors established along other features: heights of land, upland vegetation, post glacial features, recharge areas, historic migration routes
extent of lands in native vegetation static	extent of lands in native vegetation increasing
number of native plant and animal species decreasing	number of native plant and animal species increasing
percent composition of non-native species increasing	percent composition of non-native species static or decreasing
individual features composed of few vegetation community types	individual features composed of many vegetation community types
numerous features are irregularly shaped with large perimeter to area ratios	features are regularly shaped with small perimeter to area ratios

TABLE 7.4.2: REPRESENTATIVE COMMUNITIES

A. WOODLAND COMMUNITIES	
A.1 Upland Forest Communities	
A.1.1 Mature Sugar Maple - American Beech Broadleaf Forest	
Canopy	Understorey
trees - sugar maple, american beech, bitternut hickory, white ash, white/red oak, basswood, red maple, paper birch, yellow birch	maple leaf viburnum, beaked hazel, witch hazel, flowering dogwood, serviceberry, rasberry, snowberry, thicket/virginia creeper, (spring vernals), trilliums, New York fern, hairy Solomon's seal, trout lilly, Christmas fern, false Solomon's seal, lily of the valley, partridge berry, beech drops, wild leek
A.1.2 Mature Sugar Maple - Mixed Hardwood Broadleaf Forest	
Canopy	Understorey
sugar maple, bitternut hickory, black/white ash, ironwood, american elm, blue beech, basswood, black walnut	as above and marsh marigold, water hemlock, white avens, fowl meadow grass, spotted touch me not, wood nettle, thicket creeper, trout lilly, cleavers, bedstraws, prickly gooseberry, cufleaved toothwort, zigzag godenrod, downy yellow violet, herb Robert, Christmas fern, maidenhair fern, wild leek
A.2 Successional Broadleaf Forests (upland)	
A.2.1 Trembling Aspen Successional Forest	
Canopy	Understorey
trembling aspen, paper birch, large toothed aspen, red maple, sugar maple	similar to 2, with more shrubs including dogwoods, sumac, choke/pin cherry, viburnums, witch/beak hazel, perhaps with some meadow species. Understorey may also include saplings of mature upland forest
A.2.2 Trembling Aspen - White Ash Successional Forest	
Canopy	Understorey
trembling aspen, white ash, sugar maple, white elm, basswood, balsam poplar	as above
A.2.3 Ironwood - White Ash - Sugar Maple Successional Forest	
Canopy	Understorey
ironwood, white ash, sugar maple, trembling aspen, white cedar	as above

TABLE 7.4.2: REPRESENTATIVE COMMUNITIES, cont'd.

D. SWAMP FORESTS	
D.1 Southern Boreal Swamp	
Canopy	Understorey
tamarack, cedar, white pine, white spruce, black spruce, balsam poplar, paper/yellow birch, aspen	red osier dogwood, labrador tea, raspberry, bunchberry, marsh fern, fowl manna grass, sphagnum
D.2 Silver Maple - Red Maple Swamp	
Canopy	Understorey
usually silver or red maple dominates with black ash, yellow birch, white elm, white ash, balsam basswood, black maple hemlock	dogwoods, mountain maple, riverbank grape, virginia creeper, fowl manna grass, sensitive fern, marsh fern, field horsetail, cut grass, retrorse sedge, cyperus like sedge, false nettle, raspberry, marsh bedstraw, wood fern, devils beggarticks, spotted jewelweed
D.3 Mixed Broadleaf Swamppoplar	
Canopy	Understorey
black ash, elm, aspen, balsam poplar, white/yellow birch	as above with common elder, pussy willow, spotted joe pie weed, water horehound, rough goldenrod, bulbet fern, white snakeroot, wood nettle
D.4 Thicket Swamps	
Canopy	Understorey
usually dominated by dogwoods, alder or willow species. Associated species may include mountain maple, speckled alder, bittersweet, firethorn, winterberry, honeysuckle, sweet gale, chokecherry, swamp rose, peachleaf willow, pussy willow, sand bar willow, black willow, elderberry, meadowsweet, whithrod nannyberry, highbush cranberry	similar to 14 and 15 although maybe sparce

TABLE 7.4.2: REPRESENTATIVE COMMUNITIES, cont'd.

E. SEMI-OPEN AND OPEN HABITATS	
E.1 Savanna	
generally prairie/meadow plant associations with scattered trees or clumps of trees, often specifically limited to oaks, cedars, although others may appear savanna-like	
E.2 Prairie	
big bluestem, little bluestem, side oats grama, kalms brome grass, canada wild rye, prairie june grass, panic grasses, switch grass, indian grass, tall cord grass, dropseeds, needle grass, sedges, bush clovers, wild lupine, flowering spurge, fragrant sumac, New Jersey tea, Virginia flax, racemed milkwort, seneca snakeroot, shrubby St. John's wort, whorled loosestrife, evening primrose, violet, gentian, nut grass, yellow stargrass, white camas, slender ladies tresses, american hazel, hill's oak, bastard toadflax, long fruited anemone, buttercups, rock cress, saskatoon berry, prairie cinquefoil, sand cherry, pasture rose, tick trefoil, wild licorice, bush clover, butterfly weed, green milkweed, false foxglove, mountain mints, pinweed, dragonhead, bluets, puccoon, gromwell, haregell, sky blue aster, smooth aster, arrow leaved aster, field thistle, robins plantain, sneezeweed, rockrose, frostweed, sunflower, blazing star	
E.3 Meadow	
Species of fertile soils	bracken fern, canada bluegrass, wild strawberry, silvery cinquefoil, yellow avens, hairy stemmed spurge, spotten spuge, climbing bittersweet, common milkweed, spreading dogbane, hedge bindweed, heal-all,common gergamot, dogmint, clammy ground cherry, purslane speedwell, canada goldenrod, tall goldenrod, lance leaved aster, calico aster, heath aster, New England aster, annual fleabane, Philadelphia fleabane, sunflowers
Species of impoverished soils	canada bluegrass, poverty grass, ensheathed dropseed, witch grass, sleepy catchfly, wild strawberry, early goldenrod, grey goldenrod, heath aster, annual fleabane, horesweed, pussytoes, pearly everlasting, fragrant cudweed, low cudweed, black eyed susan, woodland sunflower, poison ivy

F.1 MARSHES

G.1 NON-TREED BOGS AND FENS

H.1 OLD FIELD - EXTRACTIVE - AGRICULTURE

TABLE 7.4.3: EDGE PLANTS

Soil Moisture	Dry to Well Drained	Moist, Well Drained	Moist, Poorly Drained
Edge Species	serviceberry bittersweet gray dogwood bush honey suckle pin cherry cokecherry stafhorn sumac shrub roses flowering raspberry red raspberry snowberry	bittersweet gray dogwood red osier dogwood honeysuckle Canada plum staghorn sumac flowering raspberry red raspberry elderberry red elderberry highbush cranberry nannyberry	red osier dogwood firecherry staghorn sumac shrub willows elderberry nannyberry highbush cranberry wild grape

TABLE 7.4.4: SHADE TOLERANT (INTERIOR FOREST) PLANTS

white ash sugar maple mountain maple alternate leaved dogwood chokecherry red berried elder american yew bladdernut	zigzag goldenrod blue cohosh wild ginger early meadow rue eastern bracken wild sarsparilla enchanters nightshade jack in the pulpit wild lily of the valley wild leek	american ginseng black snakeroot goldies fern smiths melic grass climbing false buckwheat assorted fern species herb Robert white snakeroot mosses	virginia greeper canada gooseberry virginia waterleaf purple milic grass red baneberry wild columbine shortscale sedge plaintain leaved sedge thin leaf sedge springels sedge

TABLE 7.4.5: REPRESENTATIVE WILDLIFE

Marsh	Meadow/Scrub	Forest Edge	Forest Interior
american toad	canada goose	gray catbird	red backed salamander
mud puppy	mallard	wood thrush	
spring peeper	blue winged teal	rose breasted grosebeak	veery
gray treefrog	northern harrier	glue gray gnatcatcher	northern waterthrush
striped chorus frog	common snipe upland	red eyed vireo	nashville warbler
northern leaopard frog	sandpiper	white throated sparrow	ovenbird
green frog	morning dove	brown thrasher	scarlet tanager
bullfrog	short eared owl	rufous sided towhee	canada warbler
snapping turtle	willow flycatcher	red tailed hawk	red shouldered hawk
painted turtle	eastern kingbird	mourning dove	yellow bellied
map turtle	blue jay	downy woodpecker	sapsucker
blandings turtle	house wren	northern flicker	pileated woodpecker
Eastern garter snake	robin	black capped chickadee	coopers hawk
northern ribbon snake	gray catbird	blue jay	veery
northern water snake	brown thrasher	purple finch	winter wren
	cedar waxwing	black throated green	white breasted nuthatch
pied billed grebe	golden winged warbler	warbler	brown creeper
american bittern	blue winged warbler		hairy woodpecker
least bittern	yellow warbler	fox	eastern phoebe
canada goose	northern cardinal	coyote	cerulean warbler
mallard	indigo bunting	cottontail	golden crowned kinglet
northern pintail	field sparrow		hermit thrush
bluewinged teal	savannah sparrow		
gadwall	greasshopper sparrow		northern flying squirrel
american wigeon	song sparrow		woodland jumping
osprey	bobolink		mouse
northern harrier	red winged blackbird		lynx
virginia rail	eastern meadowlark		
american coot	american goldfinch		
spotted sandpiper			
swamp sparrow	short tailed shrew		
red winged blackbird	eastern cottontail		
song sparrow	eastern chipmunk		
	woodchuck		
muskrat	deer mouse		
mink	meadow vole		
	meadow jumping mouse		
	coyote		
	red fox		
	white tailed deer		

TABLE 8.1.A
IMPLEMENTATION CONSIDERATIONS FOR STREAM RESTORATION

Plan Component: *Surface Water*

Action: *Restore 8.0 km of streams in Monora Creek, Caledon Tributaries, Credit River & Second Avenue ditch using natural channel design to provide stream stability, riparian vegetation and enhance aquatic habitat. Undertake education/stewardship program.*

Facilitator: *Municipality*

Contributor: *CVC, special interest groups*

Official Plan Considerations: *Develop Official policies which encourage:*

- *natural stream channel design;*
- *supports stream restoration works, where required; and*
- *stewardship programs*

Other Implementation Mechanisms:

Tree By-law pursuant to the Municipal and/or Trees Act
Fill By-law pursuant to the Municipal Act
Topsoil Removal By-law
Work Permits pursuant to the Conservation Authorities Act
Fisheries Act

Time Frame:

short term (0 - 10 yr)	•	*Lower Monora Creek (tributary north and south branches)*
medium term (11 - 20 yr)	•	*Caledon Tributaries, Credit River, Second Avenue, middle Monora Creek*

Cost:

short term (0 - 10 yr)	•	*$2,200,000*
medium term (11 - 20 yr)	•	*$ 581,000*
TOTAL		*$2,781,000*

Funding Alternatives: *Funding through municipal and/or Conservation Authority initiatives, special interest groups, corporations, or environmental foundations.*

Other Comments: *Opportunities to utilize efforts of and funding from non-government sources should be pursued.*

TABLE 8.1.B
IMPLEMENTATION CONSIDERATIONS FOR DEVELOPING AN URBAN FORESTRY PROGRAM

Plan Component: *Greenland*

Action: *Initiate an urban forest program to ensure the long term health of trees/forests within the Town of Orangeville*

Facilitator: *Town of Orangeville*

Contributor: *CVC, special interest groups*

Official Plan Considerations: *General Official Plan policy which supports the formation of a tree rehabilitation and replacement program within the Town*

Other Implementation Mechanisms: *Tree By-law pursuant to the Municipal Act*

Time Frame:

short term (0 - 10 yr) to medium term (11 - 20 yr) • *Town of Orangeville*

Cost:

short term (0 - 10 yr) to medium term (11 - 20 yr) • *$100,000*

Funding: *Alternatives include municipal and landowner/special interest group funds*

Other Comments: *Initiation of a program by staff to educate the public and oversee the plan should be undertaken*

TABLE 8.1.C
IMPLEMENTATION CONSIDERATIONS FOR AGRICULTURE STEWARDSHIP FENCING & BUFFERS

Plan Component: *Surface Water*

Action: *Initiate a program to minimize the impact of livestock access to watercourses. Undertake education/stewardship program.*

Facilitator: *CVC*

Contributor: *OMAFRA, special interest groups*

Official Plan Considerations: *General policies to promote good agricultural practices and stewardship*

Other Implementation Mechanisms:

Time Frame:

short term (0 - 10 yr)

- *Eastern Tributary*
- *Middle Caledon Tributary*

Cost:

short term (0 - 10 yr)

- *$28,800*

Funding: *Alternatives include joint funding between CVC, OMAFRA, landowner and special interest groups*

Other Comments: *Staff to work with rural landowners to provide education and technical assistance. Opportunities for financing through special interest groups to be considered.*

TABLE 8.1.D
IMPLEMENTATION CONSIDERATIONS FOR NATURALIZATION OF SIGNIFICANT NATURAL FEATURES
(including Environmentally Significant Areas)

Plan Component: *Greenland*

Action: *Protect lands designated as Significant Natural Features, undertake education/stewardship program, develop regeneration/management plans*

Facilitator: *Municipality/CVC*

Contributor: *Municipality/CVC, MNR, OMAFRA, special interest groups*

Official Plan Considerations: *Designation of natural environmental resources (as identified in the Subwatershed No. 19 Recommended Plan) within each municipal Official Plan, using either existing/new land use designations. Inclusion of associated land use policies to control development adjacent to these areas, including completion of EIS's.*

Other Implementation Mechanisms:
Tree By-law pursuant to the Municipal and/or Trees Act
Fill By-law pursuant to the Municipal Act
Public land acquisition policies in built up areas

Time Frame:

short to long term (0 - 30 yr)

- *Rosehill Swamp*
- *Melville Marsh*
- *Orangeville Reservoir*
- *Monora Park*
- *Dufferin Hunters & Anglers property*

Cost:

short to long term (0 - 30 yr)

- *$500,000 to $2,000,000 or $17,000 to $66,000 annually*

Funding: *Funding through municipal and/or Conservation Authority initiatives, special interest groups, corporations, or environmental foundations.*

Other Comments: *Development of a successful education/stewardship program is the key to implementing program. Coordinated efforts with special interest including Upper Credit Field Naturalists should be pursued. Cost dependent upon further work defining degree by which natural regeneration is occurring and availability of nursery stock through existing programs. Donations from trust funds, private sector to be considered as should cost sharing with private landowner. Development of a Management Plan for each area is also required.*

TABLE 8.1.E
IMPLEMENTATION CONSIDERATIONS FOR NATURALIZATION PLANS FOR VALLEYLAND CORRIDORS

Plan Component: *Greenland*

Action: *Protect lands along designated corridors; undertake appropriate eduction/stewardship program; regeneration of 5.9 km of valleyland corridors*

Facilitator: *Municipality/CVC*

Contributor: *MNR, OMAFRA, special interest groups*

Official Plan Considerations: *Designation of valleyland corridors (as identified in the Subwatershed No. 19 Recommended Plan) within each municipal Official Plan, using either existing/new land use designations. Inclusion of land use policies to control development adjacent to these areas.*

Other Implementation Mechanisms:

Tree By-law pursuant to the Municipal Act
Fill By-law pursuant to the Municipal Act
Fill permits pursuant to the Conservation Authorities Act
Public land acquisition policies in built up areas
Environmental Impact Studies

Time Frame:

short to long term (0 - 30 yr)

- *Rosehill Swamp to Melville Marsh*
- *Dufferin Hunters & Anglers/Monora Park to Orangeville Reservoir*
- *Orangeville Reservoir to Melville Marsh*
- *Melville Marsh to adjacent Credit Valley*

Cost:

short to long term (0 - 30 yr)

- *$500,000 to $2,000,000 or $17,000 to $66,000 per year*

Funding: *Funding through municipal and/or Conservation Authority initiatives, special interest groups, corporations, or environmental foundations.*

Other Comments: *Development of a successful education/stewardship program is the key to implementing program. Cost dependent upon further work defining degree by which natural regeneration is occurring. Stewardship agreements regarding public access needs to be considered. Development of guidelines for management/maintenance of lands including use of native species needed.*

TABLE 8.1.F
IMPLEMENTATION CONSIDERATIONS FOR NATURALIZATION OF UPLAND VEGETATED CORRIDORS AND KEY TABLELAND WOODLOTS

Plan Component: *Greenland*

Action: *Undertake a plan with private landowners to enhance existing woodlots/corridors through revegetation*

Facilitator: *CVC/Municipality*

Contributor: *Municipality, MNR, special interest groups*

Official Plan Considerations: *Incorporation of policies to maintain and encourage enhancement of key corridors and tableland woodlots. Incorporation of revegetated areas into Official Plans as Class 1 or 2 lands.*

Other Implementation Mechanisms: *Tree By-law pursuant to the Municipal and/or Trees Act, Development Agreements, Preformance Contracts Environmental Impact Studies*

Time Frame:
short to long term (0 - 30 yr)

Cost:
short to long term (0 - 30 yr)

- *included with Valleyland Corridor costs*

Funding: *Funding through municipal and/or Conservation Authority initiatives, special interest groups, corporations, or environmental foundations.*

Other Comments: *Development of a successful education/stewardship program is the key to implementing program. Revegetated areas should be protected from land use change via policy or Official Plan designation*

Table 3.9 Rosgen (1993) classification of stream types for the study sites.

Station	Rosgen(1994) Stream Type	Entrenchment Ratio	Width / Depth Ratio	Sinuosity	Channel Slope	Channel Material
SITE 1	E4b (bf)	5.74	5.04	1.05	.026	gravel
SITE 2	E5	31.45	6.16	1.53	.006	sand
SITE 3	E5b (bf)	5.0	5.5	1.12	.031	sand
SITE 4	C5	6.96	14.13	1.40	.0033	sand
SITE 5	E4b (bf)	5.41	6.41	1.10	.021	gravel

bf = best fit

Table 3.10 Plan and Profile Characteristics

Station	Bankful Width (m)	Bankful Depth (m)	Bank Height (m)	Floodplain Width (m)
SITE 1	2.87	.57	.97	16.5
SITE 2	2.34	.38	.48	73.6
SITE 3	2.0	.36	.6	10.0
SITE 4	10.6	.75	.9	73.75
SITE 5	3.4	.53	.76	18.4

Table 3.11 Hydraulic, Substrate and Sediment Characteristics

Station	Bankful Discharge (cms)	Measured Discharge (cms)	Mannings 'n'	Substrate (mm)		Substum (mm)	
				D_{50}	D_{85}	D_{50}	D_{85}
SITE 1	0.383	0.10	.062	1.5	7.0	1.85	6.25
SITE 2	0.549	0.10	.051	.1	5.5	.18	5.0
SITE 3	0.308	0.03	.048	.16	3.1	.7	5.0
SITE 4	6.136	0.88	.035	1.3	3.0	.19	2.6
SITE 5	0.470	0.03	.055	6.0	13.0	3.3	8.9

TABLE 3.12: Comparison of Observed and Simulated Flow Volumes By Season for 1990

SEASONAL PERIOD	OBSERVED FLOW SERIES (OBS; m^3)	PREDICTED FLOW SERIES (SIM; m^3)	(OBS/SIM)
JAN-FEB	391*	515	1.32
MAR-APR-MAY	994	995	1.00
JUN-JUL-AUG	303	653	2.16
SEP-OCT-NOV	493	699	1.42
DEC	267	299	1.12
TOTAL	2,448	3,161	1.29

* Corrected For Missing Flows

TABLE 3.13: Comparison of Hydrologic Budget Components for Urban and Non-Urban Land Use Types

LAND USE	HYDROLOGIC COMPONENT			
	Q (%)	I (%)	ET (%)	BASFLO (%)
URBAN	19.8-28.5	40-46	30-40	7.5-41.1
AGRICULTURAL	7.2-11.7	45-53	38-46	9.1-94

TABLE 3.14: Baseflow Component by Sub-Basin

SUB-BASIN No.	BASEFLOW		LAND USE TYPE	PHYSIOGRAPHIC UNIT
	(mm)	(%)*		
325	56	12	AGR	SD/GO
326	-	98	RES	SD/CST/GO
327	258	62	RES	SD/CST
323	337	69	AGR	SD/GO
321	47	10	AGR	SD/GO
328	30	7.5	RES	GO/SD
311	350	72	AGR	SD/GO/CST
312	310	64	AGR	SD/GO
313	245	51	AGR	GO/SD
331	52	9.8	AGR	SST/SD/GO
332	47	9.1	AGR	SD/CST/GO
333	27	9.5	RVR	GO/SST
304	55	11.7	COM-RES	CST/GO/SD
351A	341	66	AGR	SD/GO/CST
351B	48	9.3	AGR	SD/GO
352	46	9.3	AGR-RES	CST/GO
353	70	17.2	BUS-RES	CST
361	STP	n/a	RES	GO/CST/SD
362	492	94	AGR	GO/SD/CST
363	498	93	AGR	SD/CST
365	496	91	AGR	SST/SD
367	130	25	AGR	SST/SD
368	338	62	AGR	GO/SD

RES = REsidential; AGR = Agricultural; BUS = Business; COM = Commercial; RVR = Reservoir; STP = Sewage Treatment Plant; SD = Stratified Drift; GO = Glaciofluvial Outwash; CST = Clay Silt Till; SST = Sand Silt Till

* Expressed as a percent of infiltration

TABLE 3.15: BIOTIC INDEX VALUES FOR STATIONS LOCATED IN THE CREDIT RIVER SUBWATERSHED NO. 19

	Station											
	1	2	3	4	6	7	8	9	10	11	12	13
Biotic Index												
Water Quality Index	9	13	13	9	7	8	7	10	15	14	16	11
EPT Index	14	19	19	14	5	9	5	5	13	17	15	15
% Oligochaeta	6	0	1	1	5	5	2	76	9	0	0	0
% Ephemeroptera	1	25	18	3	1	4	0	1	4	14	38	21
% Plecoptera	1	8	6	0	0	0	0	0	2	2	7	1
% Trichoptera	16	14	21	70	17	8	42	3	39	44	18	14
% Coleoptera	3	5	1	5	15	24	45	5	3	24	13	36
% Chironomidae	39	7	28	9	51	47	2	2	29	5	6	4
% Hydropsychidae of Trichoptera	94	44	81	99	100	93	100	94	55	77	30	92

Legend:

Station No. 1:	Credit River upstream of Melville
Station Nos. 2 - 4:	Caledon Tributaries
Station Nos. 6 - 7:	Mill Creek
Station Nos. 8 - 12:	Monora Tributaries
Station No. 13:	Eastern Tributaries

TABLE 3.16: FRAMEWORK FOR CHARACTERIZING ENVIRONMENTAL QUALITY IN SUBWATERSHED NO. 19

RESTORATION/REHABILITATION/ENHANCEMENT/MITIGATION PROTECTION

Type I Pristine Aquatic Community	Type II Slightly Degraded Aquatic Community	Type III Moderately Degraded Aquatic Community	Type IV Severely Degraded Aquatic Community
FISHERIES			
IBI >36 • brook trout	IBI <36 • brook trout	IBI <30 • pike • darters • sunfish • suckers • mimic shiner • common shiner	• longnose dace • central mudminnows • brown bullhead • brook stickleback
MACROINVERTEBRATES			
WQI >13 At least four of the following: • *Leuctra* • *Ectopria* • *Diplectrona* • *Promoresia* • *Glossosoma* • *Parapsyche*	WQI = 11 - 13 At least eight of the following: • *Isoperla* • *Baetis* • *Paraleptophlebia* • *Amphinemura* • *Leuctra* • *Taeniopteryx* • *Hydroptila* • *Rhyacophila* • *Diplectrona* • *Neophylax* • *Diamesa*	WQI = 9 - 10 At least ten of the following: • *Turbellaria* • *Nais pardalis/bretscheri* • *Tubifex tubifex* • *Erpobdella dubia* • *Baetis* • *Palaleptophlebia* • *Stenonema vicarium* • *Optioservus* • *Cheumatopsyche* • *Hydropsyche* • *Micropsectra* • *Polypedilum* • *Simulidae* • *Pseudolimnophila* • *Ferrissia*	WQI < 8 At least seven of the following: • *Nais pardalis/bretscheri* • *Limnodrilus hoffmeisteri* • *Tubifex tubifex* • *Cheumatopsyche* • *Hydropsyche* • *Optioservus* • *Erpobdella dubia* • *Probezzia* • *Ceratopogon* • *Rheotanytarsus* • *Chaetocladius* • *Diplocladius* • *Parametriocnemus* • *Physella*
STATION LOCATION			
Monora Creek • upper reaches of northern and southern tributaries **Mill Creek** • short section in upper reaches between Hwy 9 and B Line **Caledon Tributaries** • lower reaches of tributaries 2 and 3	**Monora Creek** • middle and lower reaches of northern tributary • upper and lower reaches of southern tributary **Mill Creek** • small sections in upper reaches **Eastern Tributaries** • small section of lower and middle reaches **Caledon Tributaries** • lower reaches of tributary 1 **Credit River** • between Hwy 10 crossings	**Monora Creek** • middle reaches of southern tributary **Mill Creek** • small section of upper reaches north of Hwy 9 • lower reaches **Eastern Tributaries** • sections of lower reaches **Caledon Tributaries** • section of middle and upper reaches, tributaries 2 and 3 **Credit River** • south of Reservoir above northernmost Hwy 10 crossing • Orangeville Reservoir • Melville Marshes	**Monora Creek** • middle tributary **Mill Creek** • middle reaches **Eastern Tributaries** • majority of upper and middle reaches **Caledon Tributaries** • majority of upper reaches and sections of middle reaches for all tributaries

TABLE 3.17: BIOPHYSICAL PERFORMANCE STANDARDS FOR AQUATIC ECOSYSTEM OBJECTIVES - SUBWATERSHED NO. 19

Aquatic Performance Standard	AQUATIC ECOSYSTEM OBJECTIVE			
	Type I	Type II	Type III	Type IV
HYDROLOGY				
• baseflow	• minimum 30% of average annual daily flow	• minimum 10-20% of average annual daily flow	• minimum 5% of average annual daily flow or sufficient to maintain isolated pools	• minimum to maintain isolated pools, may be <5% of average annual daily flow
• bankfull frequency	• 1-2 times per year	• 1-2 times per year	• as required to protect downstream aquatic communities	• as required to protect downstream aquatic communities
CHANNEL MORPHOLOGY	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features
• average pool area as % of total surface area at low flow	• >12%	• >4%	• >4%	• >4%
• average riffle area as % of total surface area at low flow	• >12%	• >10%	• generally >5%	• may be <5%
• average minimum summer pool depth	• 0.5 m	• 0.3 m	• 0.2 m	• 0.2 m
• bankfull width to depth ratio	• generally <10	• generally 5-10	• generally 5-10	• no requirement
IN-STREAM COVER	• minimum total in-stream cover 30-40% by surface area • woody debris present up to 10% of surface area • minimum 15% of surface area with overhead cover • minimum 5% of surface area with overhead cover	• minimum 10% of stream area during low flow • 10-20% of bottom of pool/backwater habitats covered by logs, vegetation, woody debris and boulder • cover at stream margins critical for juvenile fish	• minimum 5% of stream area during low flow • 10% of bottom of poola/breakwaters covered by logs, vegetation, woody debris and boulder	• minimum 5% of stream area during low flow • 5% of bottom of pools/ backwaters covered by logs, vegetation, woody debris and boulders

TABLE 3.17: BIOPHYSICAL PERFORMANCE STANDARDS FOR AQUATIC ECOSYSTEM OBJECTIVES - SUBWATERSHED NO. 19

Aquatic Performance Standard	AQUATIC ECOSYSTEM OBJECTIVE			
	Type I	Type II	Type III	Type IV
SUBSTRATE	• well-sorted riffle zones • maximum 25% fines in spawning substrates • maximum 30% fines in riffle zones • upwelling conditions required • minimum 50% of riffles composed of cobble, rubble, small boulder	• D50 in pools generally <80 mm • fines in riffle zones moderate to low (<50%)	• D50 in pools generally <40 mm • more fines in riffle zones,generally >50%	• no requirement
RIPARIAN HABITAT				
• shaded during 1000-1400 hr	• minimum 35%	• minimum 0% • maximum 50-75%	• minimum 0% • maximum 75%	• minimum 0% • maximum 100%
• woody debris	• important component of in-stream cover and roughness	• important for roughness and refuge during peak flows	• woody debris less important	• less important
WATER QUALITY				
• maximum annual water temperature	22°C	30°C	31-35°C	31-35°C
• average annual total suspended solids (ppm)	<20	<150	<200	<400
• dissolved oxygen (ppm)	>5	>3-4	>2	<2
• spills	none	none	none	none
BARRIERS	• remove as feasible	• removal as feasible	• minimize as feasible	• minimize as feasible

TABLE 3.18: SUMMARY OF IBI RESULTS, CREDIT RIVER SUBWATERSHED 19, JULY - AUGUST 1994.																		
FISH SAMPLING STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TOTAL NO. OF FISH	179	184	65	47	23	106	6	68	228	203	27	156	31	124	0	60	53	32
TIME (seconds)	463	684	1009	704	804	402	769	507	603	725	571	701	750	947	157	842	760	996
WATERSHED AREA (km2)	3.1	5.4	45.3	4.3	42.9	1.9	40.6	2.2	6.1	9.5	2.2	2.9	2.3	6.3	1.1	12	2.9	1.9
NATIVE SPECIES	10	3	9	2	4	3	2	2	5	5	2	5	1	7	0	7	1	3
DARTERS / SCULPINS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SUNFISH / TROUT	2	1	2	1	1	0	0	0	0	0	2	0	1	1	0	3	1	1
SUCKERS / CATFISH	1	1	1	0	1	0	1	0	0	1	0	1	0	2	0	1	0	0
BROOK TROUT	1	1	1	1	1	0	0	0	0	0	1	0	1	1	0	1	1	1
LONG/BLACKNOSE DACE	16	0	16	0	1	0	0	57	130	1	0	130	0	36	0	8	0	7
OMNIVOROUS CYPRINIDS	108	0	5	0	0	13	0	0	8	5	0	3	0	0	0	0	0	0
CARNIVORES > 20cm	0	5	0	0	0	0	0	0	0	0	0	0	1	2	0	1	2	1
BLACKSPOT	7	0	3	0	0	0	0	0	0	2	0	3	0	7	0	0	0	1
CATCH per UNIT EFFORT	23.2	16.1	3.9	4.0	1.7	15.8	0.5	8.0	22.7	16.8	2.8	13.4	2.5	7.9	0.0	4.3	4.2	1.9
IBI	38	42	34	30	28	30	24	26	26	32	34	30	36	40	0	36	34	38
SCORE	3	4	3	2	2	2	2	2	2	3	3	2	3	3	0	3	3	3
HEALTH	Good	Excellent	Good	Fair	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Good	Good	No Fish	Good	Good	Good

Legend:

Station No. 1	Caledon Tributary C	Station No. 2	Caledon Tributary B
Station Nos. 3, 5, 7	Credit River	Station Nos. 4, 6	Caledon Tributary A
Station Nos. 8, 9, 10	Mill Creek	Station Nos. 11 - 18	Monora Creek

TABLE 5.1: LISTING OF ALTERNATIVE BMPs

Section No.	Alternative
5.3.1	Water Quality/Quantity Facilities
5.3.2	Infiltration Facilities
5.3.3	Site Planning
5.3.4	Aquatic Habitat Restoration
5.3.5	Terrestrial Habitat Restoration
5.3.6	Wetland Creation
5.3.7	Source Control
5.3.8	Public Education
5.3.9	Reforestation
5.3.10	Sediment/Erosion Control
5.3.11	Natural Channel Design
5.3.12	Urban Retrofitting
5.3.13	Buffer Zones
5.3.14	Groundwater and Baseflow Protection

TABLE 5.4.1: RURAL BMP's

1. BUFFERS

Buffer/Filter Strip
Fenced Waterways
Grassed Waterways

2. QUANTITY/QUALITY CONTROL FACILITIES

Settling Ponds
Manure Storage Facilities
Milkhouse Waste Treatment
I Slots
Irrigation Tailwater Recovery
Septic System Replacement

3. SITE PLANNING

Strip Cropping
Crop Rotation
Conversation Tillage
Terracing
Cover Cropping
No Till Crop Production
Ridge-Till
Contour Cropping

4. SOURCE CONTROLS

Integrated Past Management
Fertilizer Management
Management of Permanent Vegetation
Pesticide Management
Animal Waste Management

5. REFORESTATION

Critical Area Planting
Woodlot Management

6. NATURAL CHANNEL DESIGN

7. WETLAND CREATION

8. PUBLIC EDUCATION

9. TERRESTRIAL HABITAT ENHANCEMENT

10. GROUNDWATER RECHARGE AND BASEFLOW PROTECTION

TABLE 6.1: MAINTAIN EXISTING ECOLOGIC CONDITIONS

Measure	Description	Environmental Benefit	Cost	Comments
Stream Restoration	• restore 1.3 km of stream to stabilize reaches and protect aquatic, terrestrial habitat	• correct stream instability which leads to erosion, excessive sediment supply • protect existing aquatic, terrestrial habitat	$780,000	• average cost of $600/metre used • use of volunteer groups could reduce unit cost
Agriculture Stewardship Fencing and Buffers	• undertaking of fencing and buffer program at two locations to stabilize stream reaches	• reduce stream bank erosion • reduce bacterial loadings	$25,000	• cost estimate includes supply of material and volunteer labour to undertake measure
Groundwater Management Strategy	• undertake a study to protect groundwater	• protection of local groundwater supply and baseflow to local streams	$100,000 to $150,000	• estimate includes only the cost to undertake study
Urban Forestry Program	• undertake urban program to protect sustainability of urban forest habitat	• protection of trees and associated habitat in urban areas	$100,000	• cost estimate based on annual costs of $10,000 to provide expertise and materials
Recreational Trail System	• develop recreational trail system that protects ecologic linkages and functions	• recreational • educational	not costed	
Best Management Practices for Urbanizing Areas	• select a series of BMPs that will protect existing environmental conditions should land use changes occur	• all natural environmental resources are to be protected	not costed	• see Section 7.6 for further details

TABLE 6.2: RESTORATION AND ENHANCEMENT OF KEY ECOLOGIC CONSTRAINTS

Measure	Description	Environmental Benefit	Cost	Comments
Stream Restoration	• restore 5.2 km of stream to stabilize reaches and protect aquatic, terrestrial habitat	• correct stream instability which leads to erosion, excessive sediment supply • protect existing aquatic, terrestrial habitat	$2,600,000	• average cost of $600/metre used • use of volunteer groups could reduce unit cost
Agriculture Stewardship Fencing and Buffers	• undertaking of fencing and buffer program at two locations to stabilize stream reaches	• reduce stream bank erosion • reduce bacterial loadings	$10,000	• cost estimate includes supply of material and volunteer labour to undertake measure
Flood Protection	• carry out flood protection program to reduce susceptibility to flooding	• reduction in flood susceptibility	$85,000	
Naturalization of Significant Natural Features and Valleyland Corridors	• restore/enhance habitat conditions in core vegetated areas and along valleyland corridors (1,250 ha of which up to 430 ha may need revegetation)	• wildlife habitat • core natural areas • representative communities • unique features • high biodiversity • habitat for special status species • hydrologic function • support aquatic systems	$500,000 to $2,000,000	• average cost of $5,000/ha • naturalization of 75 percent to 0 percent • cost includes plant species, volunteer labour assumed
Naturalization of Upland Vegetated Corridor and Key Tableland Woodlots	• restore/enhance habitat conditions along upland corridors and woodlots in high recharge areas (450 ha)	• hydrologic function • wildlife habitat • representative communities • high biodiversity	$500,000 to $2,000,000	• average cost of $5,000/ha • naturalization of 75 percent to 0 percent • cost includes plant species, volunteer labour assumed

Measure	Description	Environmental Benefit	Cost	Comments
Restoration of Existing Stormwater Management Facilities and On-Line Ponds	• restoration/removal of six man-made ponds or stormwater management facilities	• water quality • terrestrial habitat • aquatic resources • recreation • education	$1,500,000	• unit cost of $100,000 to $150,000 for five ponds/facilities • $750,000 for Milady Pond
Relocation of Well No. 5	• relocation of well such that impact on baseflow in streams is reduced	• baseflow • aquatic resources • water quality	$500,000	• estimate based on similar works completed elsewhere
Removal of Melville Dam	• removal (or by-pass) of Melville Dam to restore natural channel characteristics and improve habitat for native fishery	• water temperature • restore natural channel characteristics • aquatic resources	$1,100,000	• estimate based on similar works completed elsewhere • $300,000 for dam removal and $800,000 for stream restoration works

TABLE 6.3: PROPOSED MEASURES AND ASSOCIATED BENEFITTING ENVIRONMENTAL RESOURCES

Measure	Benefitting Environmental Resources						Cost Range[1] (thousands)
	Groundwater	Terrestrial Resources	Aquatic Resources	Stream Stability	Water Quality	Flooding	
Stream Restoration		✓	✓	✓	✓		800 - 4800
Develop Urban Forestry Program	✓	✓					100
Livestock Access Restriction			✓	✓	✓		30 - 40
Flood Protection						✓	0 - 100
Naturalization of Significant Natural Features (including Environmentally Significant Areas)	✓	✓	✓				500 - 2000*
Naturalization of Valleyland Corridors		✓	✓	✓			
Naturalization of Upland Vegetated Corridor and Key Tableland Woodlots	✓	✓					500 - 2000*
Retrofitting of Existing Stormwater Management Facilities and Ponds			✓	✓	✓		0 - 1900
Development of a Groundwater Management Plan	✓		✓				100 - 150
Development of Recreational Trail System		✓					n/c
Relocation of Well No. 5	✓		✓				0 - 500
Removal of Melville Dam			✓				300
Various Measures for Approved Developments	✓	✓	✓	✓	✓	✓	n/c

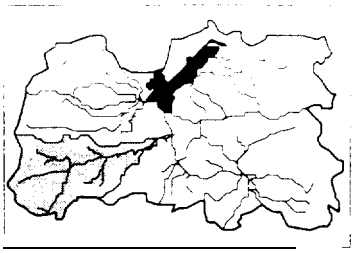
Legend:

[1] Cost is dependant upon which Ecologic Level is selected.

* Includes cost of plant material only; Volunteer/community programs assumed for planting; Range of costs given dependant upon 75% to 0% natural regeneration.

n/c Not costed.

CREDIT RIVER SUBWATERSHED 19
MILL CREEK FACT SHEET



Environmental Resources

Groundwater Resources
- significant baseflow contribution in the upper reaches above 'C' -Line
- baseflow is highly sensitive to groundwater withdrawal from the overburden or shallow bedrock
- highly susceptible to contamination

Surface Water Resources
- ***92*** ha drainage area
- permanent baseflow in headwaters, however some reduction in volume through the Town of Orangeville resulting in intermittent conditions
- 3 flood prone areas, Mill Creek at the Credit River, Dawson Road, and Centre Street East of Broadway

Aquatic Resources
- Level 2 riparian and valley corridor
- (30 % of riparian corridor in natural vegetation
- moderate to very tolerant warmwater community

Terrestrial Resources
- ***22*** features in high recharge or on riparian corridors (18 <4ha, 3@4-16 ha, l@ 16-32ha)
- 1 primary terrestrial corridor for protectiotire/vegetation
- 5 other features < 4ha

Stream Morphology
- ***50*** percent of the watercourses have natural channel systems, primarily in headwater streams
- 50 percent of the watercourses are channelized and encroached upon by historical development within the Town of Orangeville

Existing Land Uses
- = ***60%*** urbanized (Town of Orangeville)
- = 15% zoned for future urban development

Environmental Protection Targets

Groundwater
- maintain or enhance on-site recharge and discharge volumes
- maintain current groundwater quality
- protect groundwater discharge areas and volumes

Surface water quantity and quatity
- maintain existing peak flows for the 100 year storm (9.49 ml/s @ Credit River, also see Table A1.9)
- maintain baseflow as a minimum
- maximum temperature 22°C in headwater streams
- Total Phosphorus 10.1 mg/L (annual average for dry/wet weather conditions)
- Suspended Solids ≤ 20/200 mg/l (annual average for dry/wet weather conditions)
- Dissolved Oxygen 5.0 mg/L minimum at all times
- *E. coli.* 100/1,000 cts/100ml (geometric mean conditions for dry/wet weather conditions)

Aquatic Communities
- Class III moderate tolerant aquatic community
- Level 2 riparian and valley corridor
- at least 5 % of stream reaches pool:riffle dominated
- minimum pool depths: 0.2 m
- 30-50 % of banks width woody riparian vegetation

Terrestrial Communities

- protect all Class I features
- use native species for revegetating corridors
- select vegetation community types based on soil moisture/fertility, flooding/water table regime and composition of adjacent communities (also see Tables 7.4.2 to 7.4.4)
- establish terrestrial corridor (minimum width 100 m) as per Figure 7.1

Stream Morphology

- maintain post-development shear stress conditions on channel systems to pre-development conditions by controlling bankfull frequencies and durations
- maintain dynamically stable, natural channel systems
- balance sediment regime
- minimize fine sediment loads from runoff

Key Best Management Practices (refer to Section 5.0 of the main report for details)

- stormwater runoff volume controls utilizing large open space areas and centralized end of pipe facilities to infiltrate clean runoff for maintaining water budget and stream bankfull flow conditions.
- stormwater runoff flow controls and detention ponds for flood control, water quality control and stream morphology protection (see Table A 1.12).
- flood protection works at Dawson Road
- natural channel design for all stream works
- upland forest corridor resource enhancement
- riparian planting along Level 2 riparian and valley corridor
- development exclusion in all Class I features
- minimize withdrawals adjacent to the upper reaches of Mill Creek
- minimize the potential for contaminant spills and minimize applications of de-icing agents, fertilizers, pesticides etc.

Future Study Requirements

General

- Environmental Management Planning Studies on a tributary bases (may include studies listed below)
- headwater tributary assessments
- develop community (neighbourhood) based stream improvement program linking into urban renewal and cultural heritage programs

Groundwater Resources

- detailed hydrologic studies on baseflow impacts for any future groundwater withdraw or stormwater management facilities
- assessment of potential impacts of Wells 2, 3, 4 and 7 on Mill Creek

Surface Water Resources

- Hydrologic update reporting, for maintaining peak flows from proposed land use changes, as required

Aquatic Resources

- inventory headwaters for presence of coldwater species
- identify riparian and valley corridor width based on functional characteristics and existing vegetation features

Terrestrial Resources

- EIS required adjacent to all Class I features
- EIS required within/adjacent to all Class III features
- Naturalization plans for all Class I/II riparian /valley corridors and terrestrial regeneration areas

Stream Morphology

- detailed fluvial geomorphology study to determine design criteria for managing bankfull flow conditions and for natural channel design works, as required

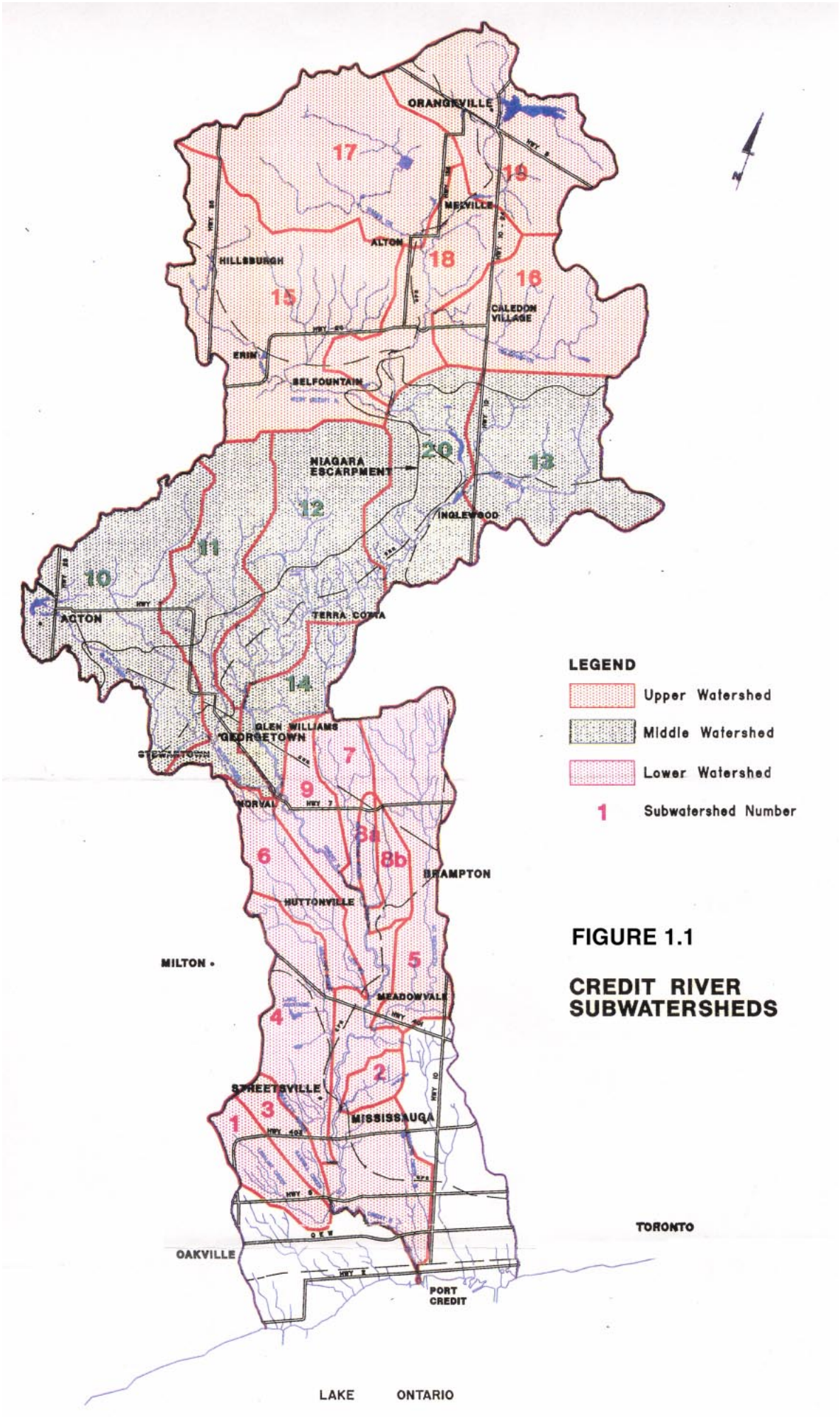


FIGURE 1.1

CREDIT RIVER SUBWATERSHEDS

CREDIT RIVER SUBWATERSHED 19

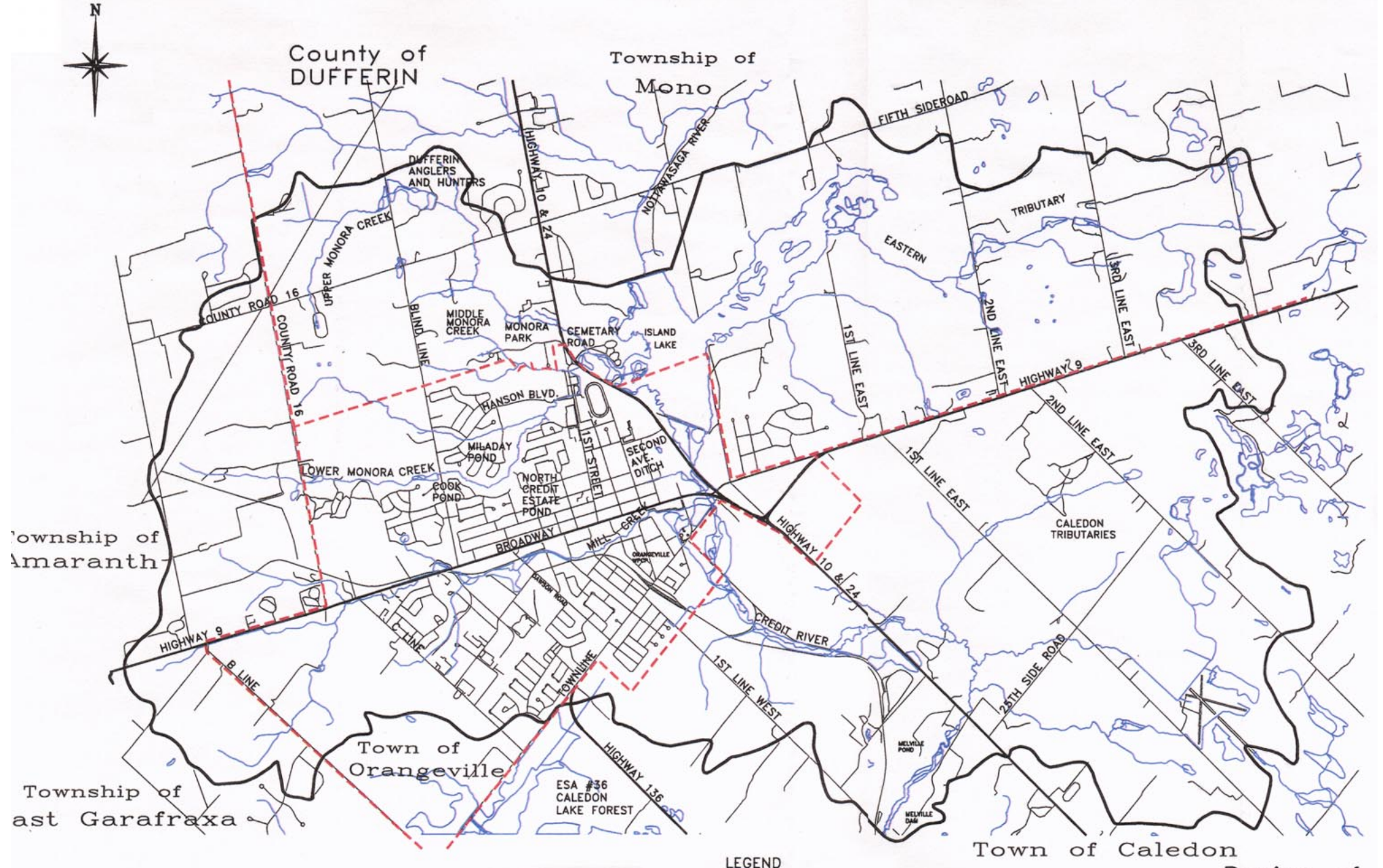


FIGURE 1.2

CREDIT RIVER SUBWATERSHED 19 STUDY—EXISTING LAND USE

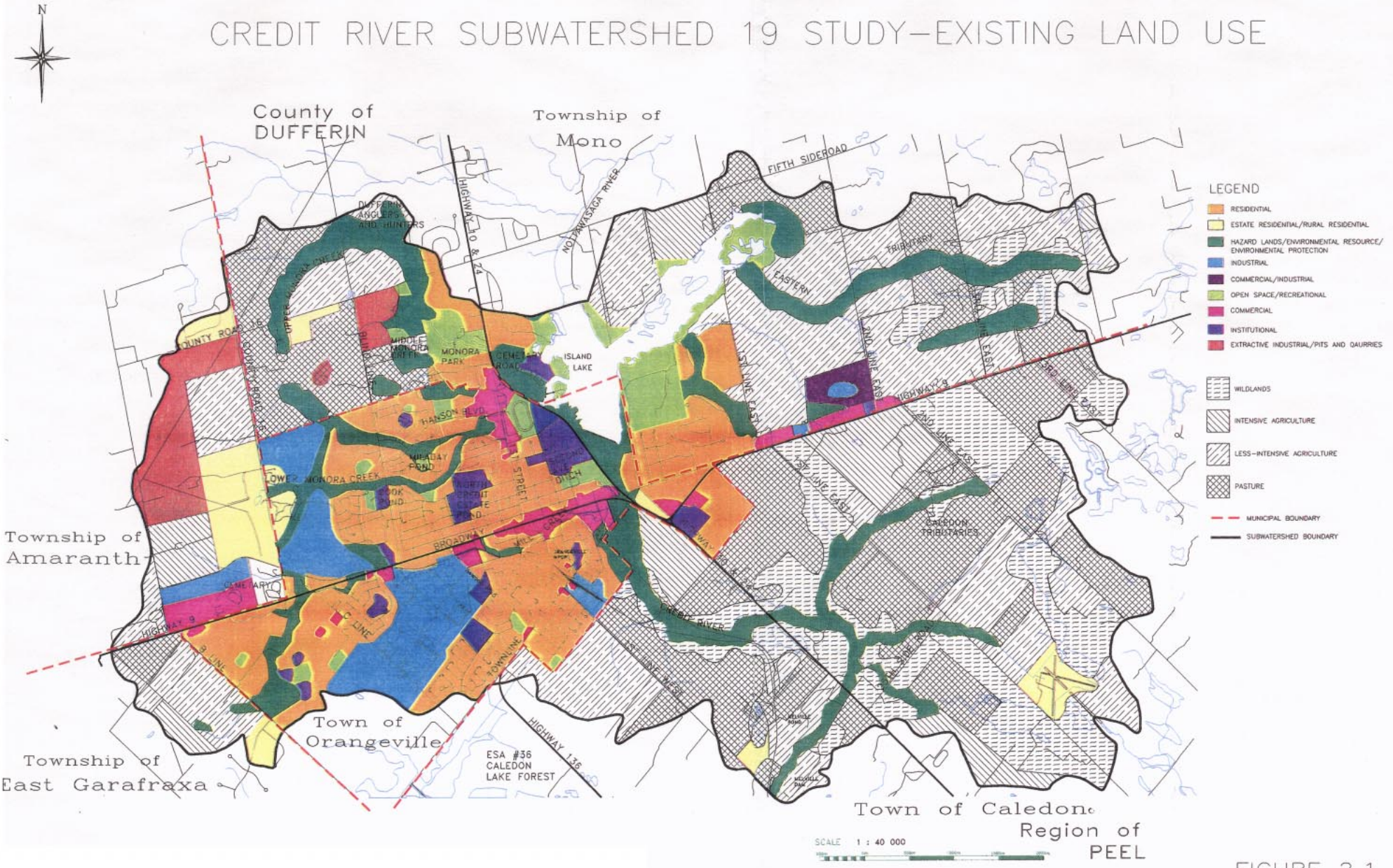


FIGURE 2.1

Credit 19 Subwatershed - 3-D View

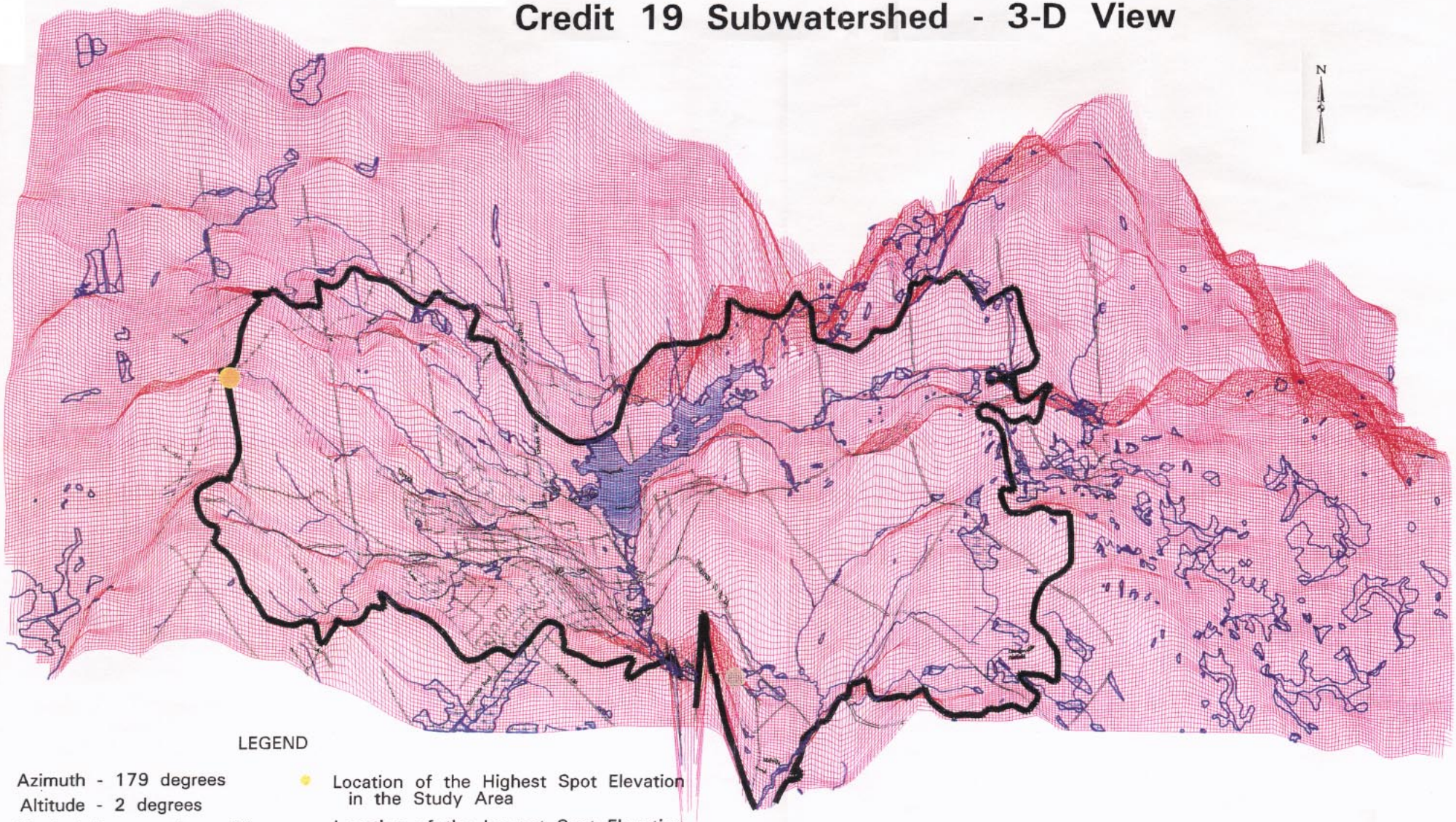


Figure 2.2

CREDIT RIVER SUBWATERSHED 19 STUDY—ENVIRONMENTAL MONITORING SITES

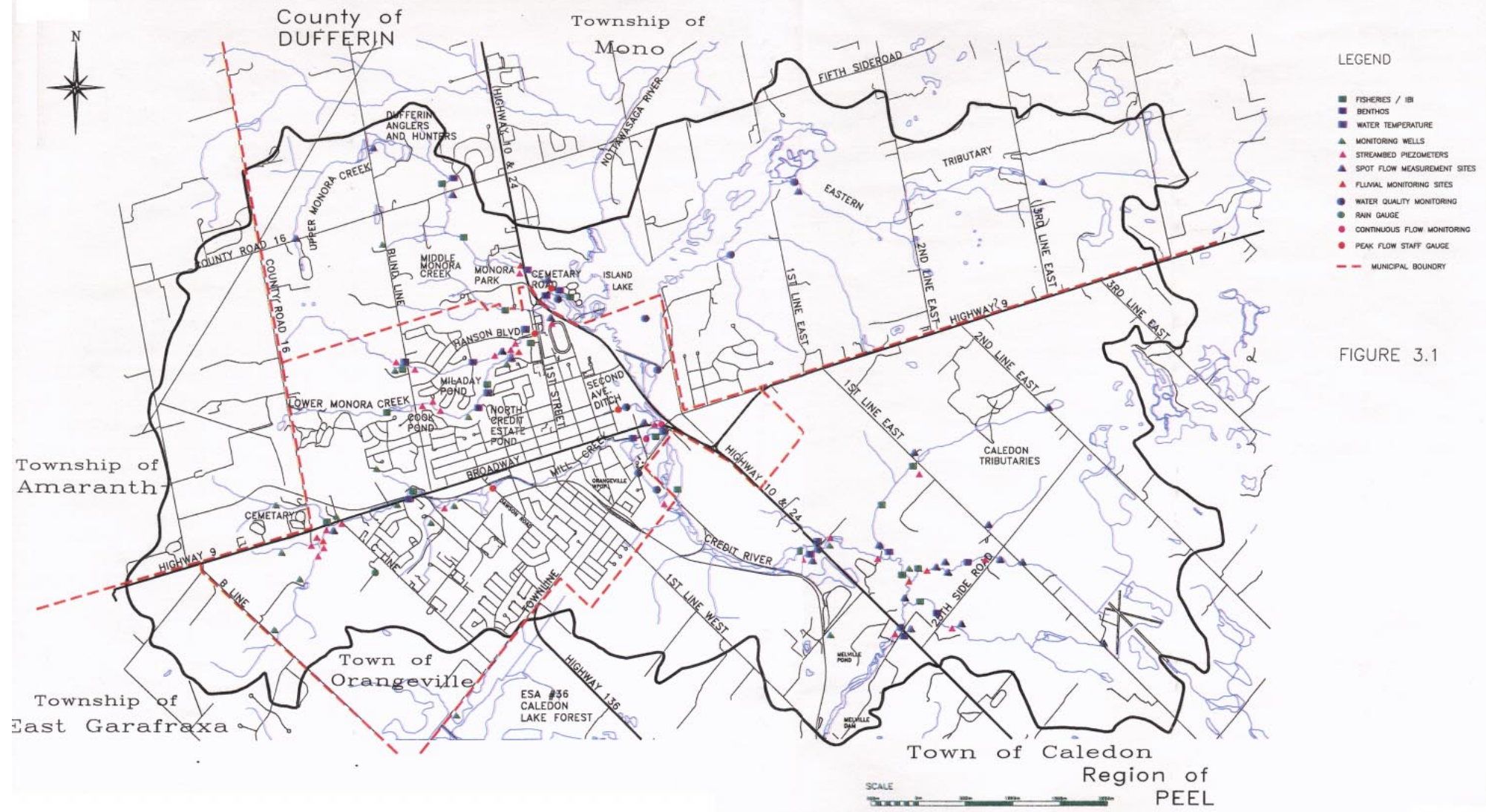
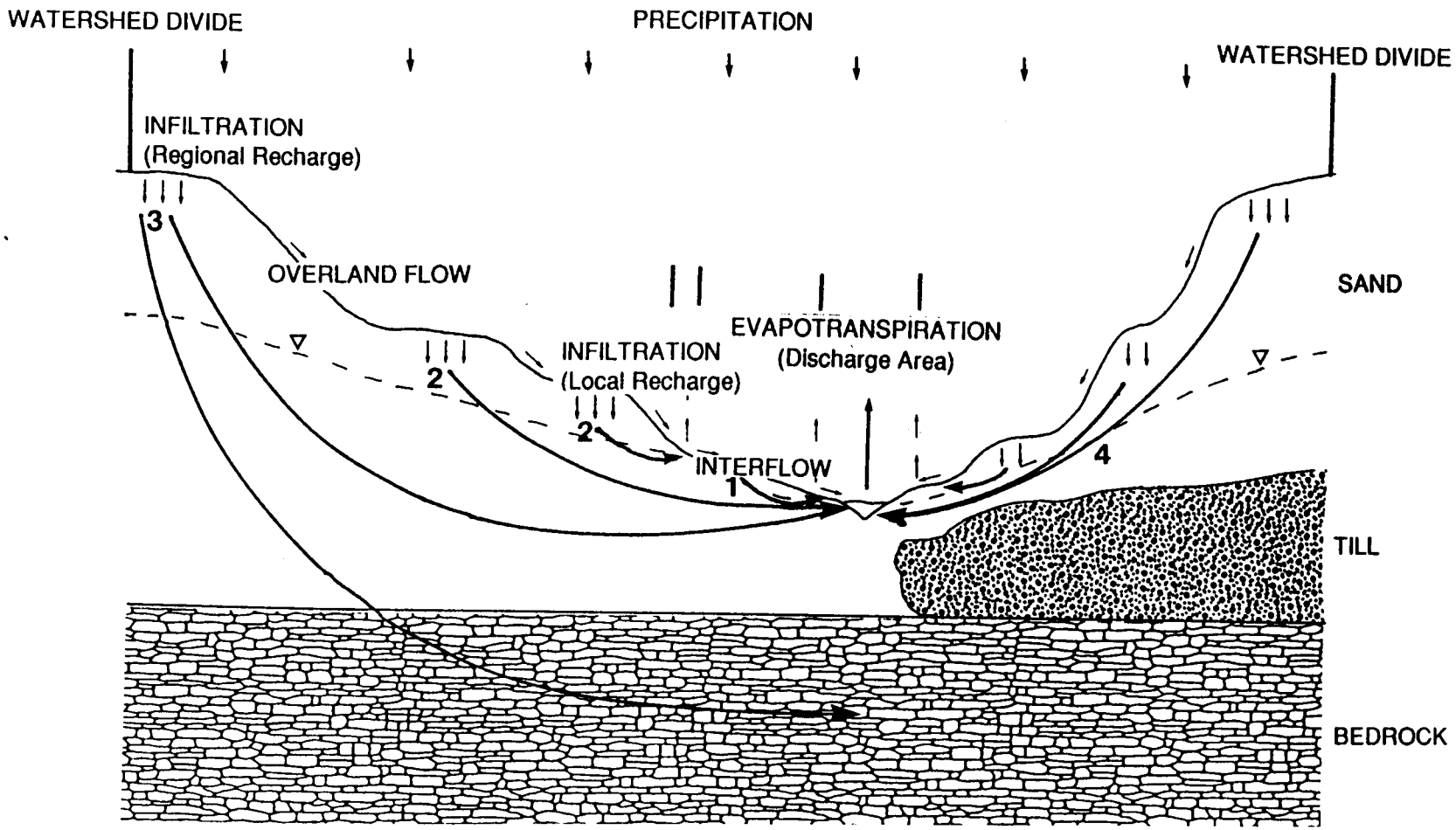
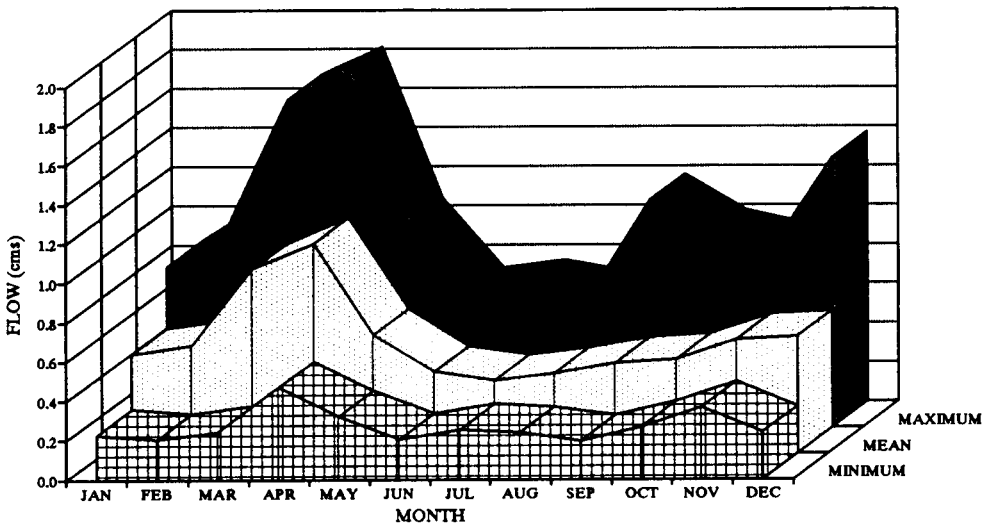


FIGURE 3.1



CREDIT RIVER VALLEY SUBWATERSHED #19 STUDY HYDROGEOLOGY COMPONENT	FIGURE 3.2 **GENERALIZED FLOW PATTERNS**	

FIGURE 3.3: CREDIT RIVER SUBWATERSHED 19
MEAN MONTHLY FLOW CHARACTERISTICS



MONTHLY FLOW (cms)

Month	Maximum	Mean	Minimum
JAN	0.82	0.51	0.23
FEB	1.01	0.55	0.21
MAR	1.67	0.94	0.24
APR	1.81	1.07	0.47
MAY	1.04	0.61	0.32
JUN	0.68	0.41	0.20
JUL	0.72	0.37	0.25
AUG	0.67	0.41	0.24
SEP	1.16	0.46	0.20
OCT	0.97	0.48	0.26
NOV	0.91	0.58	0.37
DEC	1.37	0.59	0.24

Maximum Instantaneous Discharge = 17.6 cms on 14 April 1973
Maximum Daily Discharge = 10.3 cms on 12 March 1990
Minimum Daily Discharge = 0.048 cms 6 July 1975

Data based on summary for the period of record 1967 to 1990

Reference: Water Survey of Canada Station 02HB013
Downstream of Melville Pond

CREDIT RIVER SUBWATERSHED 19 STUDY—WATER RESOURCES

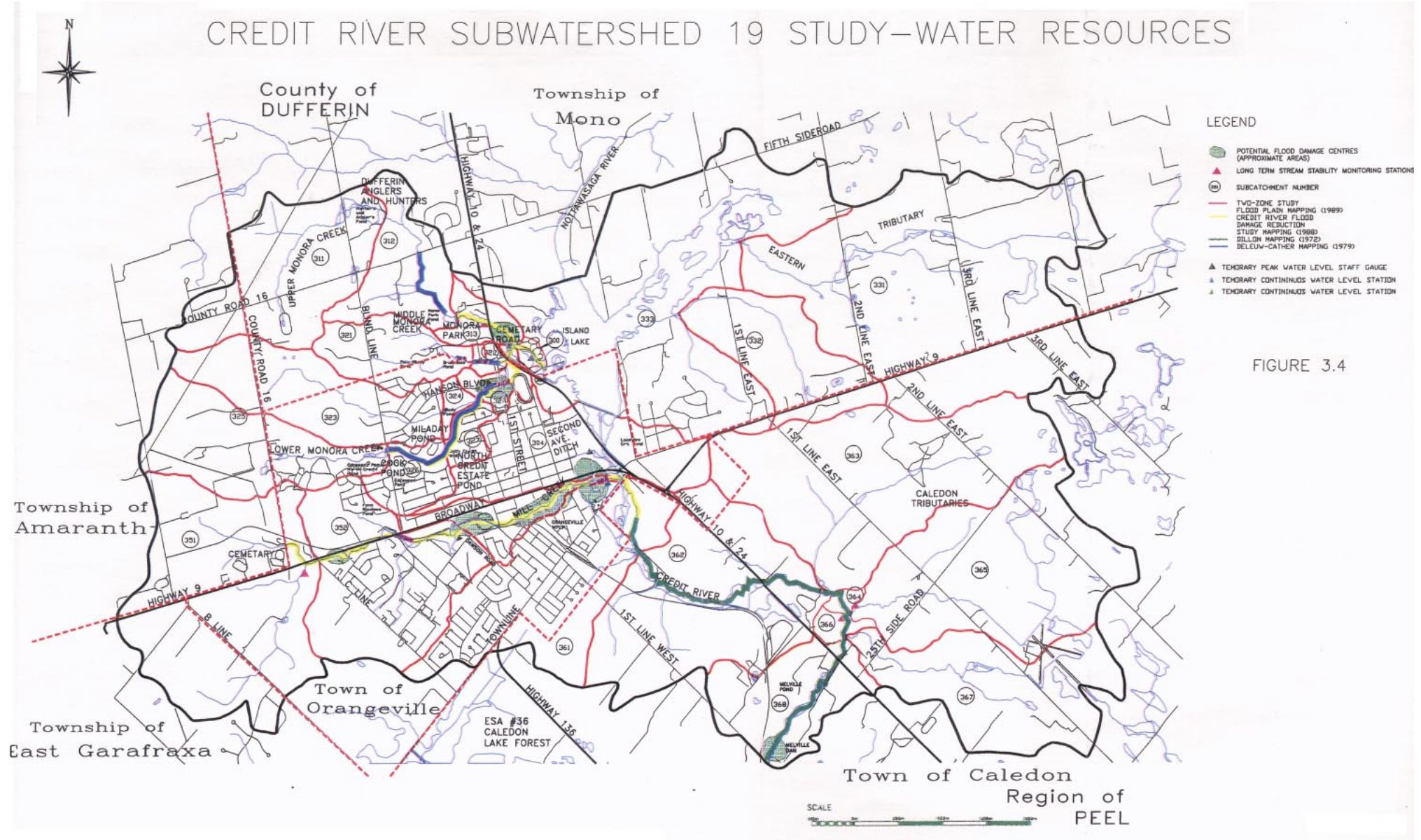
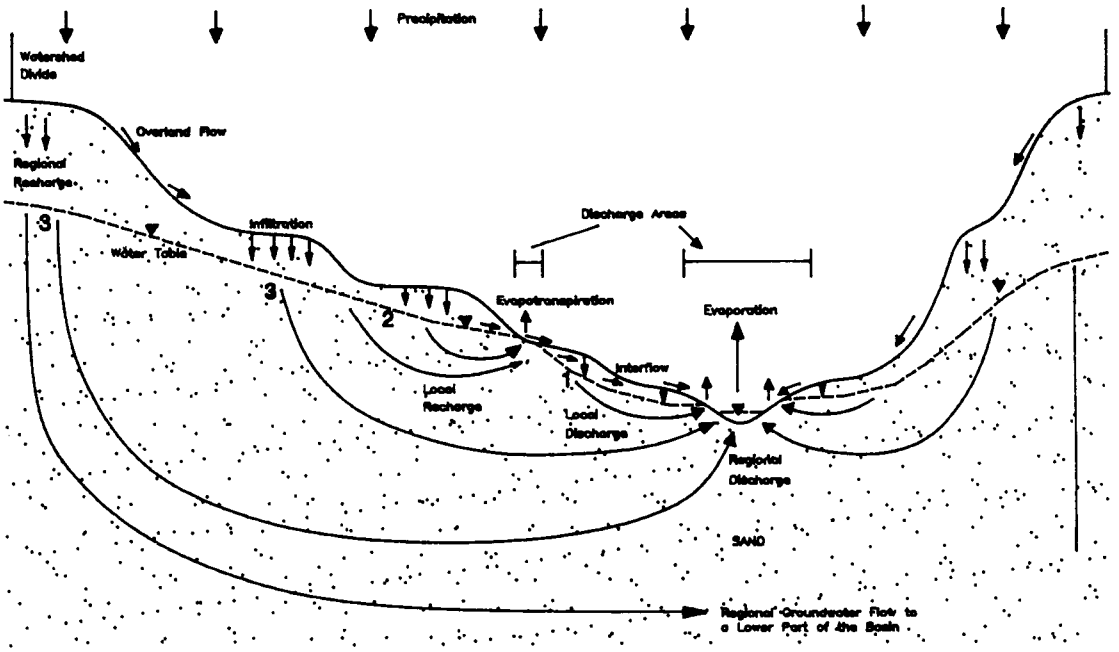
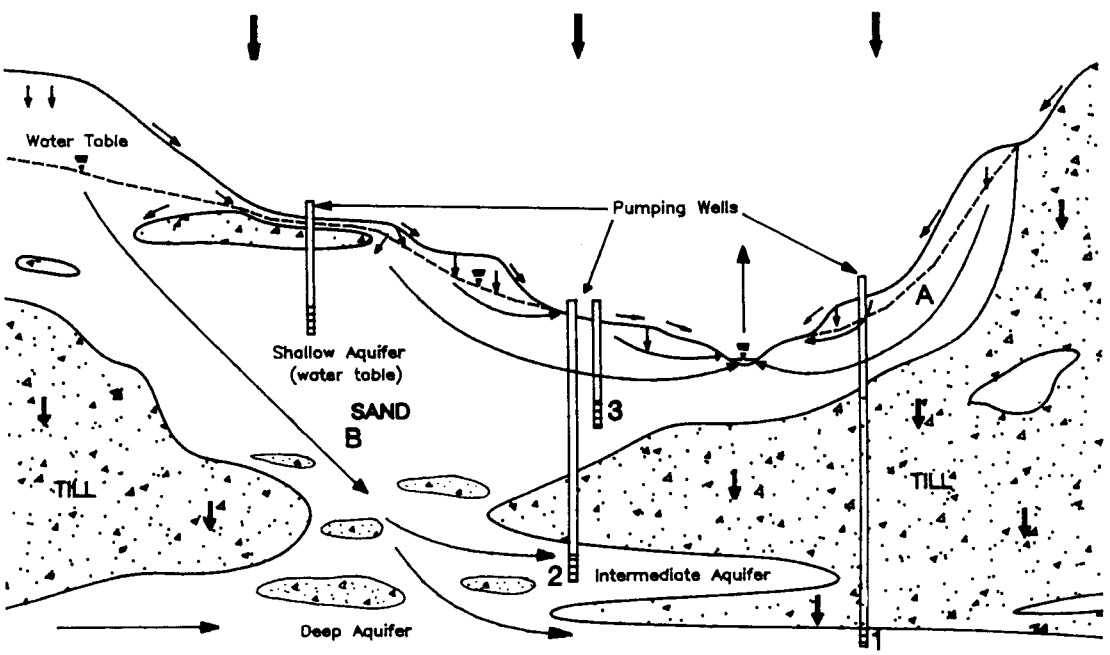


FIGURE 3.4

A

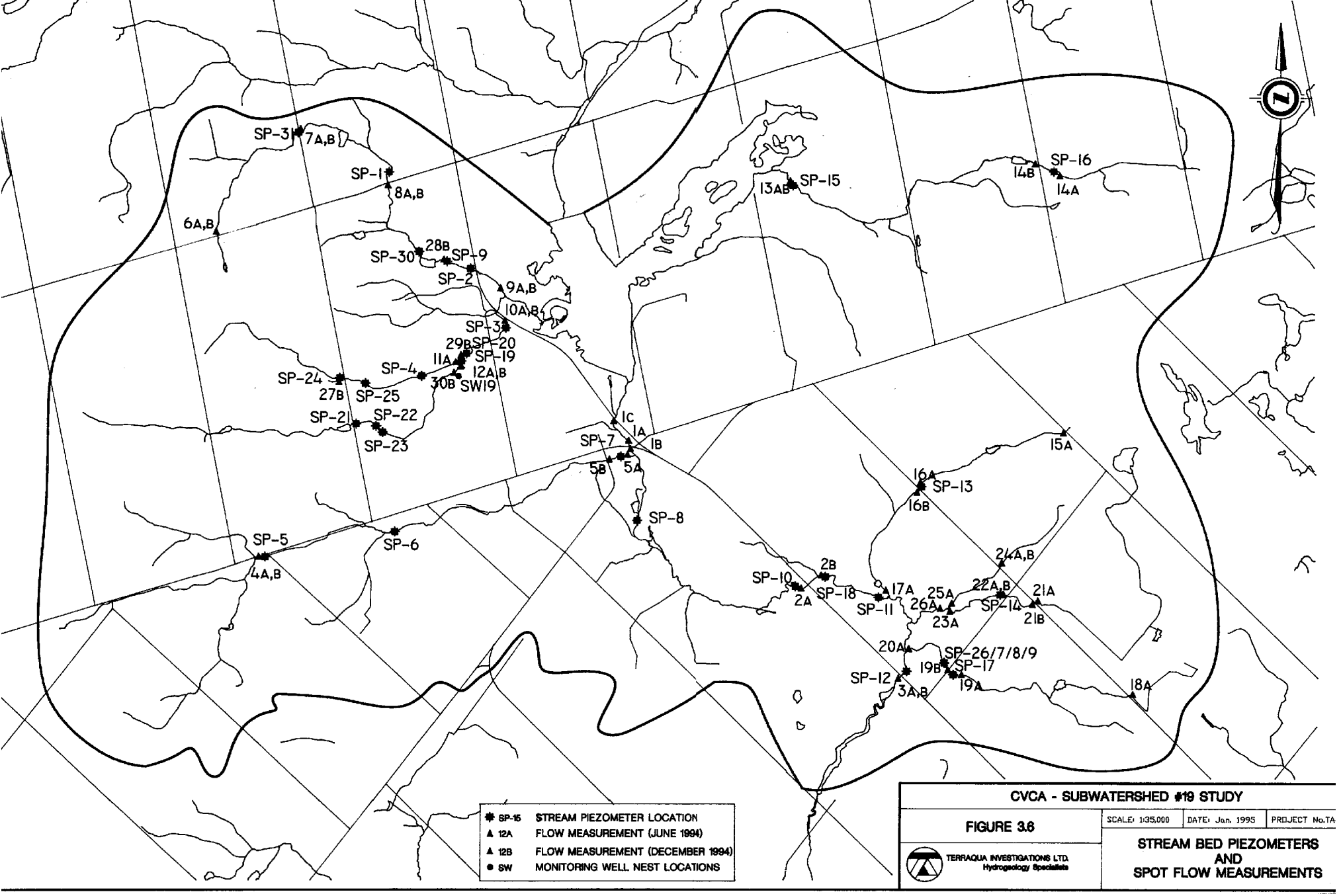


B



CVCA - SUBWATERSHED #19 STUDY			
FIGURE 3.5	SCALE: N.T.S.	DATE: Jan. 1995	PROJECT No.TA444
TERRAQUA INVESTIGATIONS LTD. © Hydrogeology Specialists	GENERALIZED GROUNDWATER FLOW AND THE INFLUENCE OF GEOLOGY TO GROUNDWATER FLOW		

FLOWPICS



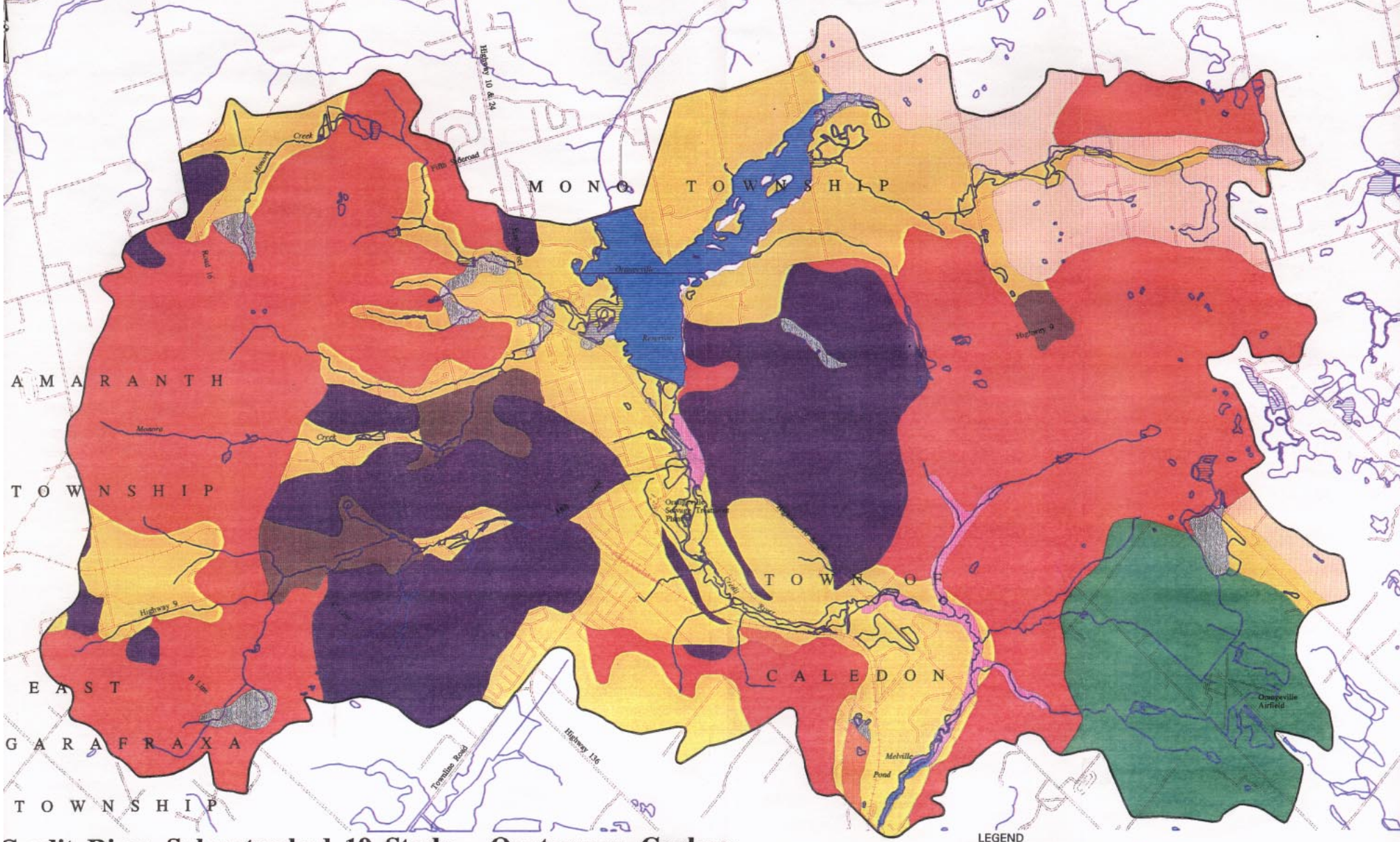
CVCA - SUBWATERSHED #19 STUDY

FIGURE 3.6

SCALE: 1:35,000 | DATE: Jan. 1995 | PROJECT No.TA

TERRAQUA INVESTIGATIONS LTD.
Hydrogeology Specialists

STREAM BED PIEZOMETERS AND SPOT FLOW MEASUREMENTS



Credit River Subwatershed 19 Study - Quaternary Geology

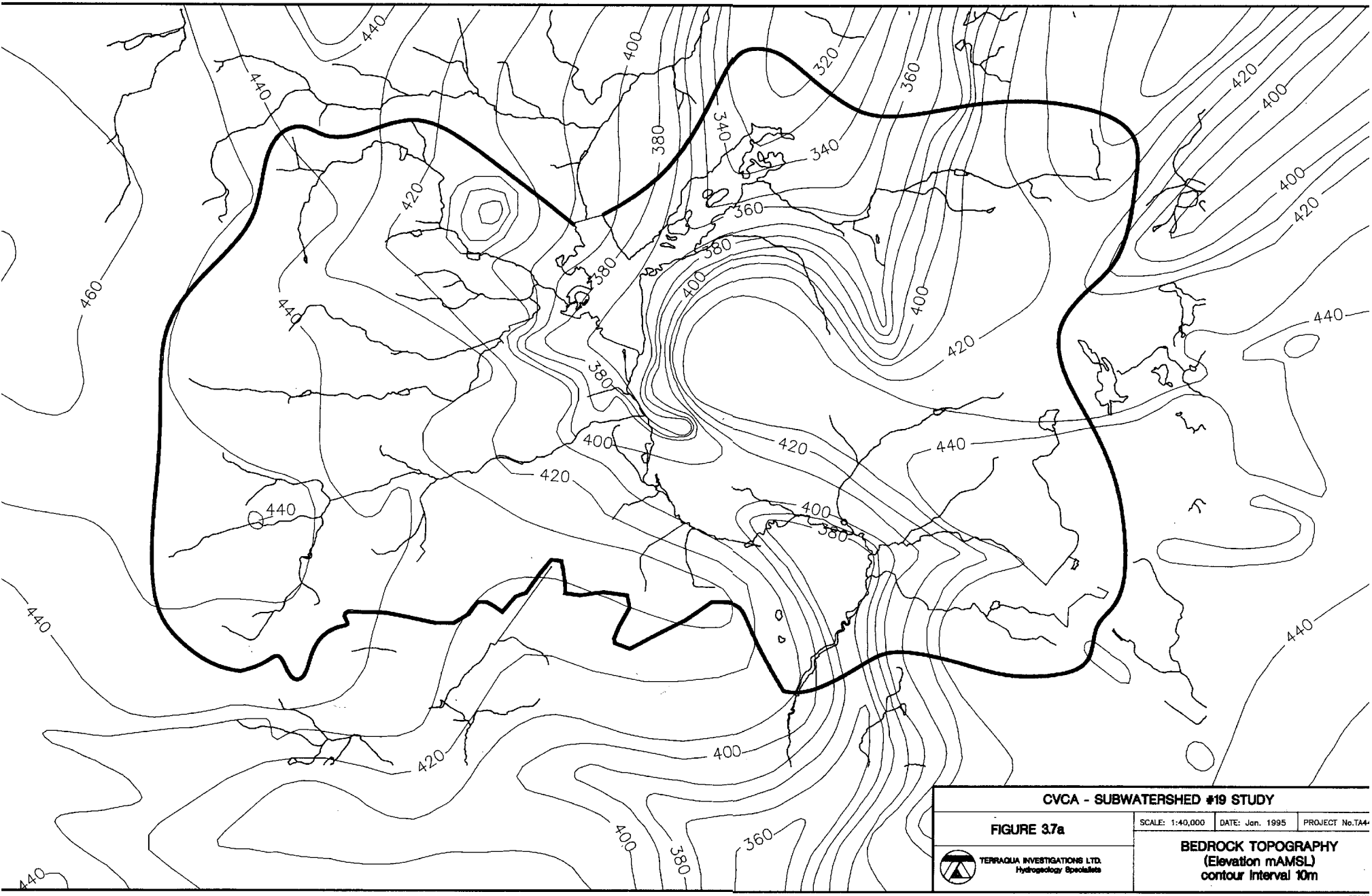
500m 0m 500m 1000m 1500m 2000m

Scale 1 : 30 000

LEGEND

- Organics (peat, muck, marl)
- Glaciolacustine Deposits (clay, silt to fine sand)
- Glaciofluvial Outwash Sand/Gravel
- Sandy Silt Till (Tavistock Till)
- Sandy Silt Till (Newmarket Till)
- Sandy Silt Till (Port Stanley Till)
- Stratified Drift - Sand and Gravel
- Dolostone
- Alluvium (undivided silt, sand, and gravel)

Figure 3.7



CVCA - SUBWATERSHED #19 STUDY

FIGURE 3.7a

SCALE: 1:40,000 | DATE: Jan. 1995 | PROJECT No.TA4

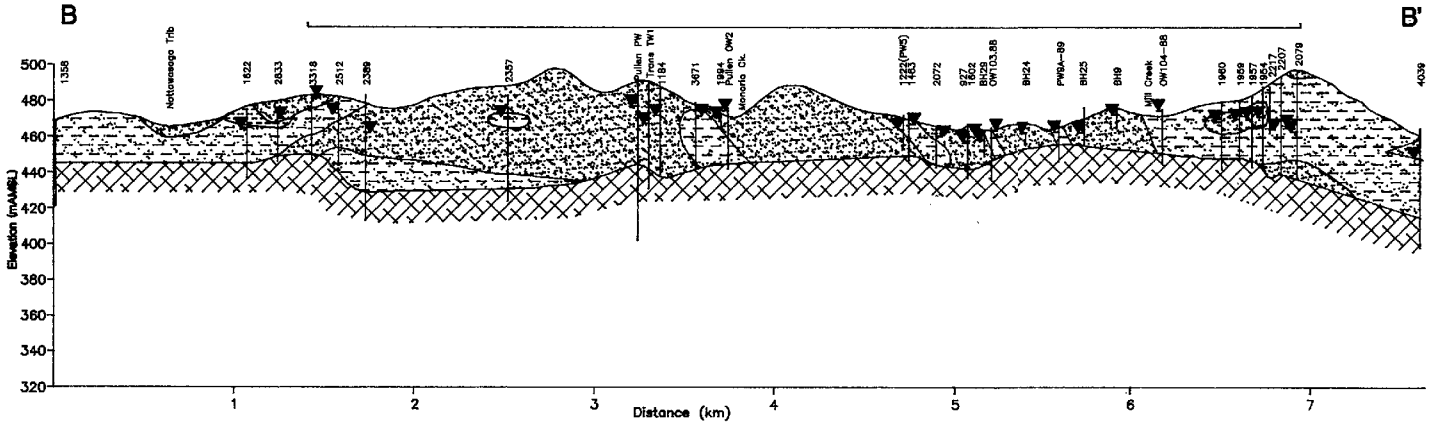
TERRAQUA INVESTIGATIONS LTD.
Hydrogeology Specialists

BEDROCK TOPOGRAPHY
(Elevation mAMSL)
contour interval 10m

BR11X

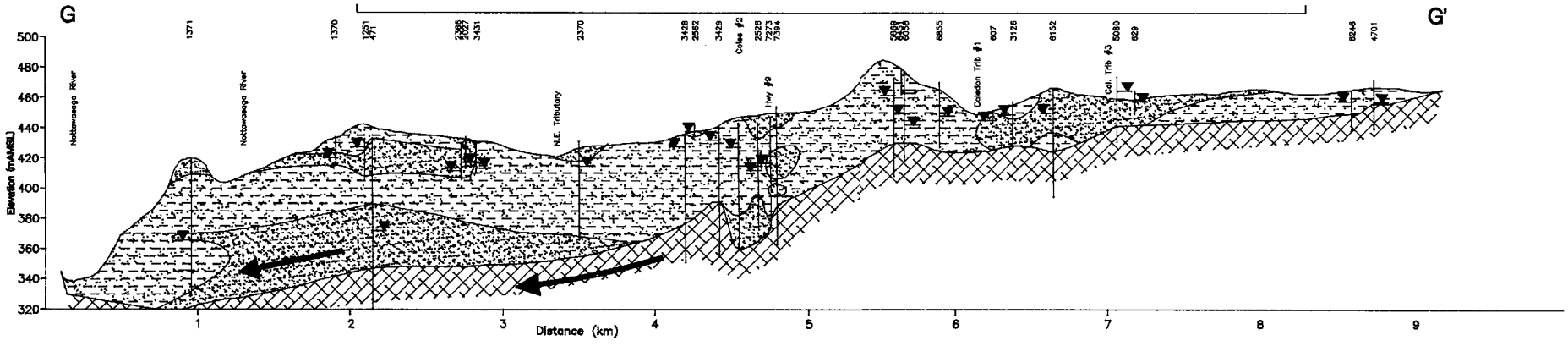
N

S

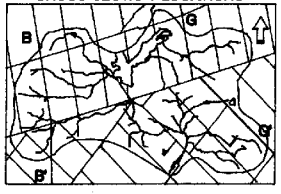


NW

SE



CROSS-SECTION LOCATIONS



LEGEND

- Permeable (Sand or Gravel)
- Semi - Permeable (Sand, Silts, minor Clay)
- Relatively Impermeable (Till)
- Bedrock (Dolostone or Shale)
- 118 MOEE Well Number
- Well
- Static Water Level
- Subwatershed 19 Boundaries
- Groundwater Flow Direction

Vertical Scale 1:3,500 Horizontal Scale 1:35,000

CVCA - SUBWATERSHED #19 STUDY

FIGURE 3.7b

Scales H1:35,000 V1:3,500 | DATE: Jan. 1995 | PROJECT No.TA44

TERRAQUA INVESTIGATIONS LTD.
Hydrogeology Specialists

HYDROSTRATIOGRAPHIC CROSS-SECTION B-B
AND
HYDROSTRATIOGRAPHIC CROSS-SECTION G-G

BG11X1

CREDIT RIVER SUBWATERSHED 19 – AREAS OF GROUNDWATER RECHARGE AND DISCHARGE

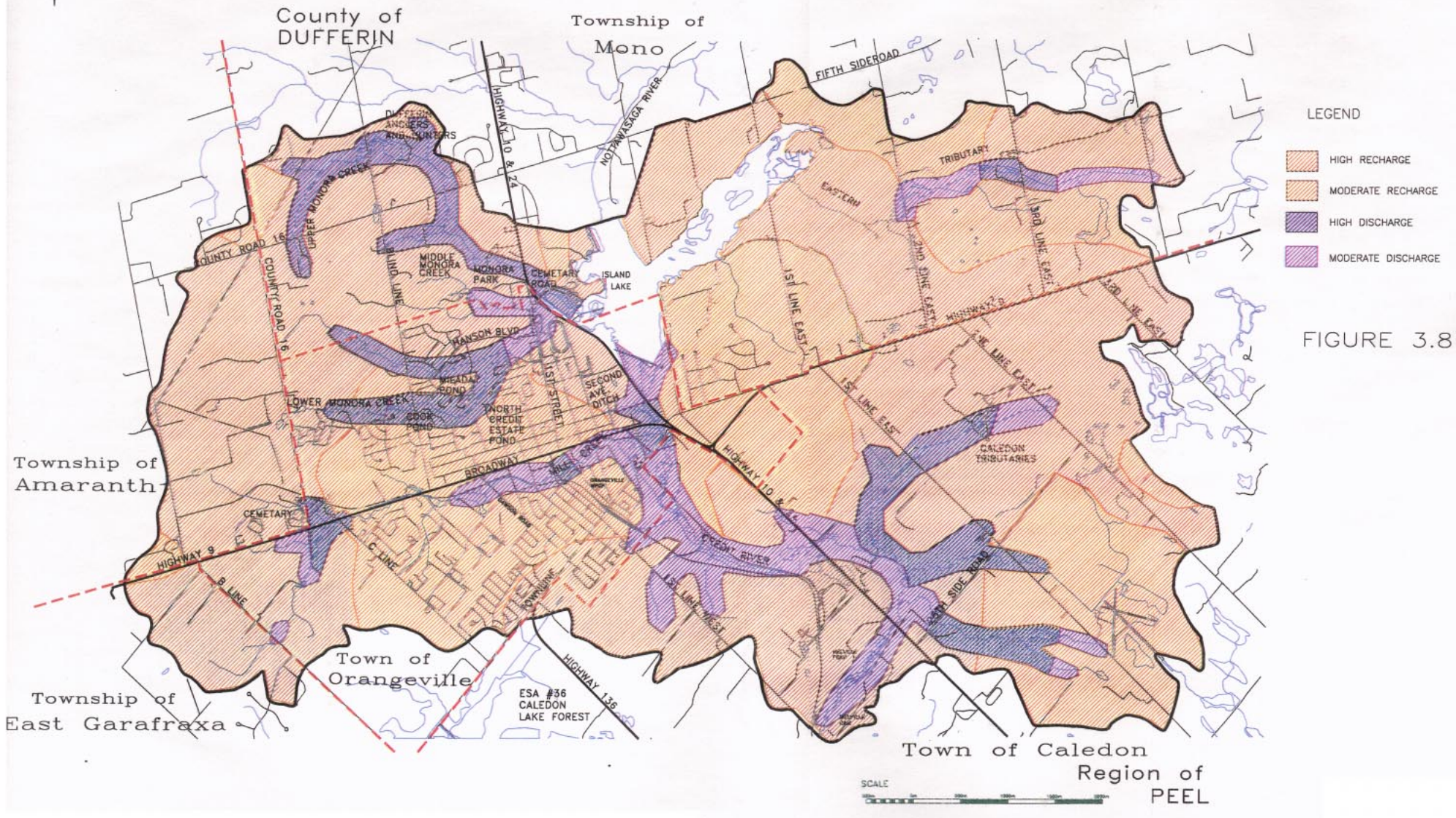
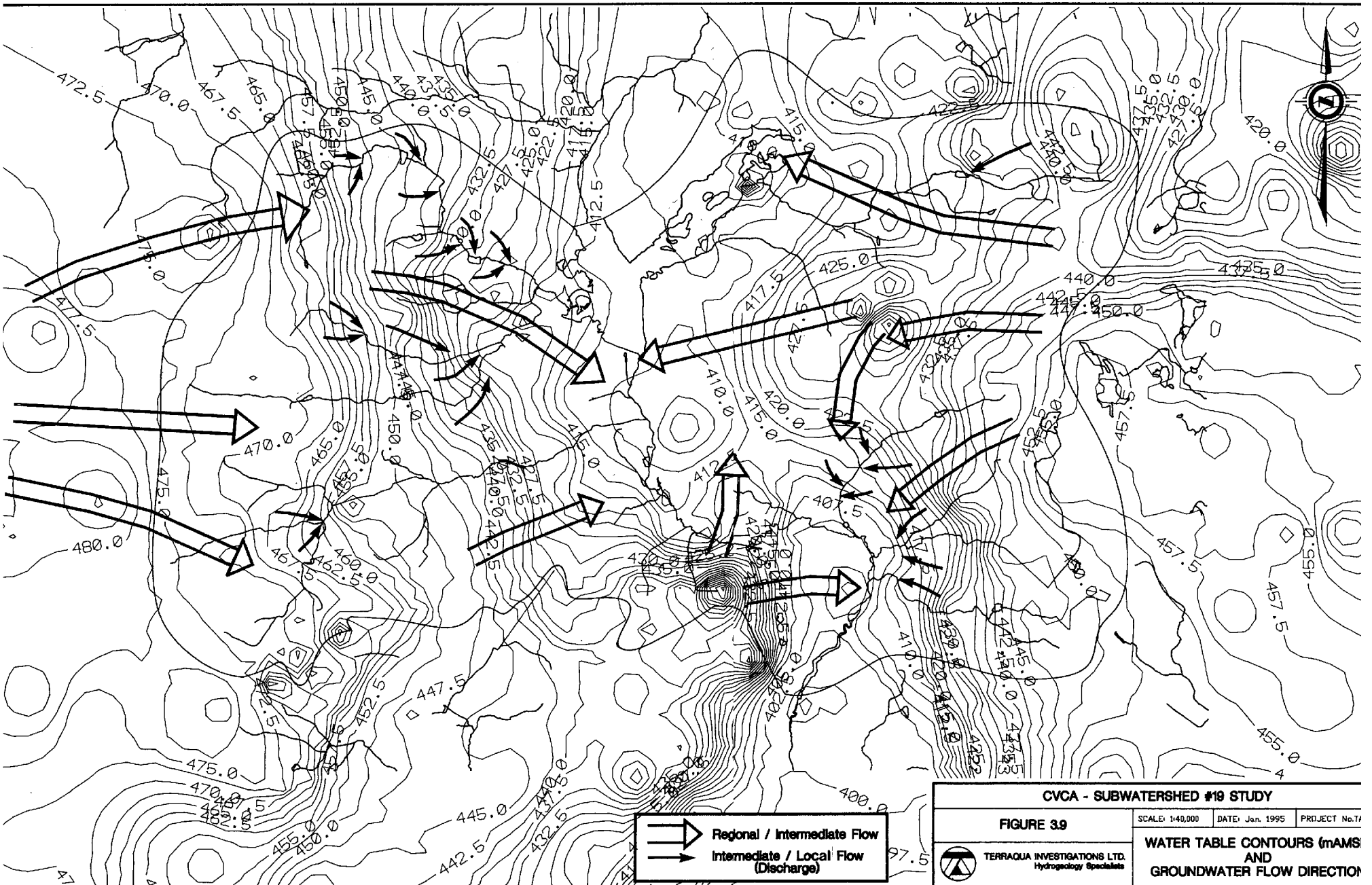


FIGURE 3.8



CVCA - SUBWATERSHED #19 STUDY

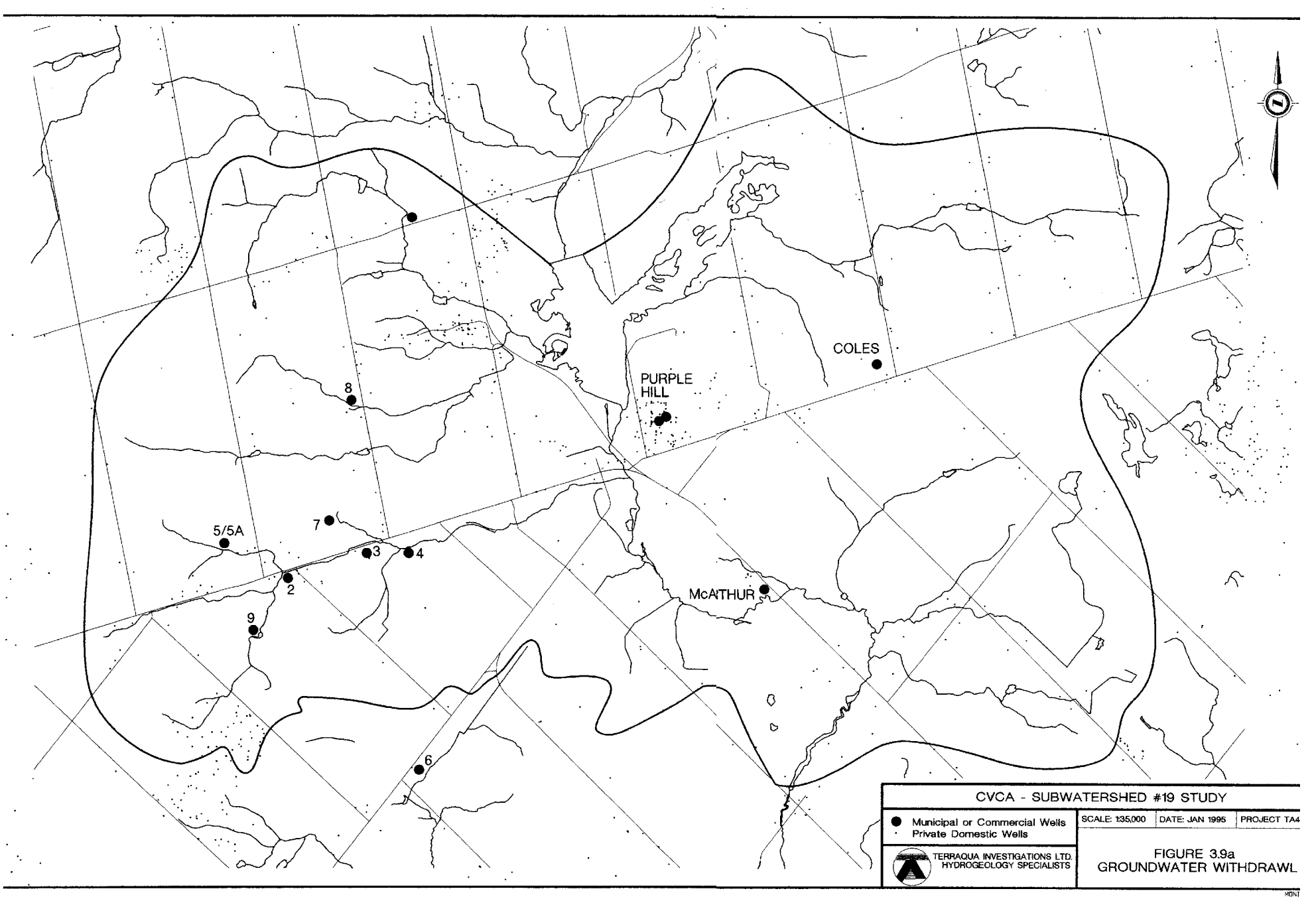
FIGURE 3.9

SCALE: 1:40,000 | DATE: Jan. 1995 | PROJECT No.TA

TERRAQUA INVESTIGATIONS LTD.
Hydrogeology Specialists

WATER TABLE CONTOURS (mAMSL)
AND
GROUNDWATER FLOW DIRECTION

VT


COLES
PURPLE HILL
8
5/5A
7
3
4
2
9
McARTHUR
6
CVCA - SUBWATERSHED #19 STUDY
Municipal or Commercial Wells
Private Domestic Wells
SCALE: 1:35,000
DATE: JAN 1995
PROJECT TA4
TERRAQUA INVESTIGATIONS LTD.
HYDROGEOLOGY SPECIALISTS
FIGURE 3.9a
GROUNDWATER WITHDRAWL

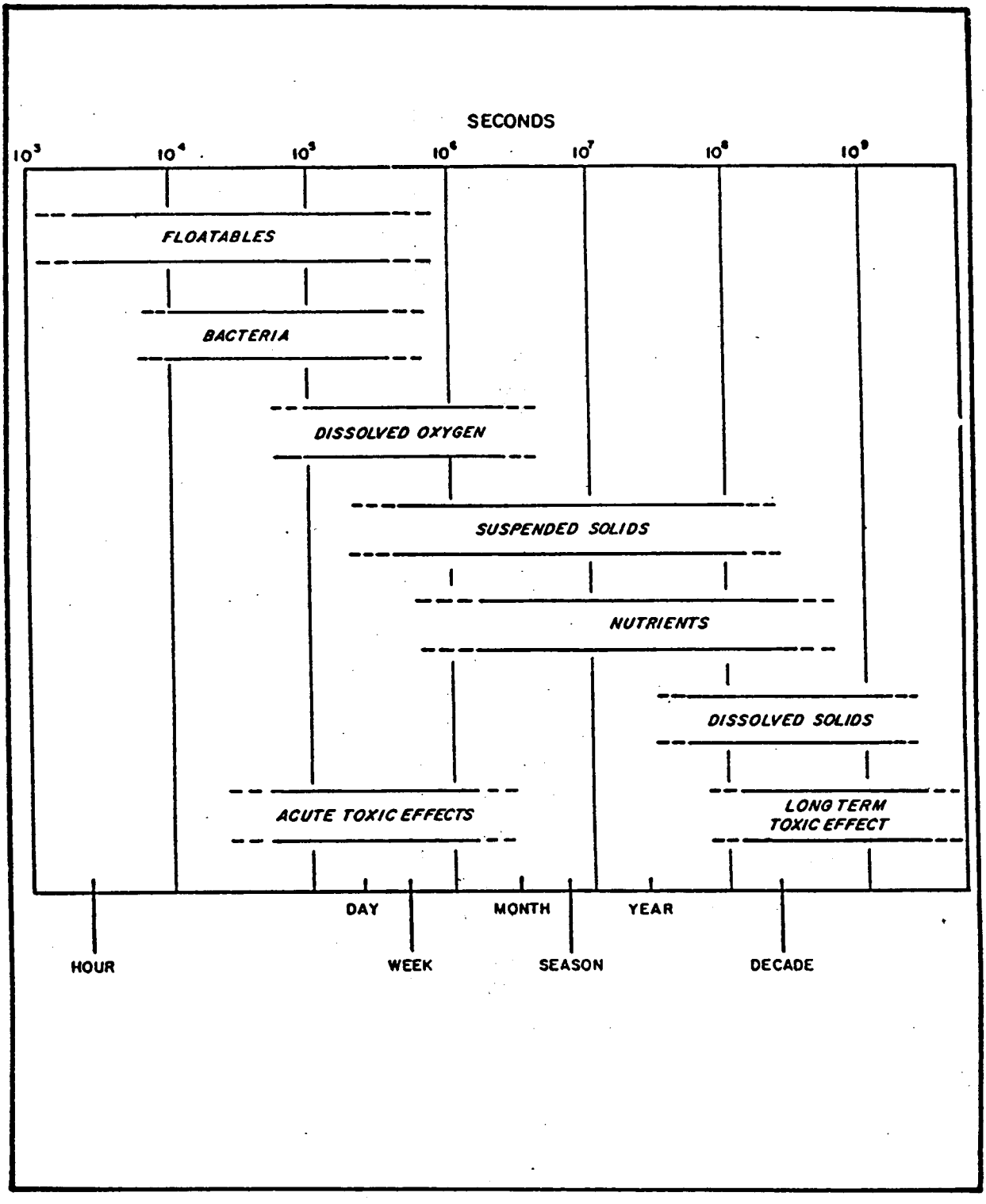


FIGURE 3.11: TIME SCALES OF STORM RUNOFF WATER QUALITY PROBLEMS

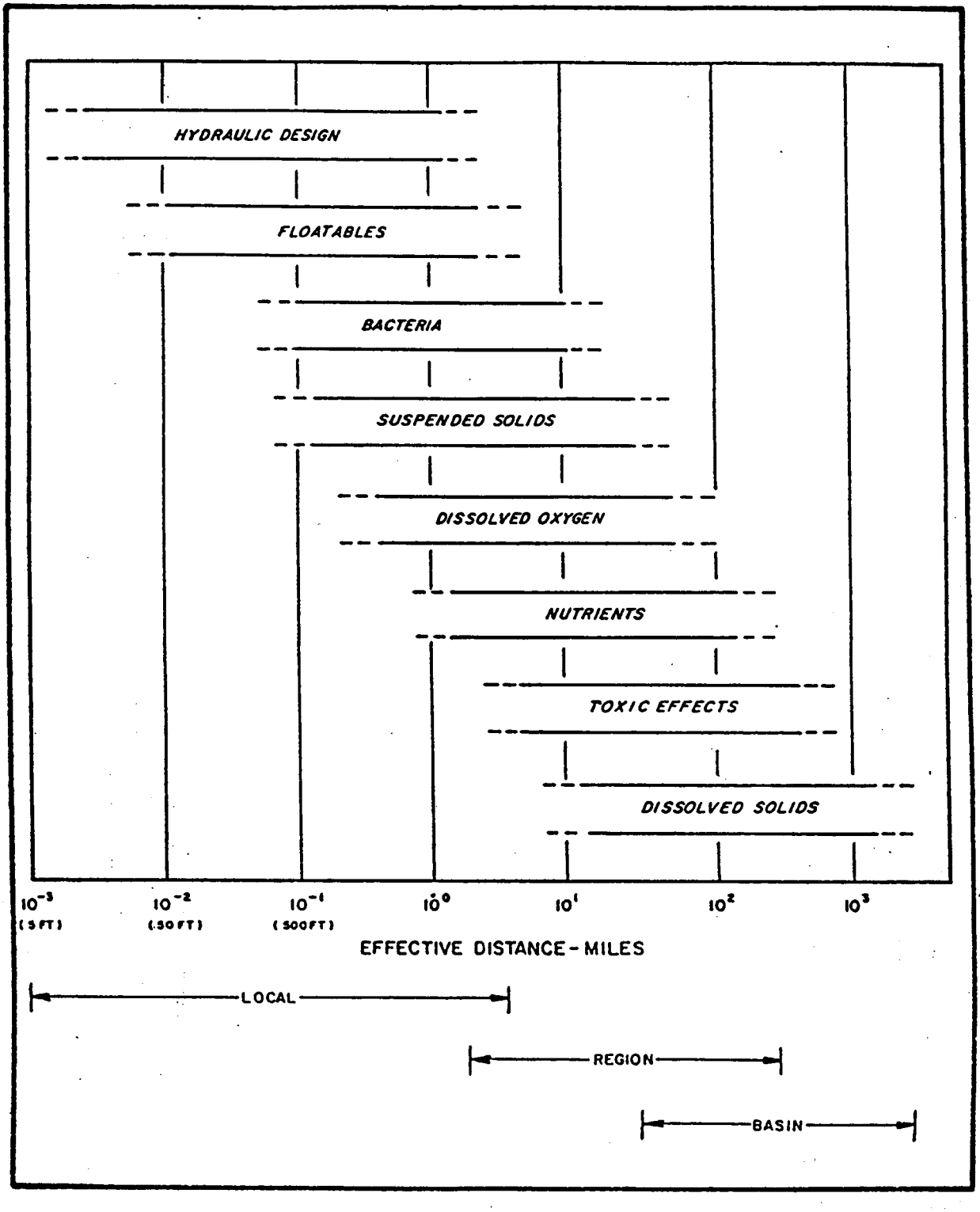
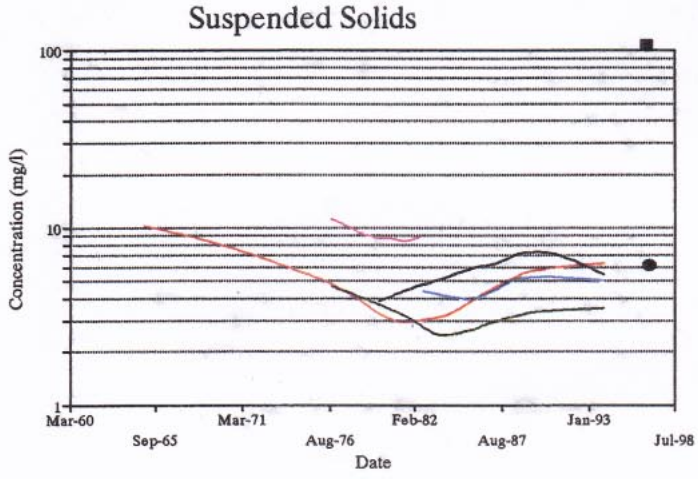
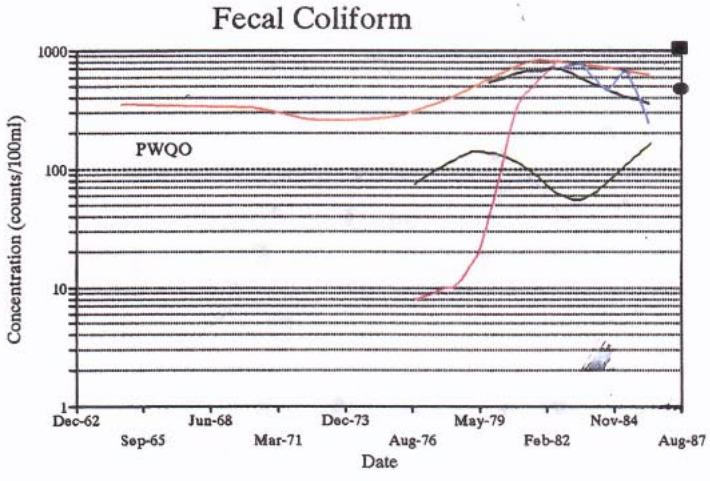


FIGURE 3.12: SPACE SCALES OF STORM RUNOFF WATER QUALITY PROBLEMS

FIGURE 3.13: Water Quality Trends For Suspended Solids, Fecal Coliform and Copper





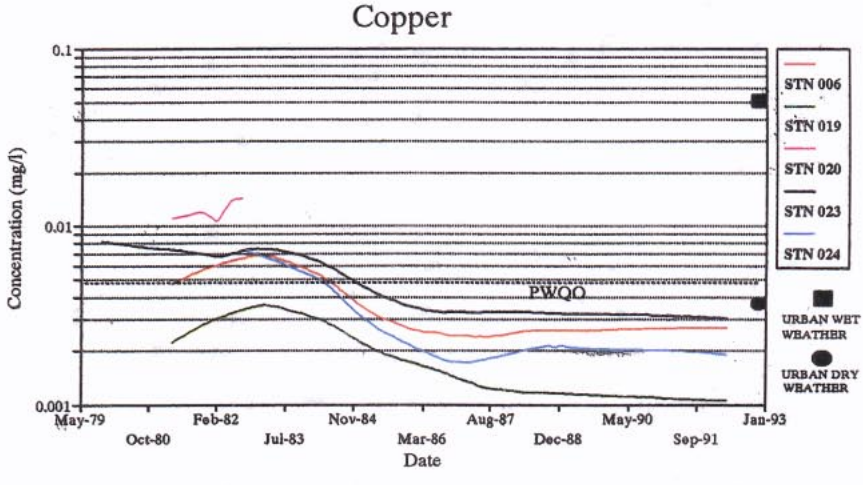
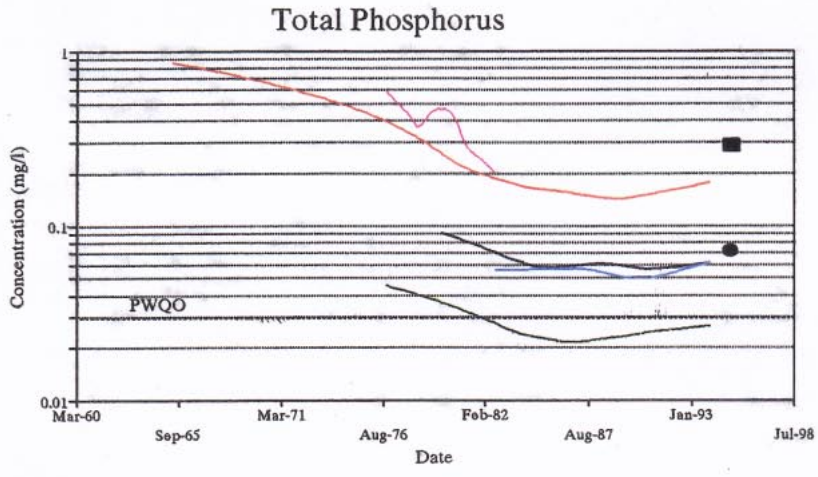
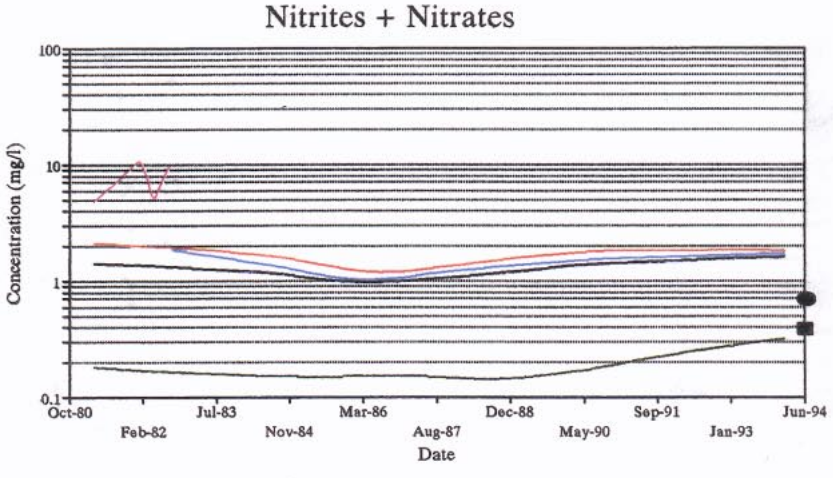


FIGURE 3.14: Water Quality Trends For Total Phosphorus, Nitrites & Nitrates and TKN





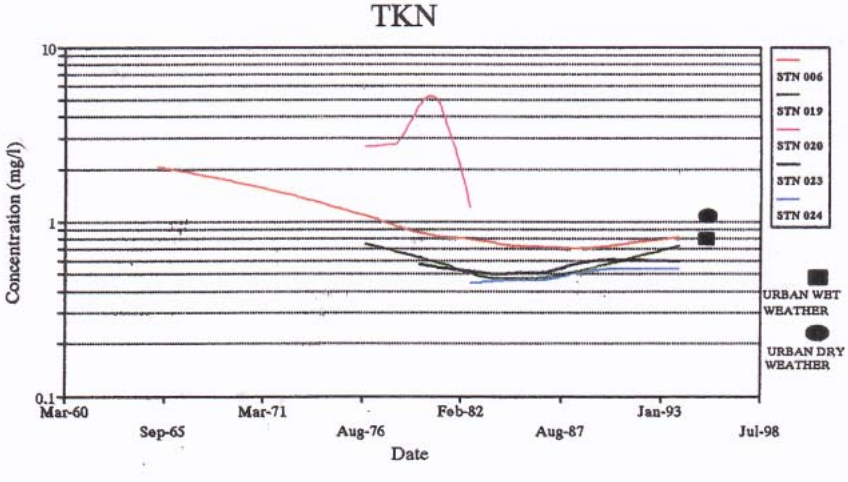
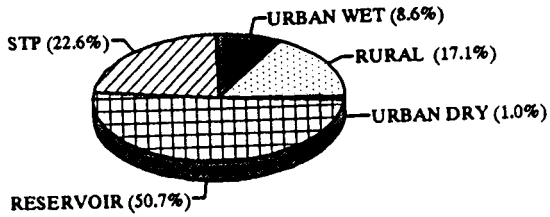
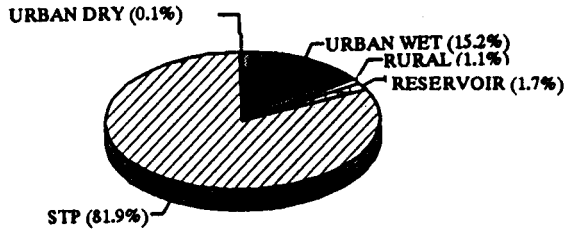


FIGURE 3.15: POLLUTANT LOADINGS SUMMARY

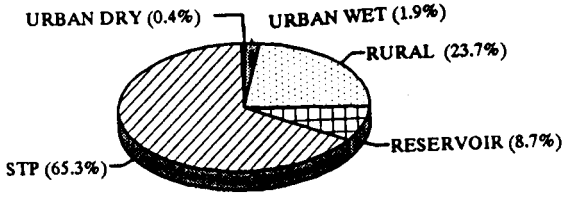
FLOW



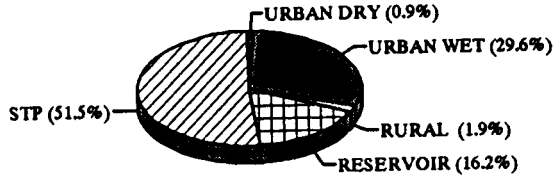
COPPER



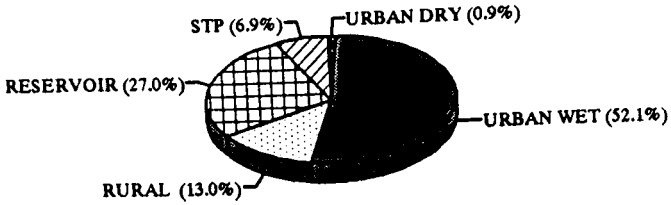
NITRITES + NITRATES



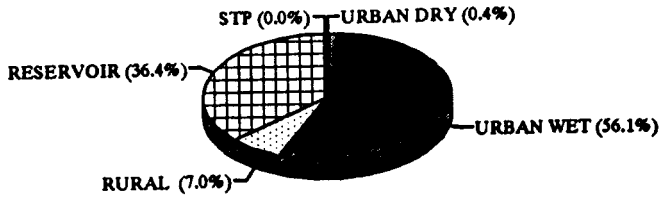
TOTAL PHOSPHORUS

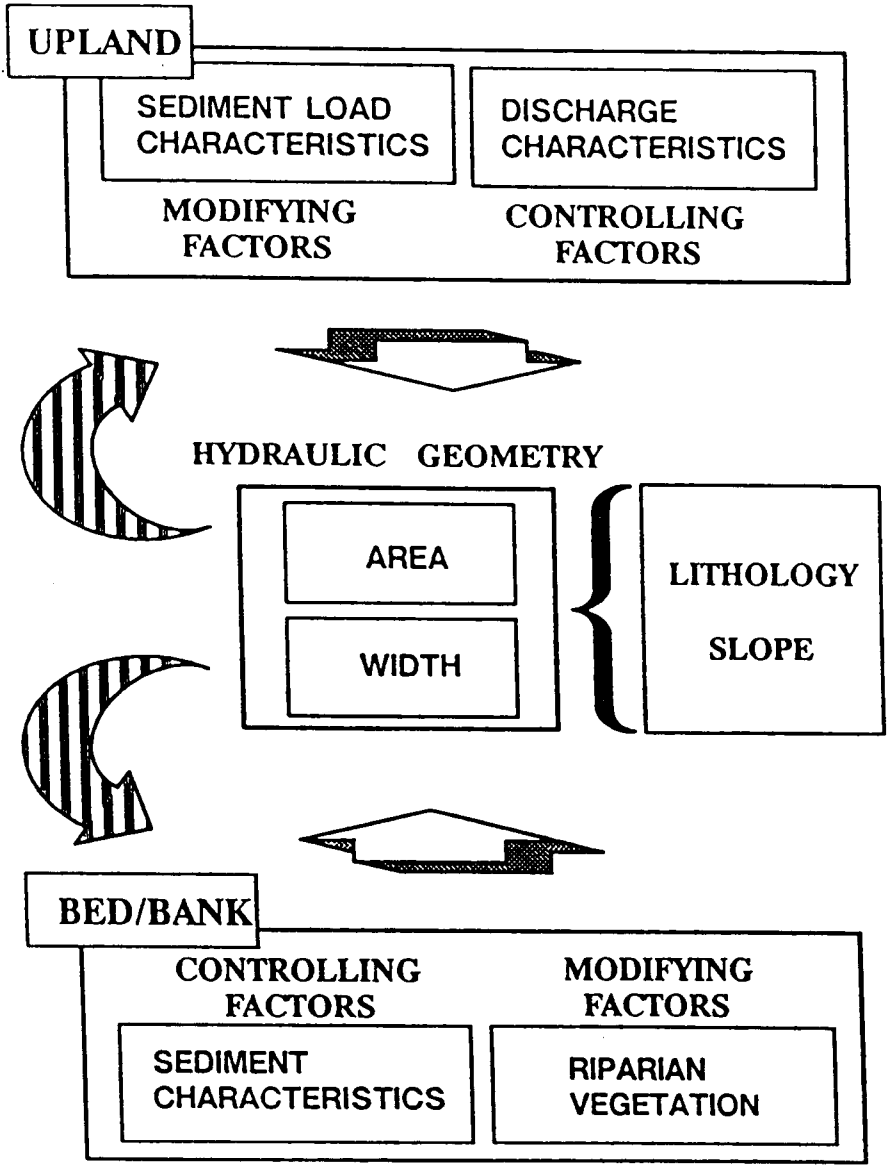


TOTAL SUSPENDED SOLIDS



FECAL COLIFORM





CONCEPTUALIZED MORPHOLOGICAL RESPONSE

FIGURE 3.16

CREDIT RIVER SUBWATERSHED 19 - SURVEY SITE LOCATION MAP

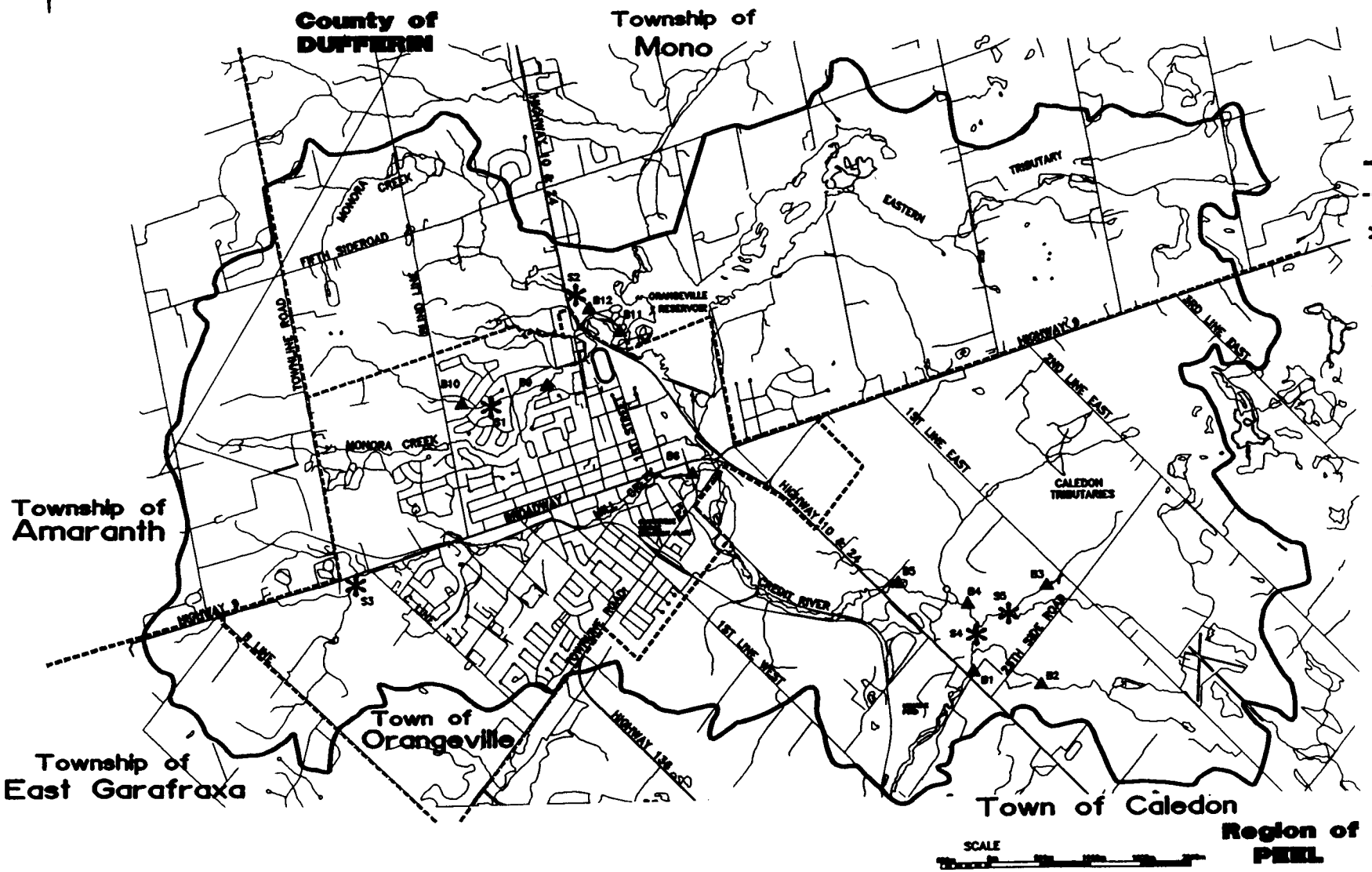
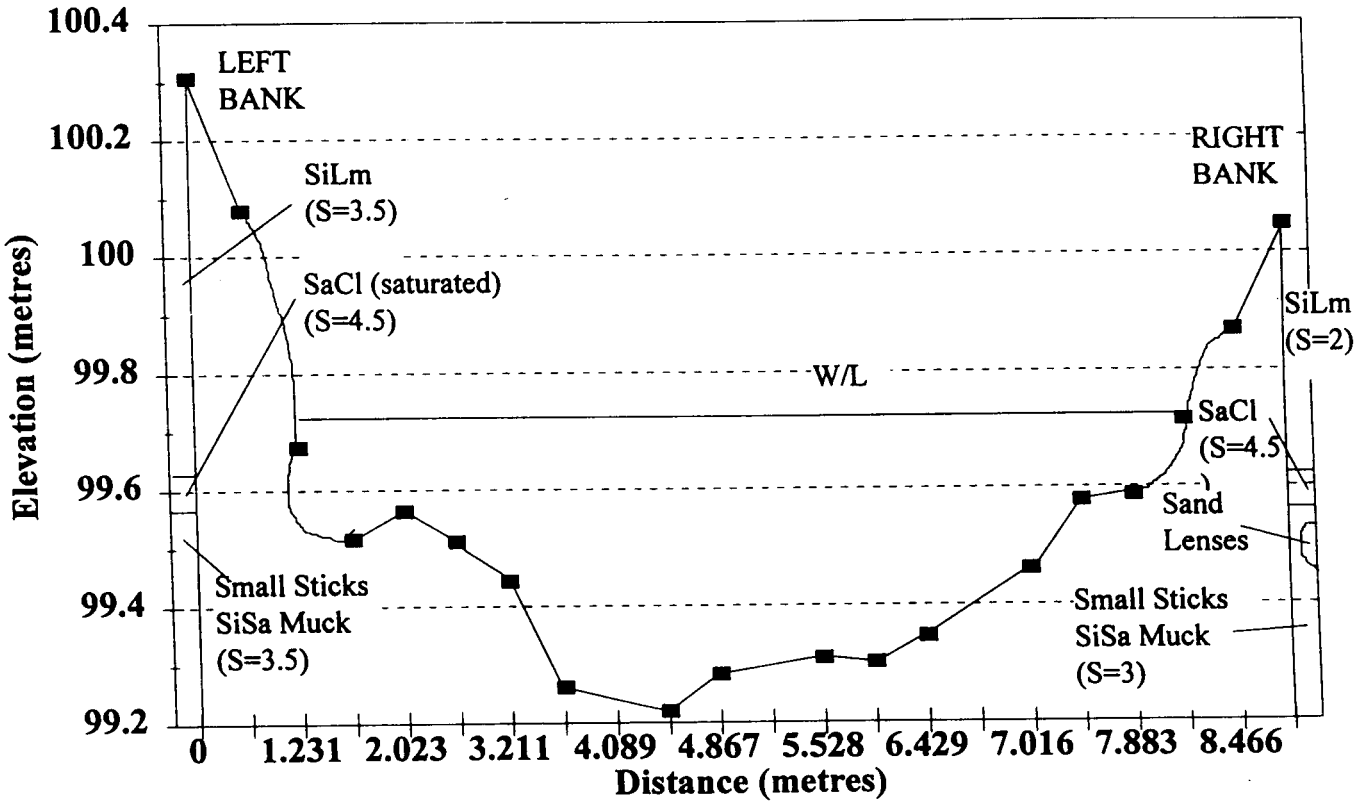
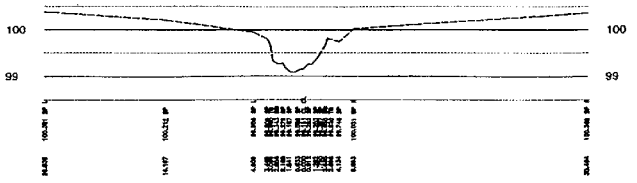


FIGURE 3.17

Figure 3.18: Bank Stratigraphy

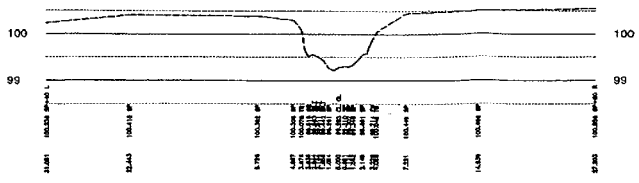
Site #4 Cross Section D





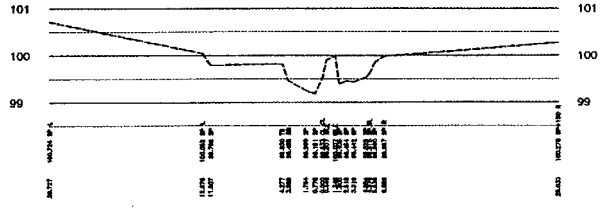
SECTION A–A

SCALE HOR. 1:250
VER. 1:50



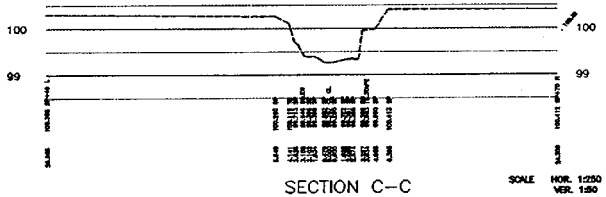
SECTION D–D

SCALE HOR. 1:250
VER. 1:50



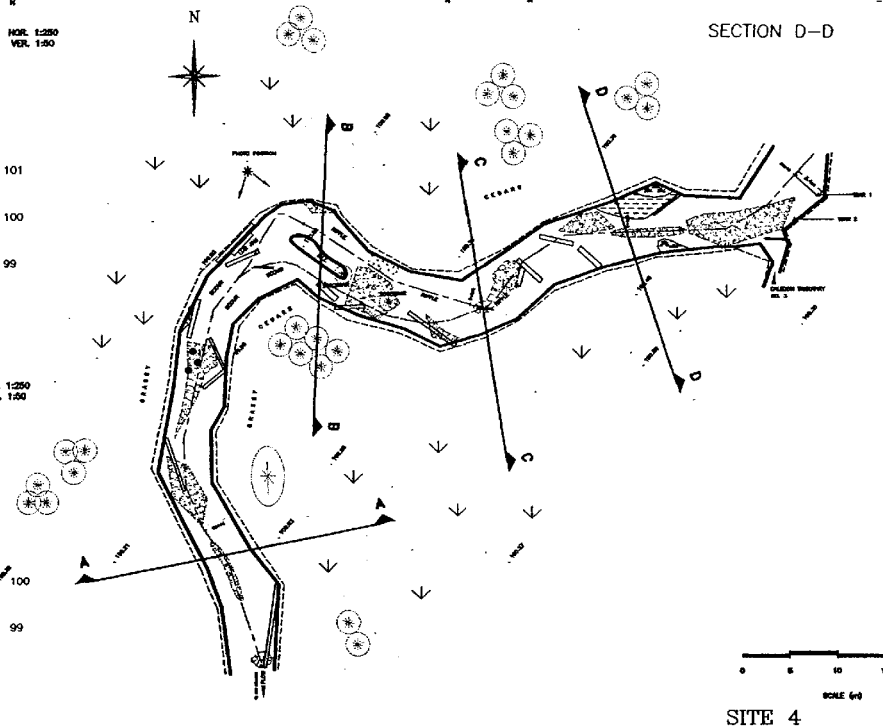
SECTION B–B

SCALE HOR. 1:250
VER. 1:50



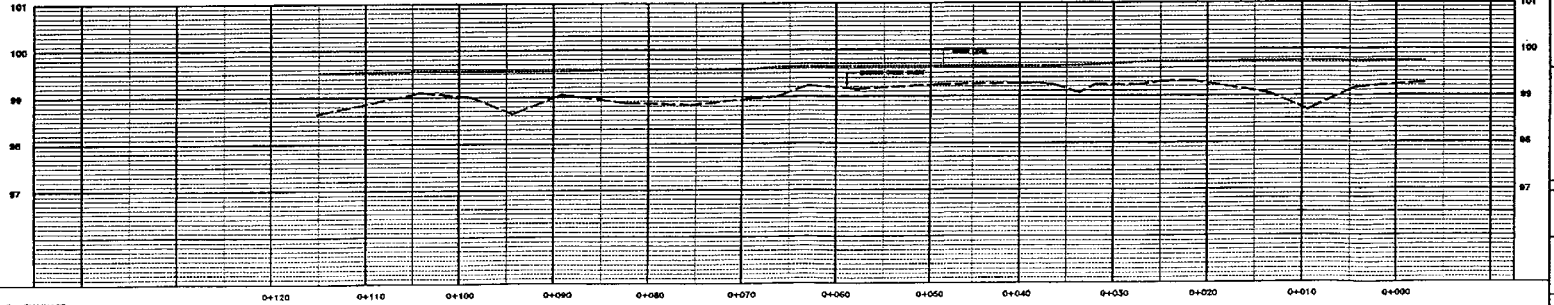
SECTION C–C

SCALE HOR. 1:250
VER. 1:50



SITE 4

CREDIT RIVER – DOWNSTREAM OF CALEDON TRIBUTARY NO. 2



℄ CHAINAGE

LEGEND

- POOL
- TOP OF BANK
- EXISTING ELEVATION
- STUMPS
- LOGS
- CEDARS
- SCRUB
- SUBMERGENT MACROPHYTES
- HERBACEOUS PLANTS

BENCHMARK:

SET ELEVATION TOP TBAR 1
ELEVATION 100.16m

NOTE: SITE WAS SURVEYED NOVEMBER 10, 94.

Aquafor Beech Limited

DESIGN BY

APPROVED BY

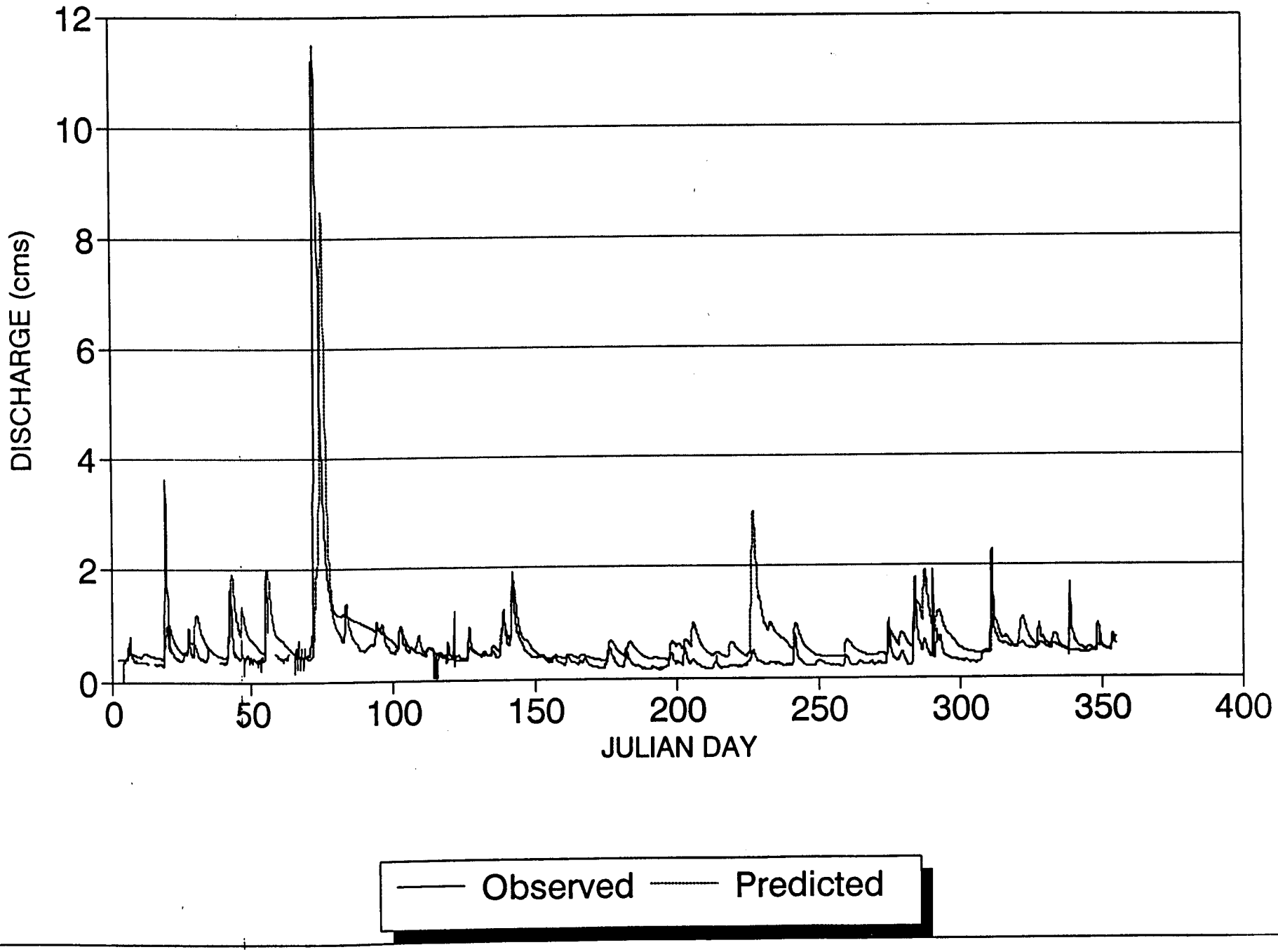
FIGURE 3.19

CREDIT RIVER TRIBUTARY SITE 4
ORANGEVILLE, ONT.

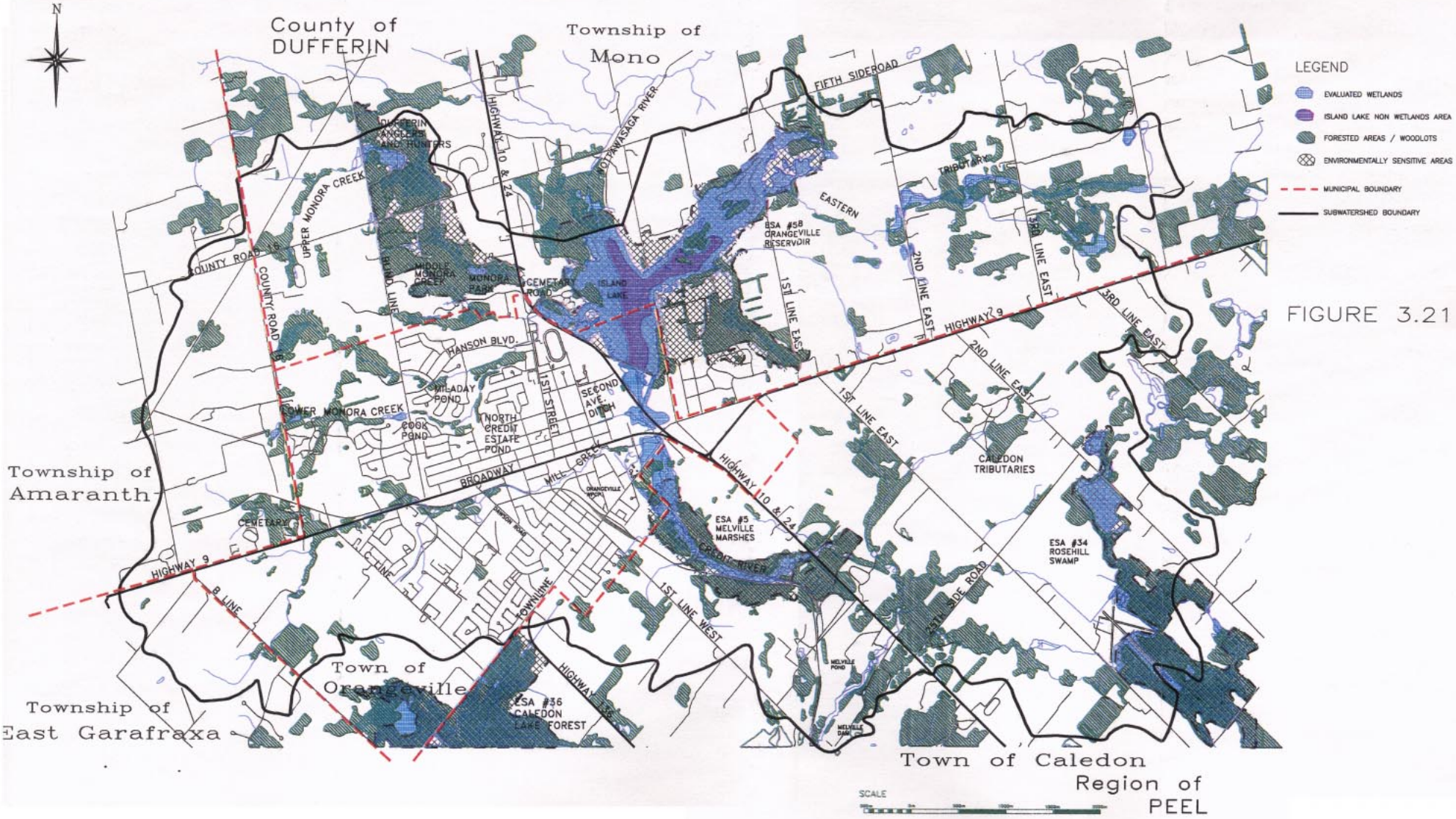
SCALE H.V.S.	AREA	PROJECT No.
DRAWN BY P.M.	CHECKED BY	PLAN No. 6516-A
DATE NOV. 1994	SHEET OF	

FIGURE 3.20: CREDIT RIVER - SUBWATERSHED 19

1990 (STN. # 2HB01390)



CREDIT RIVER SUBWATERSHED 19 – TERRESTRIAL RESOURCES



LEGEND

- EVALUATED WETLANDS
- ISLAND LAKE NON WETLANDS AREA
- FORESTED AREAS / WOODLOTS
- ENVIRONMENTALLY SENSITIVE AREAS
- MUNICIPAL BOUNDARY
- SUBWATERSHED BOUNDARY

FIGURE 3.21

CREDIT RIVER SUBWATERSHED STUDY – EXISTING AQUATIC COMMUNITIES

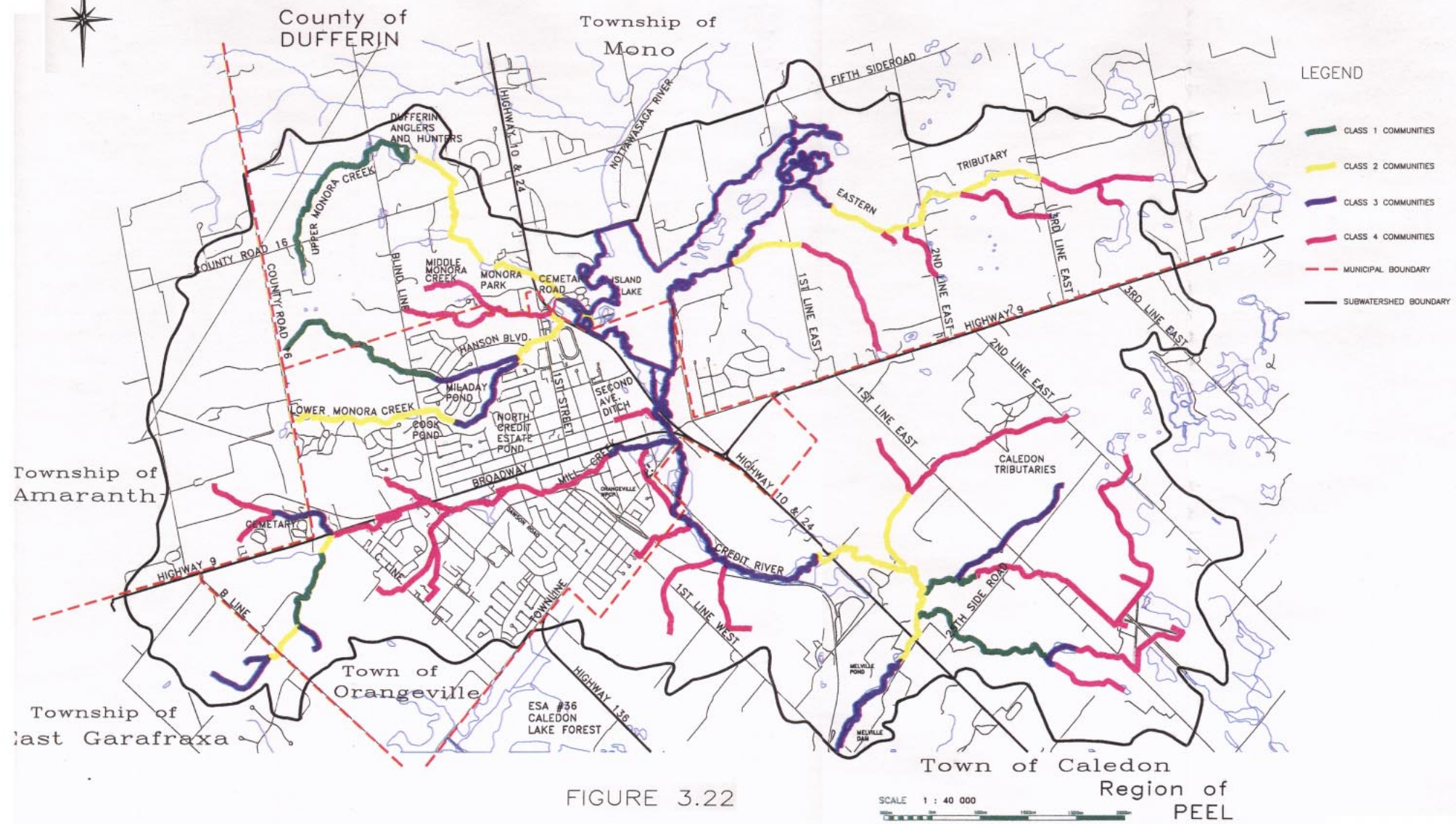


FIGURE 3.22

ENVIRONMENTAL PLANNING FOR THE CREDIT RIVER HEADWATERS SUBWATERSHED 19

ALTERNATIVE No. 1 MAINTAIN EXISTING ECOLOGIC CONDITIONS

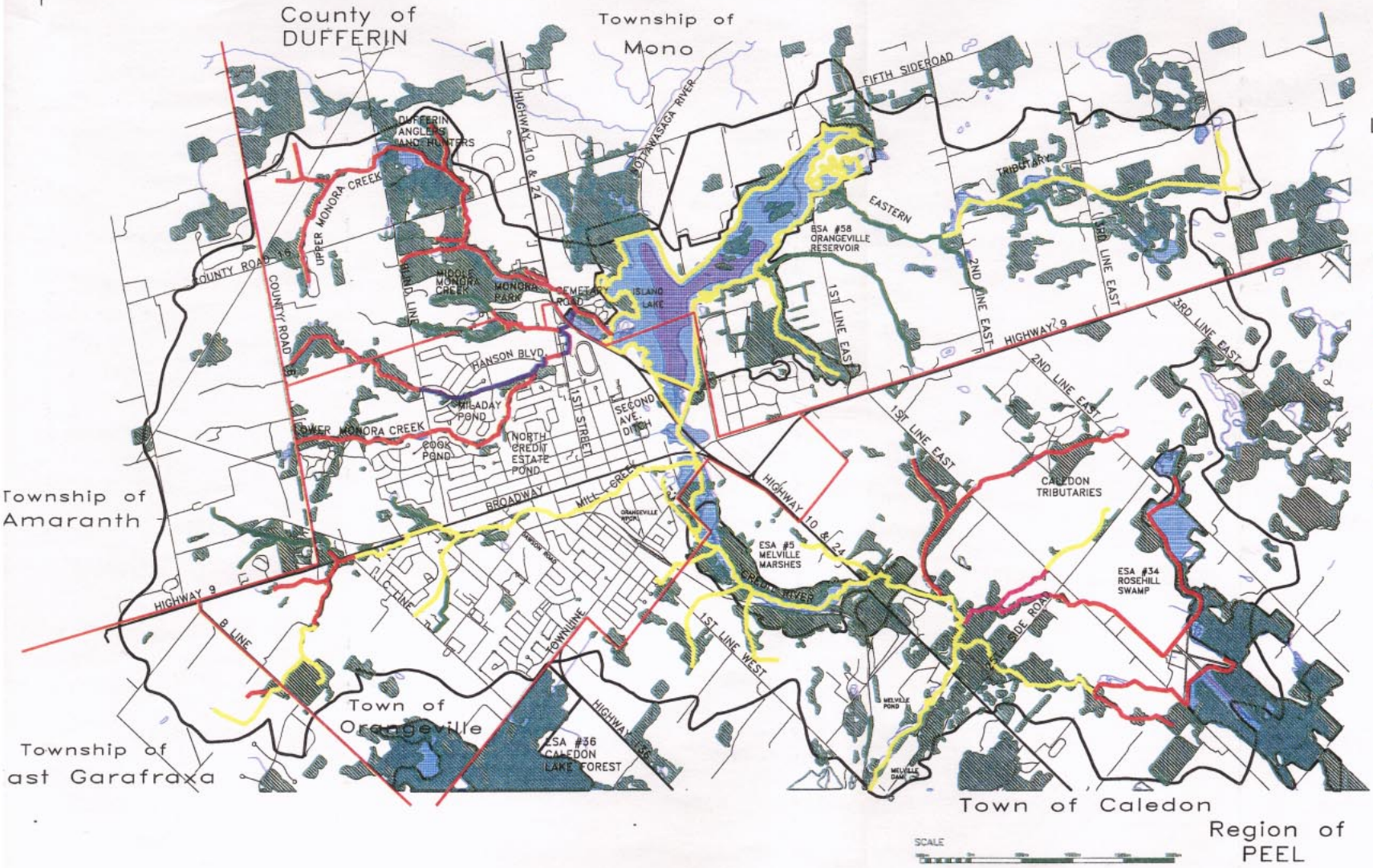
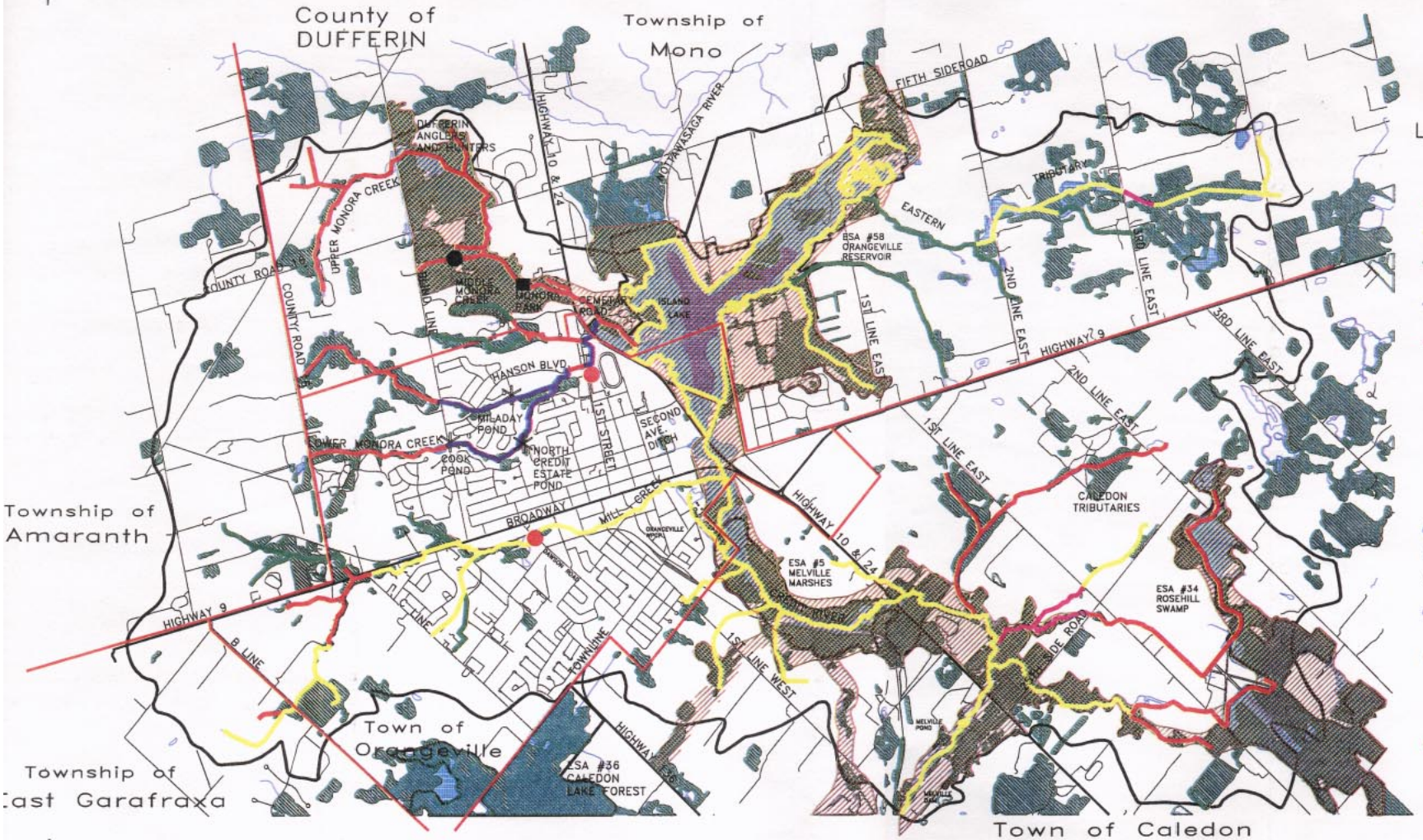


FIGURE 6.1

ENVIRONMENTAL PLANNING FOR THE CREDIT RIVER HEADWATERS
SUBWATERSHED 19
ALTERNATIVE No. 2 RESTORATION/ENHANCEMENT OF KEY ECOLOGIC CONTRAINTS



LEGEND

PROTECT EXISTING AQUATIC FEATURES
- LEVEL 1 (eg. sensitive coldwater (brook trout stream)
- LEVEL 2 (eg. less sensitive (warmwater stream)
- LEVEL 3 (eg.intermitent stream)

REMEDIATE SEDIMENT IMPACTS AND CHANNEL INSTABILITY

REMEDIATE RIPARIAN IMPACTS (CATTLE ACCESS)

SWM POND RETROFIT (eg. fish passage)

DAM RETROFIT (eg. water temperature control)

DAM REMOVAL (eg. fish passage)

PROTECT EXISTING TERRESTRIAL FEATURES
- EVALUATED WETLANDS
- FORESTED AREAS / WOODLOTS
- ENVIRONMENTALLY SENSITIVE AREAS
- ISLAND LAKE, NON WETLAND AREA

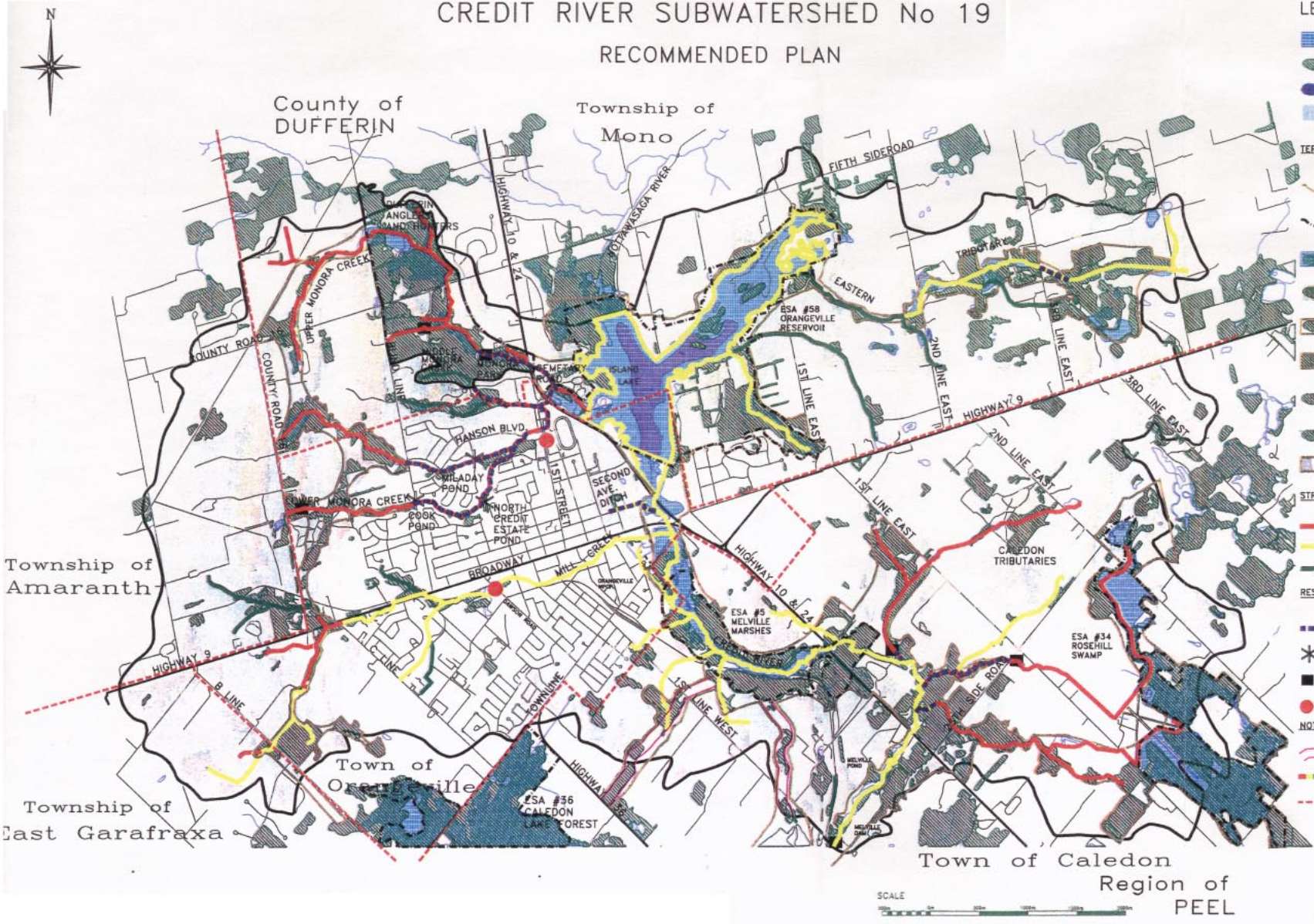
PROPOSED TERRESTRIAL CORRIDOR (with linkages to the Nottawasaga River, and Caledon Creek)

FLOOD DAMAGE CONTROL MEASURES

FIGURE 6.2

CREDIT RIVER SUBWATERSHED No 19

RECOMMENDED PLAN



LEGEND

- WETLANDS
- WOODLANDS
- ISLAND LAKE, NON WETLAND AREA
- HIGH RECHARGE AREAS

TERRESTRIAL SYSTEM	PROTECTION STATUS
TERRESTRIAL CORE AREAS AND CORIDORS	CLASS 1/2/3
ESA'S/LARGE NATURAL AREAS	CLASS 1
WETLANDS AND CONTIGUOUS WOODLANDS	CLASS 1
NATURAL FEATURES WITHIN HIGH RECHARGE AREAS	CLASS 1
OTHER NATURAL FEATURES WITHIN TERRESTRIAL CORE AREAS AND CORRIDORS	CLASS 2
100m WIDE VALLEY CORRIDOR	CLASS 1
NATURAL FEATURES IN LOW/ MODERATE RECHARGE AREAS	CLASS 2
WOODLANDS CONTIGUOUS WITH WITH LEVEL 1/2 STREAM	CLASS 2
TARGETTED AREAS FOR STEWARDSHIP PROGRAMS	CLASS 3

STREAM AND VALLEY CORRIDOR SYSTEM	
LEVEL 1 RIPARIAN CORRIDOR	CLASS 1
LEVEL 2 RIPARIAN CORRIDOR	CLASS 1
LEVEL 3 RIPARIAN CORRIDOR	CLASS 2

RESTORATION/ENHANCEMENT PROJECTS

- LEVEL 1/2 STREAM RESTORATION
- SWM POND RETROFIT
- POND BYPASS/RETROFIT
- FLOOD DAMAGE CONTROL PROJECT

NOTES:

- 100m WIDE UPLAND CORRIDOR
- 50m WIDTH
- MUNICIPAL BOUNDARY

FLOODLINES AND FILL LINES NOT SHOWN AS THEY ARE NOT AVAILABLE FOR THE ENTIRE SUBWATERSHED

FIGURE 7.1

CREDIT RIVER SUBWATERSHED 19 MANAGEMENT PLAN
PROPOSED TRAIL SYSTEM

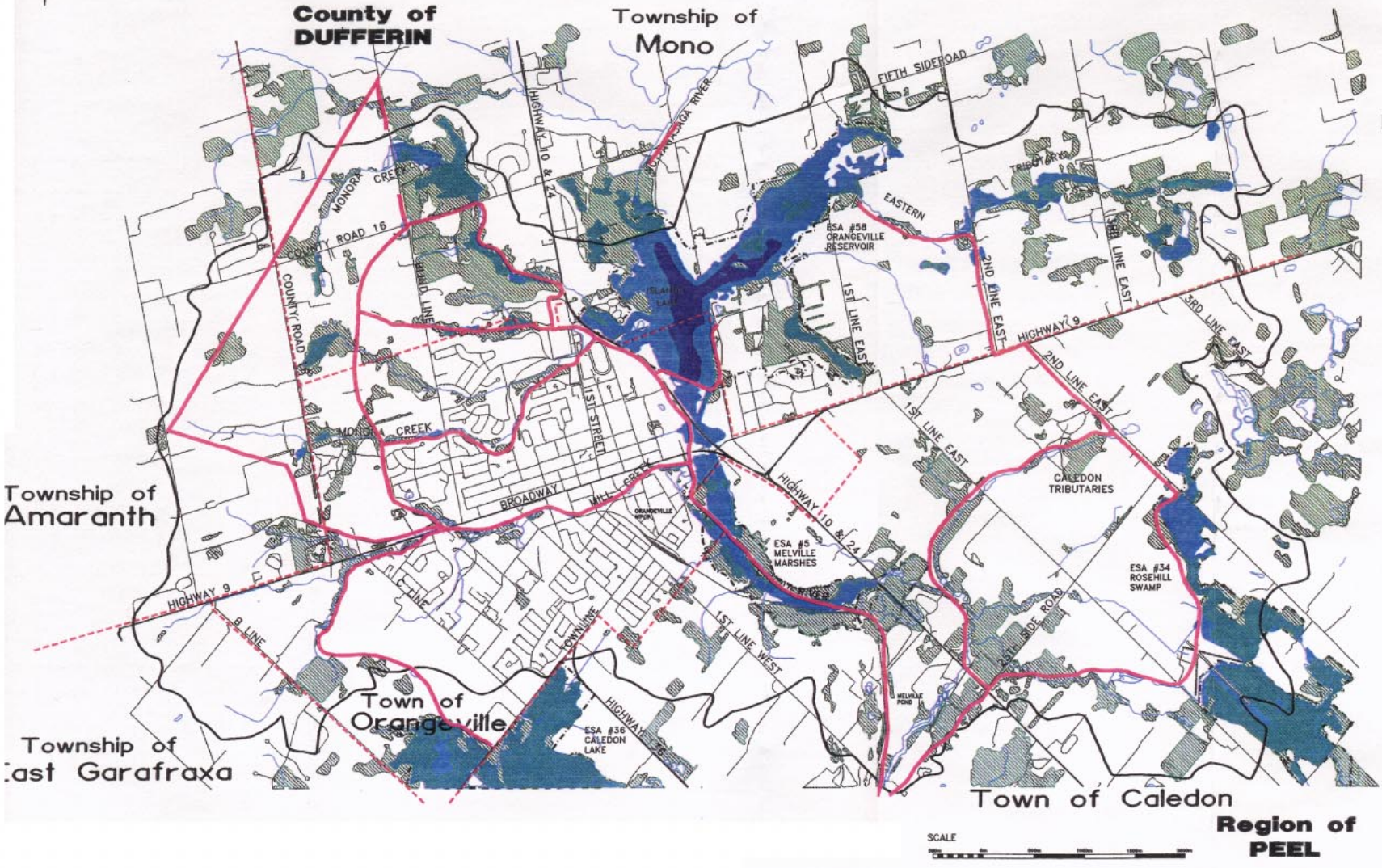
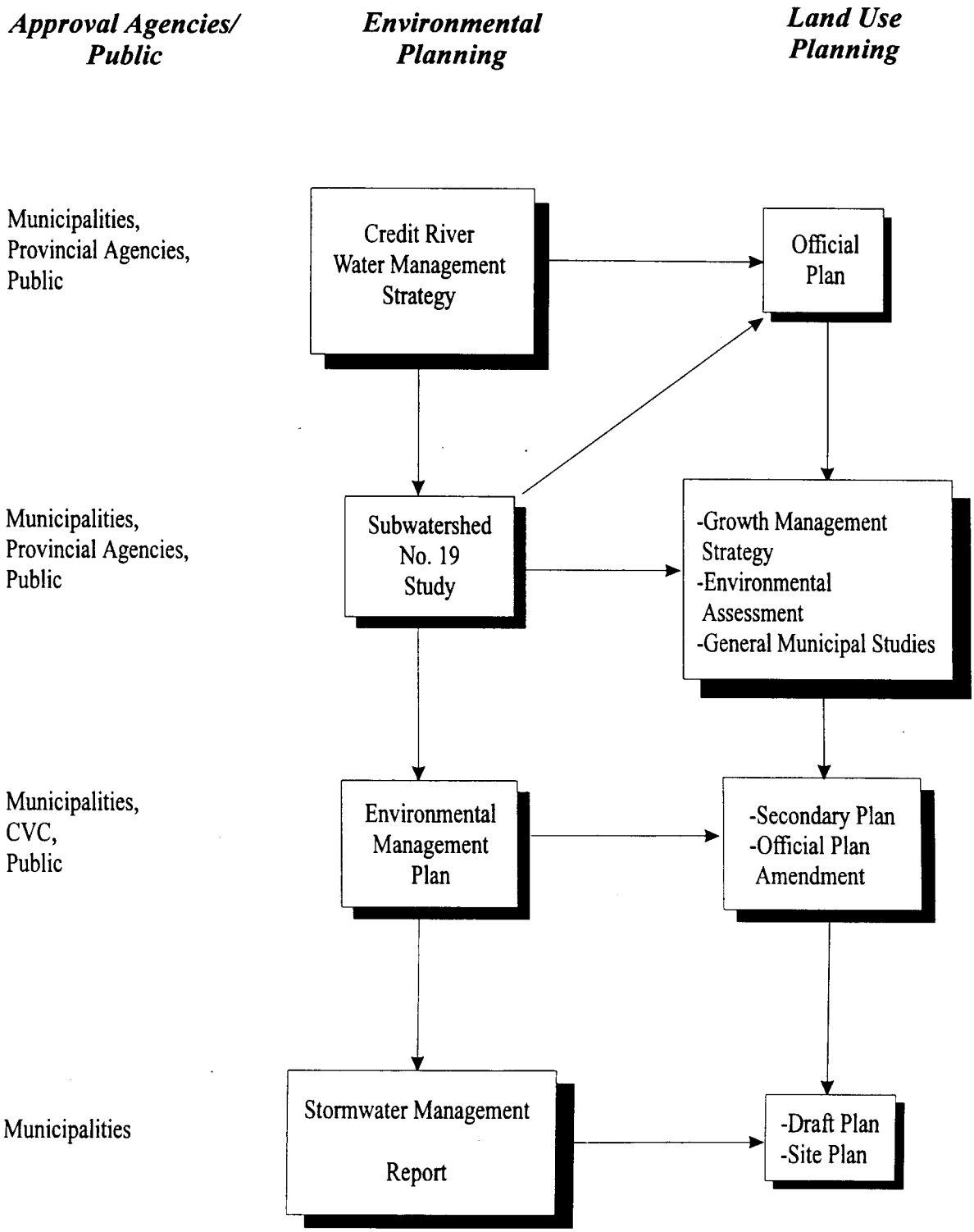
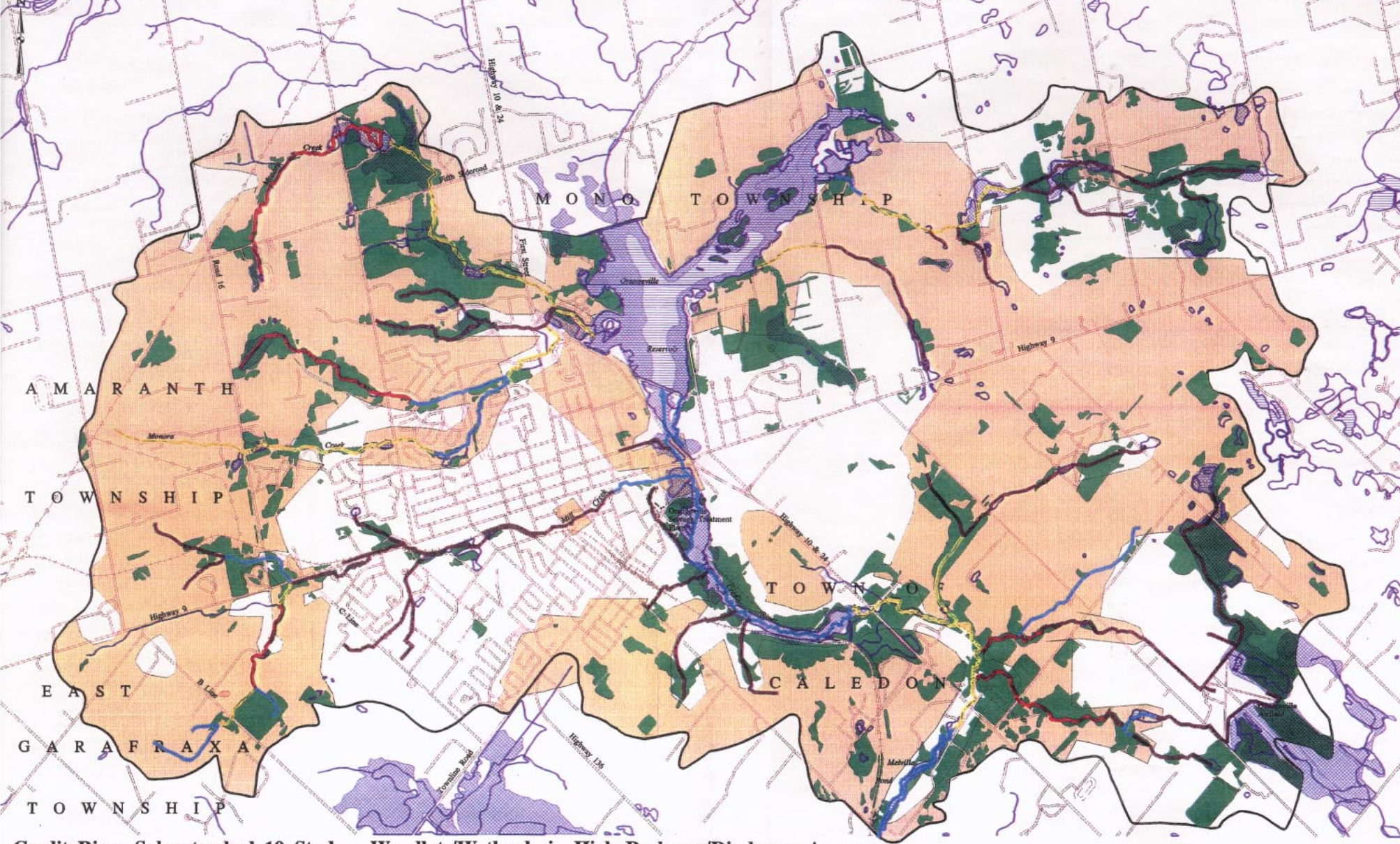


FIGURE 7.2

Figure 8.1
PROPOSED APPROVAL PROCESS



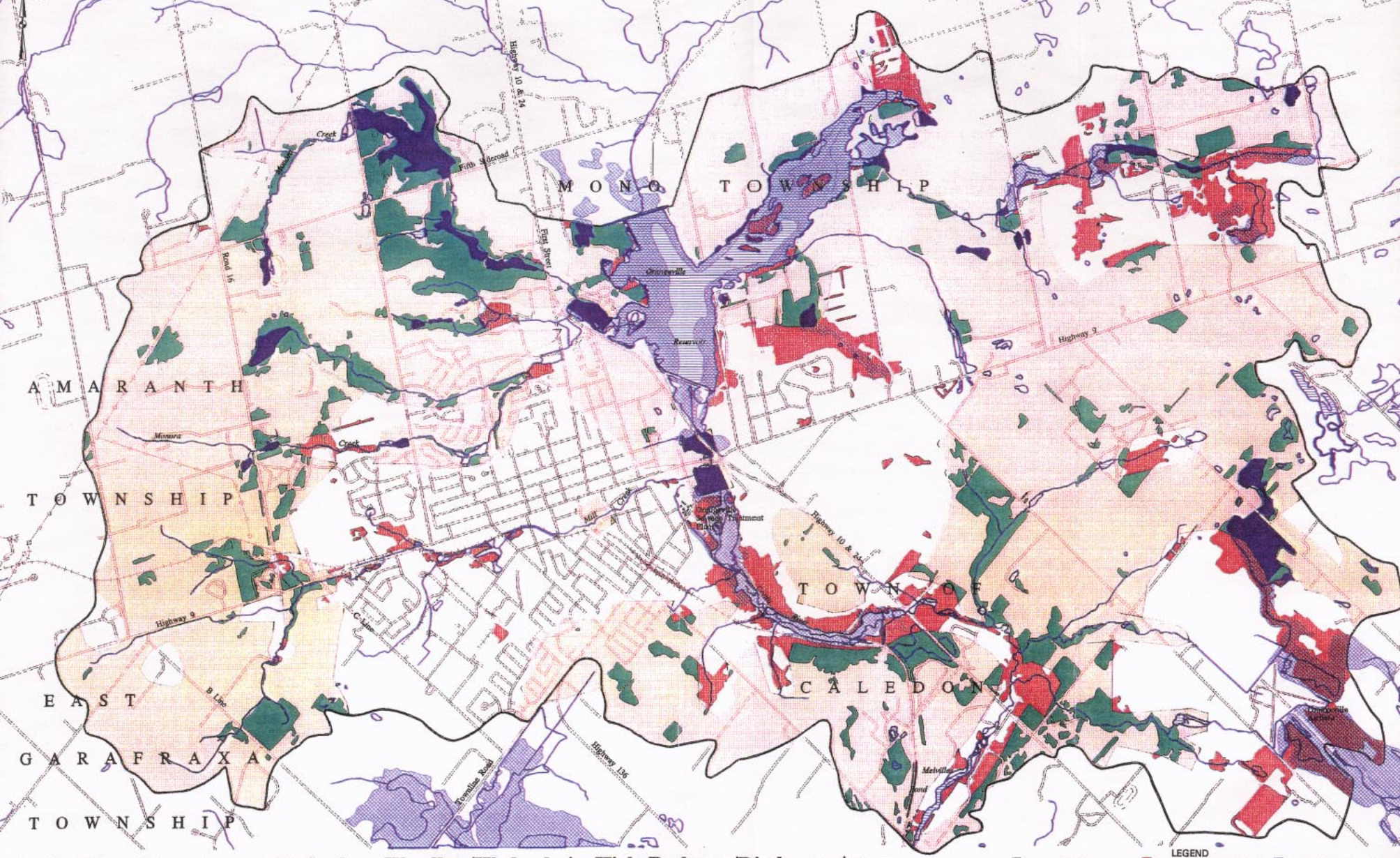


Credit River Subwatershed 19 Study - Woodlots/Wetlands in High Recharge/Discharge Areas with Existing Aquatic Communities

500m 0m 500m 1000m 1500m 2000m Scale 1 : 30 000

LEGEND

- Areas of High Recharge or Discharge
- Forested Areas
- Wetlands
- Class 1
- Class 2
- Class 3
- Class 4



Credit River Subwatershed 19 Study - Woodlots/Wetlands in High Recharge/Discharge Areas

500m 0m 500m 1000m 1500m 2000m Scale 1 : 30 000

LEGEND

- Areas of High Recharge or Discharge
- Forested Areas outside of Areas of High Recharge or Discharge
- Wetlands found outside Areas of High Recharge or Discharge
- Forested Areas within Areas of High Recharge or Discharge
- Wetlands found within Areas of High Recharge or Discharge

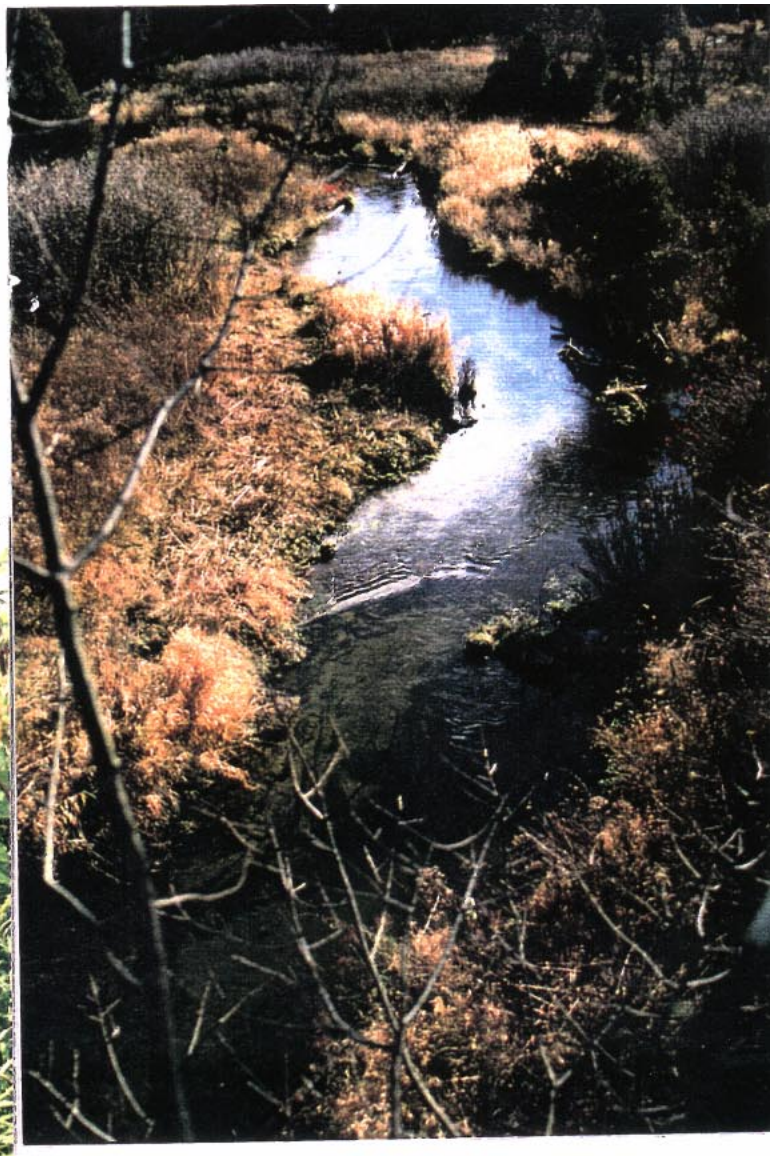


Photo 1 Credit River at Site 4.

Photo 2 North branch of Monora Creek east of Highway 10 showing E5 Type channel.

Photo 3 Unstable section of the north branch of Monora Creek east of Highway 10.

Photo 4 Stream habitat works on the northern tributary of the south branch of Monora Creek.

Photo 5 Channel realignment downstream of the confluence of the northern and southern tributaries of the south branch of Monora Creek.

Photo .6 Bank erosion and siltation on the lower reach of the southern tributary of the south branch of Monora Creek.

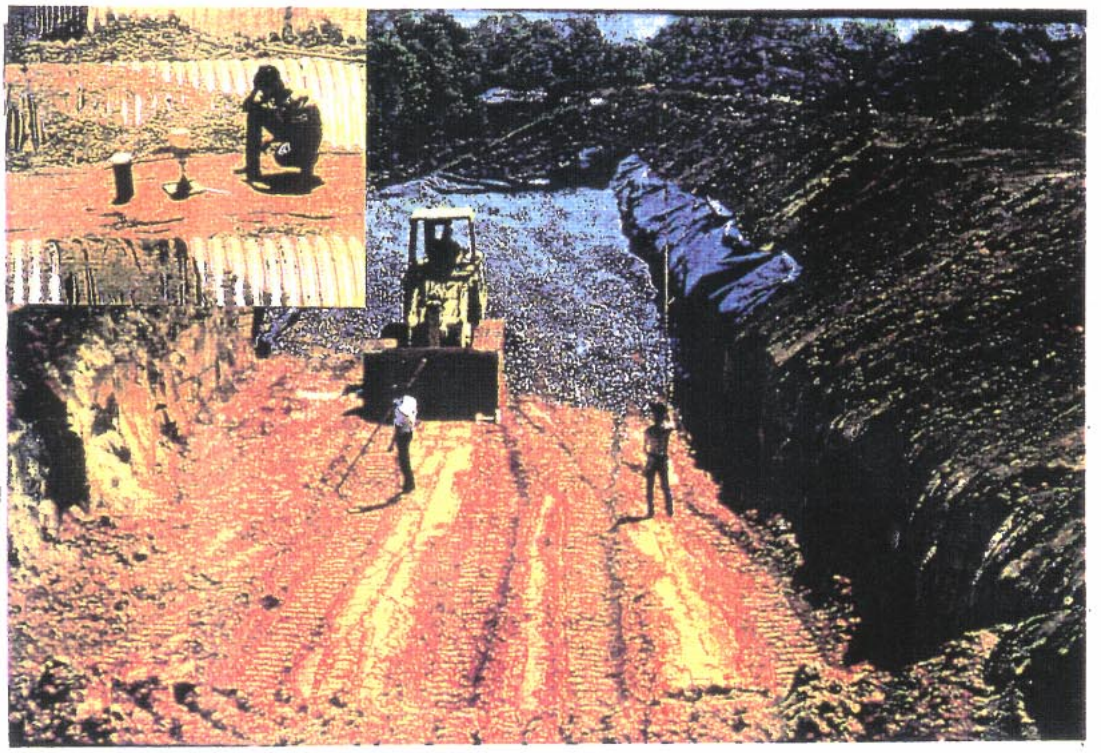


Photo 5.1: Illustration of an infiltration facility servicing a residential development. Insert shows perforated (bottom half only) corrugated steel pipe and observation wells.

Photo 5.2: Illustration of an infiltration trench servicing a commercial development.

Photo 5.3: Illustration of an infiltration basin incorporated into subdivision design. Runoff from adjacent roads is directed to the parkette area.

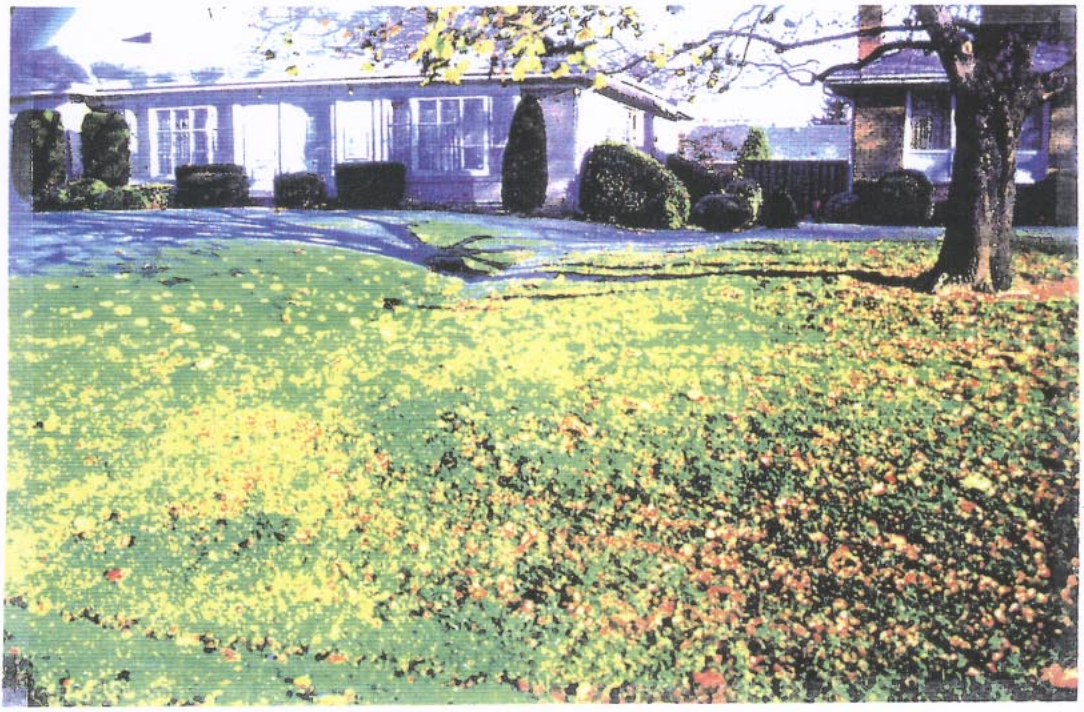


Photo 5.4 Illustration of traditional subdivision using swales to convey flows.

PHOTO 7.1: A SECTION OF MONORA CREEK WAS RECENTLY NATURALIZED; THEREBY PROVIDING A STABLE STREAM REACH WITH SUITABLE HABITAT CONDITIONS FOR THE RESIDENT FISHERY.

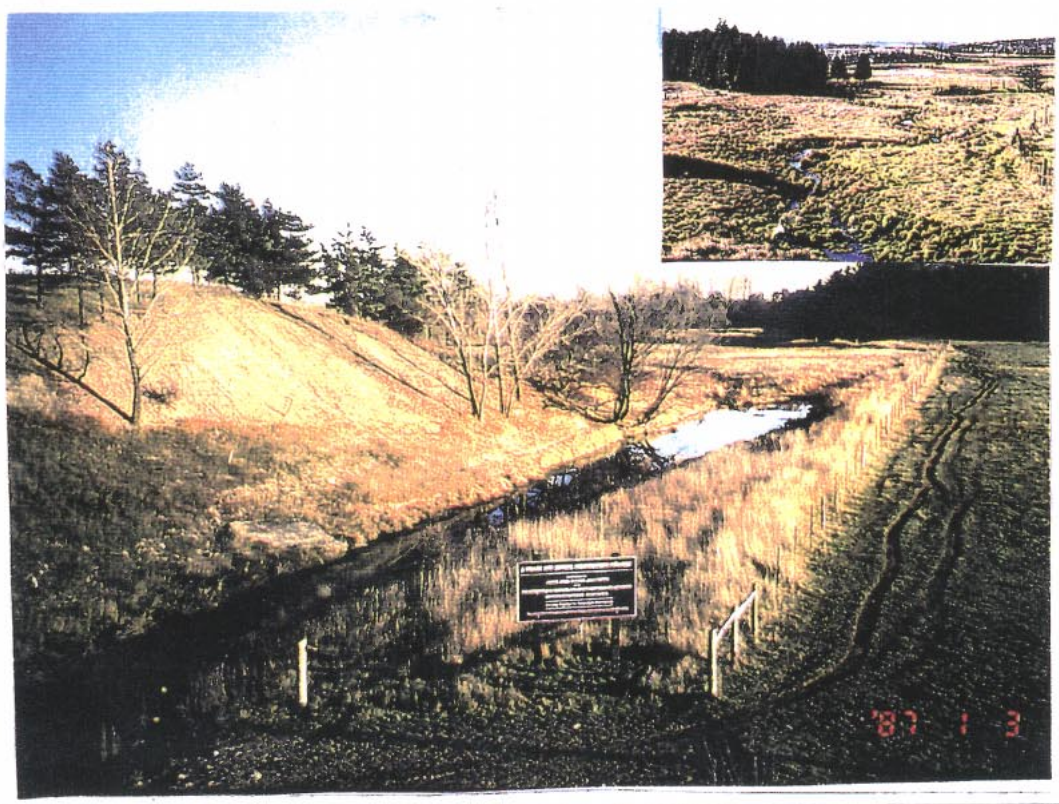


PHOTO 7.2: EXCESSIVE CATTLE GRAZING ALONG STREAMS RESULTS IN EROSION OF STREAM BANKS (INSERT). THIS, IN TURN, RESULTS IN EXCESSIVE SEDIMENT BEING TRANSPORTED DOWNSTREAM. THE SEDIMENT ADVERSELY IMPACTS THE RESIDENT FISH COMMUNITIES BY SMOTHERING EGGS AND REDUCING FOOD SOURCES. SEVERAL VOLUNTEER GROUPS HAVE PARTICIPATED IN LIMITING ACCESS, THEREBY ALLOWING THE STREAM BANKS TO NATURALLY REGENERATE.

PHOTO 7.3

SEVERAL STORMWATER MANAGEMENT PONDS TO CONTROL FLOODING AND EROSION WERE CONSTRUCTED IN THE 1970s AND 1980s. THE MILADY POND (PHOTO 7.3) IS LOCATED ALONG MONORA CREEK. IN RECENT YEARS, THESE FACILITIES HAVE BEEN RECONSTRUCTED TO PROVIDE ADDITIONAL BENEFITS, INCLUDING CREATION OF HABITAT FOR WATERFOWL, WATER QUALITY ENHANCEMENT, INTEGRATION INTO TRAIL SYSTEMS AND EDUCATIONAL OPPORTUNITIES (PHOTO 7.4).

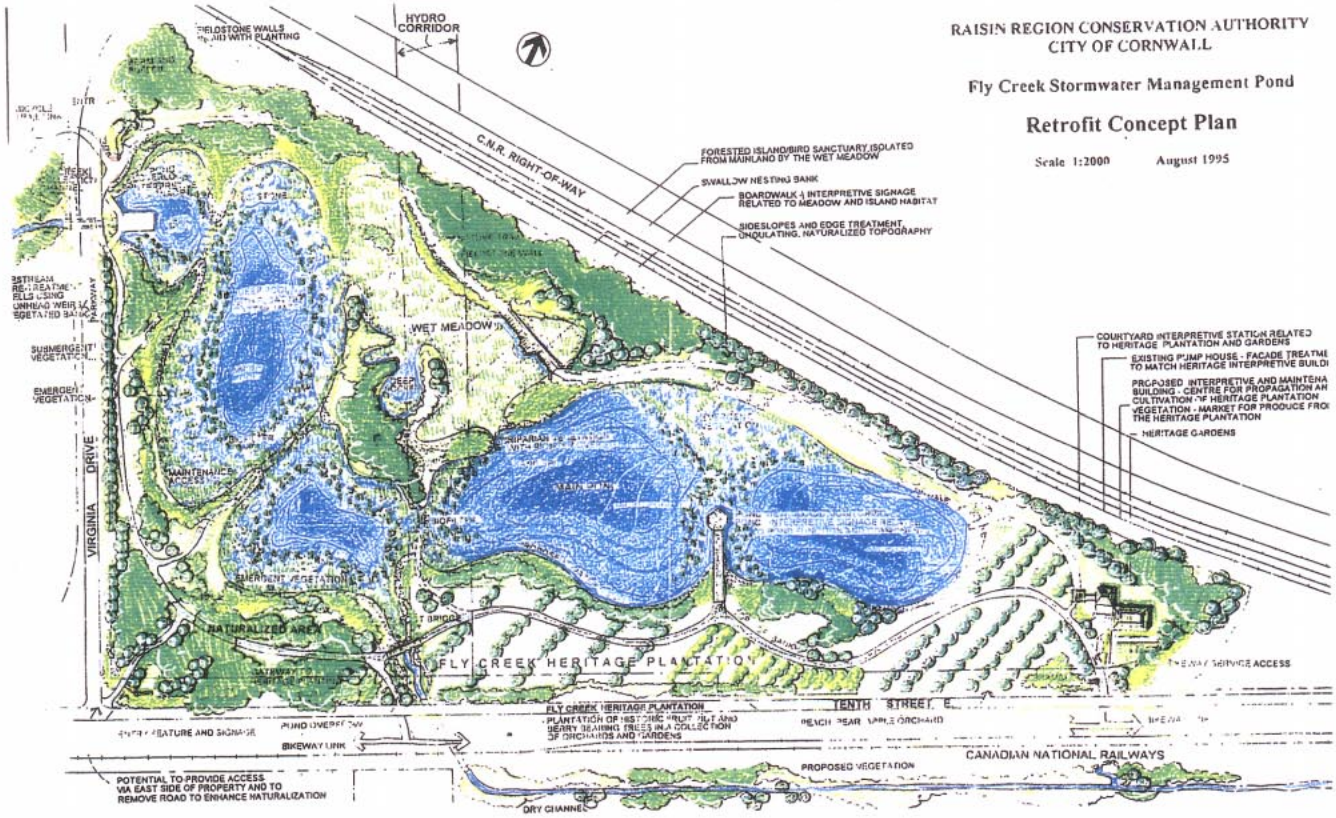


PHOTO 7.4

PHOTO 7.5: AERIAL VIEW OF THE CREDIT OXBOW AND CALEDON TRIBUTARIES IN THE LATE 1940'S

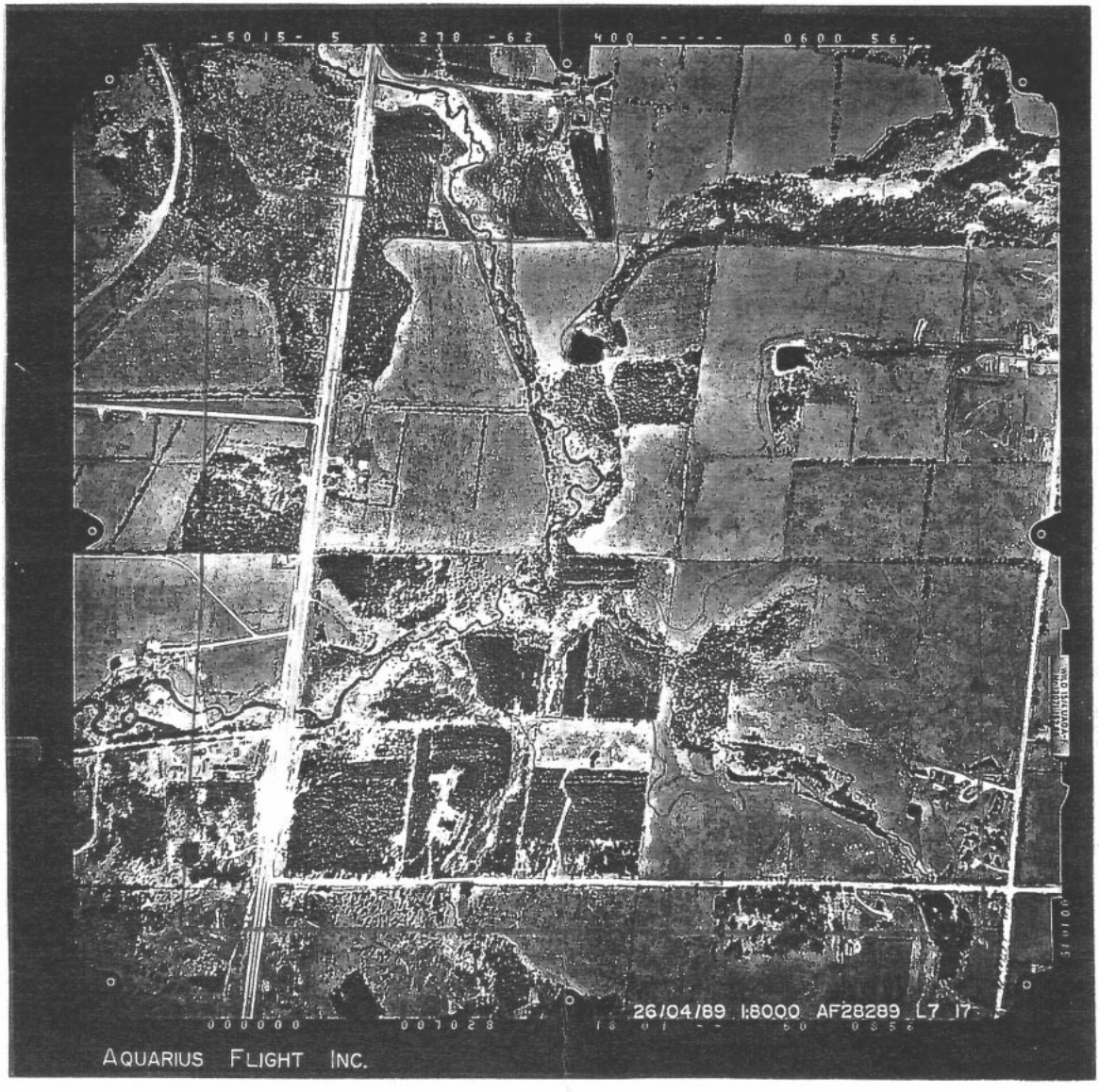


PHOTO 7.6: SAME VIEW IN 1989. NOTE THE EXTENSIVE REGENERATION AND PLANTINGS AROUND THE OXBOW AROUND HWY. 10 AND THE NORTHERN BRANCH OF THE CALEDON TRIBUTARY (TOP RIGHT OF PHOTO).

PHOTO 7.7: PANORAMIC VIEW LOOKING EAST WITH TYPICAL VEGETATION OF THE PROPOSED UPLAND TERRESTRIAL CORRIDOR IN THE FOREGROUND. MUCH OF THIS CORRIDOR IS CURRENTLY WELL FORESTED.