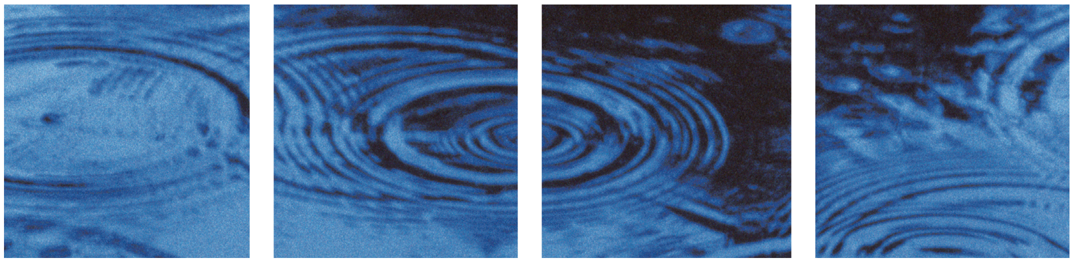

Watershed Characterization

Ausable Bayfield
Maitland Valley
Planning Region

Source Water Protection
Ausable Bayfield & Maitland Valley Partnership

Ausable Bayfield Conservation — Building Better Environmental Conscience

Maitland Valley Conservation Authority

Member of Conservation Ontario — Natural Champions

Ontario — Made possible through the support of the Government of Ontario

Watershed Characterization
Ausable Bayfield & Maitland Valley Partnership
Source Water Protection Planning Region

Assessment Report: Guidance Module 1

Version 1.0
January 2007

DRAFT

This document is a draft version and is subject to review by Conservation Ontario.

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INTRODUCTION

The Clean Water Act, which received Royal Assent on October 19, 2006, is part of the Ontario government's plan to implement recommendations from the Walkerton Inquiry and the O'Connor Report. Justice O'Connor concluded that a multi-barrier approach was the most effective method to prevent contamination from affecting drinking water. This approach includes taking action to prevent the contamination of sources of water, using adequate water treatment and distribution systems, water testing and training of water managers.

The Clean Water Act sets out a framework to identify and assess risks to the quality and quantity of drinking water sources, and to rank these risks from those requiring immediate action, to those which require monitoring to prevent elevation to a higher risk, to those risks which are negligible. The legislation also mandates the development of a source protection plan which sets out how the risks will be addressed. The plan will be carried out through official plans and other planning or regulatory requirements. Any activity that poses a significant risk to a drinking water source may be prohibited or require a site specific risk management option.

The Watershed Characterization for the Ausable Bayfield Maitland Valley Source Protection Planning Region is one of a set of modules that will help the local Source Protection Planning Committee and regional working groups to prepare an Assessment Report and a source water protection plan. It is the aim of this document to compile information on the physical, sociological and economic characteristics of the Ausable Bayfield Maitland Valley watersheds. Information will be updated as knowledge and data gaps are prioritized and filled, and used for other modules. It is anticipated that a Map Book will be produced in the future to include all the maps required for the Watershed Characterization and the Conceptual Water Budget and it will encompass up-to-date data.

TABLE OF CONTENTS

Chapter 1

WATERSHED DESCRIPTION

Version 1.0
January 2007

Prepared by

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1 Watershed Description

The *Watershed Description* uses existing information to summarize the watershed's fundamental natural and human-made characteristics, their status and trends. It provides context and support for future technical studies and public consultations and identifies major information gaps. The table of contents is a standard one from Ontario Ministry of the Environment and arranged by topic. Minor reorganization allows presentation by component watersheds for a more composite picture. Gaps are identified at the end of the document.

1.1 Overview of Source Protection Planning Region

In Part Two of the Report of the Walkerton Inquiry, Justice O'Connor recommended protection and enhancement of natural systems as one of the most effective means to protect the safety of Ontario's drinking water. He stressed the need for water protection planning to fit the functioning of the natural systems (O'Connor 2002). Since the fundamental unit for water's natural functioning is the watershed, watershed-based planning was a key recommendation. Conservation Authorities, as watershed-based jurisdictions, are well-suited to coordinate source protection planning. For optimum efficiency, the expert advisory committee on watershed-based source protection planning proposed that adjacent Conservation Authorities with similar natural functions and comparable source protection issues be grouped into a planning region (Implementation Committee 2004).

1.1.1 Drinking Water Source Protection Planning Region

The Ausable Bayfield and Maitland Valley Conservation Authorities (ABCA and MVCA) form a drinking water source protection planning region, the Ausable-Bayfield Maitland Valley Partnership. Their jurisdictions abut and their major rivers flow into Lake Huron. Their watersheds share common patterns of landscapes and natural systems. Their towns are small; their economies are based on agriculture, a growing and diverse manufacturing sector and Lake Huron-focused tourism.

Table 1-1 briefly outlines the watersheds and Conservation Authorities. Map 1-1 (Appendix D) shows their locations. The planning region includes several independently functioning watersheds.

Table 1-1: Conservation Authorities within the Source Protection Planning Area: Basic Information

	Ausable Bayfield	**Maitland Valley**
Watersheds	Ausable, Bayfield, Parkhill, numerous small watercourses outletting to Lake Huron	Maitland (including South Maitland, Middle Maitland, Little Maitland , North Maitland and Lower Maitland), Nine Mile River and numerous short streams along Lake Huron
Brief Description	Level, fertile agricultural area. High livestock concentration. Limited upstream natural areas and extensive artificial drainage. Forested river gorges and highly significant dune ecosystem. Watershed Area = 2440 km^2 Population = 45,000 Population Density = 18.44 people/km^2	Level to rolling fertile agricultural area. Very high livestock concentration. Limited natural areas and extensive artificial drainage in the south and east. More natural area to the north. Watershed Area = 3266 km^2 Population = 60,000 Population Density = 18.37/km^2
History Outline	Ausable River Conservation Authority formed in 1946 (first Conservation Authority) to deal with serious problems of local flooding, soil erosion, water supply and water quality. 1950s projects included flood control, erosion control, land purchases and Morrison Dam construction in 1959. In the 1960s, education projects and the construction of Parkhill Dam occurred. In the 1970s, flood control, erosion control and property purchases continued. The Bayfield watershed joined in 1972 and the CA name changed accordingly. 1980s brought more focus on water quality; 1990s added funding challenges and more partnerships. Since 2000, projects have dealt with private land stewardship, species-at-risk, source water protection and groundwater.	Formed in 1951, the original jurisdiction covered only the Middle Maitland. In 1961, Maitland Valley Conservation Authority was established covering the whole Maitland watershed. In 1972, 1975, and 1976 a series of enlargements added shoreline streams and Nine Mile River. Early projects included land acquisition and flood control engineering. In the 1980s, flood warning and education were added. The 1990s brought a focus on ecosystem health and functioning. The 2000s added watershed partnerships, restoration and water quality emphases (MVCA 2003).
Vision	Clean and usable watersheds where human needs and the needs of the natural environment are balanced to ensure quality of life and biological diversity today and in the future (ABCA Conservation Strategy 1993).	Maintained essential natural processes and life-support systems, preserved biological diversity, and sustainable use of ecosystems (MVCA Conservation Strategy 1989).
Mandate	To provide leadership and management, in cooperation with the community, to maintain and enhance the watershed resources now and in the future (ABCA Conservation Strategy 1993). The Programs and Services offered by the ABCA are designed to work in partnership with the landowners, municipalities and governments (provincial and federal) in managing the soil and water resources of the watershed. Each partner plays an important role in the conservation of our natural lands and waters.	To establish and undertake a program that will promote and enhance the conservation, restoration, development and management of renewable natural resources associated with water, land and people (MVCA 1984).

1.1.2 Stakeholders and Partners

Source protection planning will use a broad scale, interdisciplinary approach to manage and protect sources of drinking water. Many partners and stakeholders will be involved in the plan development; residents will contribute to and benefit from the plan implementation. Both Conservation Authorities have a strong tradition of working closely with partners in the watershed and a wide network of interested and committed contacts. Among the partners may be:

- Municipalities – the 24 lower tier municipalities (six upper tier) in the planning region provide drinking water from wells or Lake Huron. Many also treat sewage. Local taxes pay to identify wellhead and intake protection zones. All have numerous activities (e.g., road maintenance, zoning) that affect source water protection;

- Health Units – the 6 health units in the planning region administer health promotion and disease prevention programs. Drinking water source protection is basic to their mandate. They are concerned with both drinking water and beach safety;

- Members of the public – both businesses and residents – bring valuable local knowledge and will be implementation partners in their day-to-day actions, community activities and tax contributions. Their input throughout the planning process will make the outcome relevant to their needs and will strengthen their commitment;

- Provincial ministries – the policies and programs of many ministries affect water.

- Adjacent Conservation Authorities – groundwater flows cross Conservation Authority boundaries, extending the coordination of drinking water source protection;

- Federal departments – the Federal Government funds local initiatives, typically research projects involving Conservation Authorities;

- Joint Provincial and Federal Initiatives – Lake Huron Sustainability Framework through MNR, MOE, OMAFRA, and Environment Canada to encourage and support local basin communities;

- First Nations – Kettle and Stoney Point First Nations bring the insights of generations living intimately with land and waters, as well as other First Nations with claims in the region;

- Non-Governmental Organizations – many NGOs have mandates and activities that involve water protection or that have impacts on water protection. They offer in-depth knowledge of issues, valuable liaison with residents and assistance in program implementation.

1.1.2.1 Municipalities

Municipalities are key partners in the assessment of source water protection and are members of the local Conservation Authorities. Municipalities in the planning region are listed in Table 1-2 and located on Map 1-1. Table 1-2 also includes key municipal contacts: the clerk and the water manager as well as the county Planning Department contact.

Table 1-2: Municipalities in the Source Water Protection Region

County	Municipalities/Townships/ Towns	Clerk/ Administrator	Planning Dep't Contact	Water/Works Manager
Huron			Scott Tousaw	
	Ashfield – Colborne – Wawanosh	Mark Becker		Bryan Van Osch
	North Huron	Kriss Snell		Ralph Campbell
	Morris/Turnberry	Nancy Michie		Berry O'Krafka
	Howick	Arlene Parker		Wray Wilson
	Goderich	Larry J. McCabe		Kenneth C. Hunter
	Central Huron	Richard Harding		Steve Gibbings
	Huron East	John R. McLachlan		Barry Mills
	Bluewater	Janisse Zimmerman		Ross Fisher
	South Huron	Don Giberson (*acting*)		Don Giberson
Perth			David Hanly	
	North Perth	Mark Urbanski		Matt Ash
	Perth East	Glenn Schwendinger		Bud Markham
	West Perth	Pat Taylor		Mike Kraemer
	Perth South	Muriel King		William Doupe
Middlesex			Steve Evans	
	Adelaide-Metcalfe	Fran Urbshott		Eldon Bryant
	Middlesex Centre	Cathy Saunders		Maureen Looby
	North Middlesex	Shirley Scott		Joe Adams
	Lucan Biddulph	Ronald J. Reymer		Steve McAuley
Lambton			Dave Posliff	
	Lambton Shores	John Byrne		Paul Turnbull
	Warwick	Don Bruder		Arnold Syer
Wellington			Gary Cousins	
	Mapleton	Patricia Sinnamon		Sandy Vallance
	Minto	Barbara L. Wilson		Norm Fisk
	Wellington North	Lorraine Heinbuch		Gary Williamson
Bruce			Chris La Forest	
	South Bruce	David Johnston		Donald Jackson
	Huron-Kinloss	Mary Rose Walden		Hugh Nicol

1.1.2.2 Health Units

Medical Officers of Health for the six counties within the source water protection planning region:

Huron: Dr. Beth Henning
Perth: Dr. Rosana Pellizzari
Middlesex: Dr. Graham Pollett
Lambton: Dr. Chris Greensmith (Acting)
Wellington: Dr. Troy Herrick
Bruce: Dr. Hazel Lynn

1.1.2.3 Interested and Engaged Stakeholders

Members of the public are essential participants in drinking water source protection planning. They bring valuable local knowledge and will be implementation partners in their day-to-day actions, community activities and tax contributions. Their input throughout the planning process will make the outcome relevant to their needs and will strengthen their commitment. Stakeholders or groups who have already participated in a watershed planning management activity, committee or rehabilitation project form an initial contact list, Table 1-3.

Table 1-3: List of Stakeholders who have provided past input

County	Business	Contact
Huron	B. M. Ross and Associates	R.R. Anderson
Huron	Maitland Engineering Ltd.	
Huron	Sid Bruinsma Excavating Ltd.	
Huron	McCann Redi-Mix	
Huron	Merner Contracting Ltd.	
Huron	George Radford Constructing Ltd.	
Huron	Vandriel Excavating Ltd.	
Bruce	Bruce-Grey-Huron-Perth-Georgian Triangle Training Board	Virginia Lambdin
Huron	Wescast Industries Inc.	Vicky Skinner
Huron	Huron Manufacturing Associations	Monica Walker-Bolton
Huron	Volvo Motor Graders Inc.	Patrick Olney
Perth	R.J. Burnside & Associates Ltd.	
Perth	Gamsby & Mannerow Ltd.	
Perth	Johnson Engineering	
Bruce	Merlin General Corporation	Rick Goodman
Lambton	Colt Engineering	
Middlesex	M.M. Dillon	Al Mitchell
Perth	Ontario Stone, Sand & Gravel Association	Carol Hochu
Huron	Environmental Geosolutions	Stephen Boles
Perth		Mervyn Erb
Perth		Laura Neubrand
Perth		Patrick Feryn
Bruce		Leslie Nichols
Bruce		Robert Helm
Bruce		Susan Gagne
Wellington		Jeff Jacques
Wellington		Matt Robillard
Lambton		Robert Wellington
Lambton		John Couwenberg
Lambton		Gabrielle Ferguson
Middlesex		Paul Cornwell
Middlesex		Rob Langford

1.1.2.4 Provincial Agencies

Partners with Provincial Government affiliations include:

- Ministry of the Environment (MOE)
- Ministry of Natural Resources (MNR)
- Ontario Ministry of Agriculture and Food (OMAFRA)
- Ministry of Municipal Affairs and Housing (MMAH)
- Ministry of Northern Development and Mining (MNDM)
- Saugeen Conservation Authority
- Grand River Conservation Authority
- St. Clair Region Conservation Authority
- Upper Thames River Conservation Authority
- Conservation Ontario
- Pinery Provincial Park
- Point Farms Provincial Park

1.1.2.5 Federal Government

The Federal Government funds local initiatives, typically research projects coordinated with Conservation Authorities. Local water-related projects and their contacts include: Maitland Watershed Partnerships; Fisheries and Oceans Canada; Ausable River Recovery Strategy; National Water Research Institute of Environment Canada.

1.1.2.6 First Nations

First Nation partners adjacent to the planning region and with possible interest are:

- Kettle and Stoney Point First Nation
- Walpole Island First Nation

1.1.2.7 Non Governmental Organizations (NGOs)

Local NGOs that may be interested in source water protection planning are listed below. The capacity each may bring is included.

Ailsa Craig Environmental Group

Ashfield Colborne Lakefront Association: Provides information and advocacy for groundwater quality issues and other common concerns of the lakeshore community. Has a partnership with the MVCA to take water samples in small lakeshore streams and provides a volunteer base.

Bluewater Shoreline Residents Association: Interested in promoting water quality.

Business Improvement Associations: Work towards improvement and betterment of communities such as the Sarnia-Lambton Business Development and the Huron Business Development Corporation.

Christian Farmers Federation of Ontario: Chapters in Bruce, Huron, Lambton, Perth, Middlesex, Wellington Counties: Knowledge of local agricultural industry, issues and concerns.

Dairy Farmers of Ontario: Knowledge of local dairy industry, issues and concerns.

Ducks Unlimited: Knowledge of wetlands, habitat, hydrological roles of natural areas; project funding.

Huron Fringe Field Naturalists: Knowledge of local natural areas and species; possible volunteer base.

Ecological Farmers Association of Ontario: Knowledge of agricultural approaches and techniques that work with nature.

Friends of the Bayfield River: Knowledge of local area, possible volunteer base, education and water quality focused.

Goderich Port Management: Knowledge of port issues.

Huron Business Development Centre: Expertise on local business opportunities.

Huron County Water Protection Steering Committee: The mandate of the Committee is to bring together representatives of the various organizations, agencies and municipalities, to prioritize and recommend implementation measures to participating groups, and to coordinate activities at a broad scale, subject to the resources of the participating organizations (Huron County Planning and Development Department, 2005). Representatives on the *Huron County Water Protection Steering Committee* include: Huron County Council, Clerks and Treasurers Association, Local Councillors, Ausable Bayfield Conservation Authority, Maitland Valley Conservation Authority, Ministry of the Environment, Ministry of Agriculture and Food, Huron Federation of Agriculture / Christian Farmers/ Huron Farm Environmental Coalition, Huron Manufacturing Association, Huron Tourism Association, Ashfield Colborne Lakefront Association, Bluewater Shoreline Residents Association, Planning and Development Department, Drinking Water Source Protection, Lake Huron Centre for Coastal Conservation, Ontario Pork Producers, Huron Stewardship Council, B.M. Ross and Associates, and the Huron County Health Unit.

Huron Farm Environmental Coalition: Knowledge of local agricultural concerns and capacities for Best Management Practices.

Huron County Environmental Farm Plan: A voluntary assessment that is performed by farmers to assess the strength and areas of environmental concern on their farm. Farms with a complete EFP are eligible for certain grants.

Huron County Federation of Agriculture: Farmer-led dynamic lobby to bring the wishes of farmers to the provincial government.

Huron Manufacturing Association: Promotes community support and economic growth within the manufacturing sector.

Huron Stewardship Council: Knowledge of rural stewardship issues; possible project funding; staff person coordinator.

Huron Tourism Association: A resource of business members with a desire to further tourism and promote economic growth and employment opportunities.

Lake Huron Centre for Coastal Conservation: Planning and management of shoreline zone.

Lambton Chapter of the Ontario Woodlot Association: Knowledge of local woodlots, management techniques and income opportunities; communication link with landowners.

Lambton Wildlife Incorporated: Knowledge of local natural areas and species; volunteer base; staff.

Lower Maitland Stewardship Group: Members from diverse backgrounds, with an active interest in maintaining and enhancing the natural ecosystem features of the Lower Maitland River Valley.

Middle Maitland Rejuvenation Committee Volunteer base to do projects within the Middle Maitland subwatershed.

Middlesex Chapter of the Ontario Woodlot Association: Knowledge of local woodlots, management techniques and income opportunities; communication link with landowners.

Middlesex Stewardship Council: Knowledge of rural stewardship issues; possible project funding; staff person coordinator.

Nairn Creek Project: Example of stream rehabilitation and possible volunteer base for other local projects.

National Farmers Union: Knowledge of farming issues. Encourages economic and social policies to maintain family farm as the primary food-producing unit in Canada.

Perth County Visitors' Association: Promotes tourism in the area.

Perth Stewardship Council: Knowledge of rural stewardship issues; possible project funding; staff person coordinator.

Perth-Huron Chapter of the Ontario Woodlot Association: Knowledge of local woodlots, management techniques and income opportunities; communication link with landowners

Rural Lambton Stewardship Network: Knowledge of rural stewardship issues; possible project funding; staff person coordinator.

Sarnia Lambton Economic Partnership: Interested in promoting economic development and in promoting the long-term health of the community.

Sarnia Lambton Environmental Association: Association is comprised of member industries that are committed to water quality care. Perform plant outflow and river water analyses. Sponsors "Go with the flow" program to introduce groundwater care.

Tourism Sarnia Lambton: Promotes tourism in the area.

Waterloo-Wellington Chapter of the Ontario Woodlot Association: Knowledge of local woodlots, management techniques and income opportunities; communication link with landowners.

Wellington Stewardship Council: Knowledge of rural stewardship issues; possible project funding; staff person coordinator.

1.2 Geological Setting

The foundation of the planning region is a deep layer of sedimentary rock overlaid by unconsolidated material deposited by the Ice Age glaciers.

1.2.1 Bedrock Geology

The Palaeozoic sedimentary rock formations underlying the planning region are shown on Map 1-2 (Appendix D) and they are approximately 1 km deep. They were deposited near the crest of the Algonquin Arch, a Precambrian ridge underlying Southwestern Ontario and separating the Michigan basin to the northwest and the Appalachian basin to the southeast. The planning region falls on the Michigan basin side. The layers that reach the bedrock surface in the region were deposited in the Silurian and Devonian ages. The Silurian is older and represented by the dolomite Bass Island Formation. Above it, the Devonian-age formations in order are the limestone Bois Blanc Formation, the limestone and dolostone Detroit River Group of the Amherstberg and Lucas Formations, the limestone Dundee Formation and the predominantly shale Hamilton Group. The bedrock tilts gently southwest from the Dundalk Dome northeast of the planning region. The tilt exposes the strata at the bedrock surface in sequence from oldest in the northeast to youngest in the southeast with occasional windows revealing the underlying stratum (Map 1-2). Water-yielding capacities rate as very good for the Bass Island unit, excellent for the Bois Blanc unit, very good for the Detroit River Group, very good for the

Dundee unit, and fair for the Hamilton Group (Singer et al. 1997). The Huron Groundwater Study rates the Lucas Formation of the Detroit River Group generally highest yielding (International Water Consultants et al. 2003).

Numerous pre-glacial river valleys interrupt the gentle lake ward slope of the bedrock surface. A rise occurs near Arkona (Dillon Consulting and Golder Associates 2004a) and a valley extends from Parkhill southeast to Lake Erie (Dillon Consulting and Golder Associates 2004b). Bedrock exposures are few. Occasionally, stream courses have cut through the surficial deposits (James F. Maclaren 1977), e.g., at Rock Glen in the Ausable Gorge and in the lower Maitland. Sinkholes occur in several parts of the planning region, most notably in the upper Ausable and Bayfield watersheds (ABCA 1985; Malone 2003; International Water Consultants et al. 2003) (Map 3-7). Bedrock also surfaces in a few spots near Brussels in the Middle Maitland (International Water Consultants et al. 2003) and near Thedford in the Ausable watershed (Dillon Consulting and Golder Associates 2004a).

Documented bedrock uses (Conservation Branch 1949; Conservation Authorities Branch 1967; ABCA 1985) include:

- Building stone near Brussels;
- Bricks and tile from shale in the south (Thedford Quarry);
- Flint nodules from limestone at Stoney Point and traded by First Nations;
- Minor fossil fuel producing areas occur in the south half of the Ausable watershed (1985 Plan); and
- Rock salt and brine at Goderich (Sifto Canada, Goderich Mine) and Seaforth area; brine wells near Brussels.

1.2.2 Quaternary Geology

The overburden that covers the bedrock is unconsolidated sediments deposited during the Quaternary Period. It includes the Pleistocene (Ice Age) and Holocene (Recent) epochs. In the planning region, the glaciers of the most recent Pleistocene stage, the Wisconsian, largely obliterated effects of earlier stages and shaped today's land surface. They left a fine till base for much of the region and a loamier till in the northeast. Coarse textured ice contact stratified drift is also more common in the north. Melt waters deposited a web of glacial sand and gravel spillways, a delta under today's Hay Swamp, as well as several coarse-textured eskers. Glacial lake ancestors of Lake Huron extended across the western and southern parts of the planning region where they deposited beach sands and gravels at shorelines and clay and silt in the deeper areas. More recently, wind-blown (eolian) fine sands have formed dunes, floodplains collected alluvial sediments and organic soils developed from decomposed plant material (MVCA 2004).

The overburden thickness generally deepens to the west, exceeding 60 m in the Wyoming Moraine near Bayfield but thinning out to 20 m or less in the east with some of the shallowest near Brussels (International Water Consultants et al. 2003; MVCA 2004). The depth also decreases to less than 10 m from the Ausable gorge west through Thedford to Port Franks (Dillon and Golder 2004a).

Elma Till of silt, sandy silt and clayey silt is the oldest till in the region and surfaces in the east part of the planning region. The more recent Rannoch Till, a stonier silt to silty clay till, covers the central part. The most recent silt to silty clay St. Joseph Till covers the Rannoch Till near the shore and forms the Wyoming Moraine and shore bluffs. The more resistant Rannoch Till below helps to stabilize much of the shoreline. Fine sediments from eroded bluffs are deposited offshore; sands travel south along the shore to form beaches, dunes and bars. Sand and gravel beaches from the glacial Lake Warren parallel today's shore. Beaches from the later Lakes Nipissing and Algonquin have eroded away at the bluffs to become the sand of the Pinery dunes and beaches (ABCA 1985).

Generalized cross sections – both county-wide and in local municipal well areas - are presented in each of the county groundwater studies (Dillon Consulting and Golder Associates 2004: a,b; International Water Consultants et al. 2003; Waterloo Hydrogeologic 2003: a,b; Burnside Environmental 2001: a,b). They show confining units (low permeability silts and clays), sand and gravel units, and bedrock.

1.3 Hydrology

1.3.1 Watershed Form and Surface Hydrology

Physiography, topography and soils are interrelated factors affecting a watershed's surface hydrology. Rainfall easily infiltrates the coarse textured deposits of kame moraines, eskers and spillways and, as groundwater, steadily discharges from these units to maintain stream flows. Rainfall on clay till, both plains and moraines, however, tends to flow over the surface to generate spikes of flow during storms but little on-going base flow. The coarse textured units increase northward in the planning region, as do the base flows and incidence of cold water streams. The discussion uses a watershed-based format to make the links of physiography, topography and soils with surface hydrology. The main watersheds are Ausable River, Bayfield River, Maitland River, Nine Mile River, Shore Streams and Gullies. Physiography (Chapman and Putnam 1984) is presented on Map 1-3; surface hydrology features are shown on Map 1-4. Table 1-4 lists some basic statistics by watershed.

Table 1-4: Basic Surface Hydrology Statistics by Watershed

	Ausable	Bayfield	Maitland	Nine Mile	Shore
Watershed Area (km^2)	1233	497	2572	243	692
Streams and quaternary codes * direct outlet to Lake Huron	Ausable*: 2FF-03 Parkhill*: 2FF-04 Little Ausable: 2FF-05 Mud Creek*: part of 2FF-02	Bayfield*: 2FF-07 Bannockburn: 2FF-08	Maitland*: 2FE-02 South Maitland: 2FE-03 Middle Maitland: 2FE-04 Little Maitland: 2FE-05	Nine Mile*: 2FD-06	Many*:2FF-06 Many*:2FE-01 Many*:2FD-07 Many*:2FD-05 Eighteen Mile*: 2FD-04
% kame, sand plains, beach, esker, spillway	kame: 0.17 sand plains: 8.06 beach: 2.35 esker: 0.00 spillway: 6.76	kame: 0.63 sand plains: 0.52 beach: 0.03 esker: 0.17 spillway: 8.74	kame: 8.79 sand plains: 0.24 beach: 0.05 esker: 0.92 spillway: 21.06	kame: 34.49 sand plains: 0.66 beach: 0.26 esker: 0.00 spillway: 2.44	kame: 0.00 sand plains:17.41 beach: 3.43 esker: 0.00 spillway: 4.05
% poorly drained soil	82.71	67.88	27.30	28.92	78.75
Main River Gradient (m/km)	Ausable: 0.90 Parkhill: 1.03 Little Ausable: 2.22	Bayfield: 2.08 Bannockburn: 2.42	Maitland: 1.61 South Maitland: 1.79 Middle Maitland: 1.13 Little Maitland: 1.49 North Maitland: 1.43	Nine Mile: 2.54	Eighteen Mile: 3.84
Main river length (km)	Ausable: 163 Parkhill: 76 Little Ausable: 39	Bayfield: 82 Bannockburn: 39	Maitland: 80 South Maitland: 57 Middle Maitland: 95 Little Maitland: 72 North Maitland: 84	Nine Mile: 56	Eighteen Mile: 30
Drainage Density (km/km^2)	1.08	0.88	1.12	1.44	1.21
Cold Water Stream Density (km/km^2)	0.08	0.22	0.29	0.46	0.17
Municipal Drain Density (km/km^2)	0.69	0.64	0.15	0.11	0.49
Main River Base Flow Index					

<u>Ausable River</u> (Figure 1-1)

The basin includes the watersheds of the Ausable River, Parkhill Creek, Mud Creek and Dune area (see Map 1-1). The total area is 1233 km^2 in the shape of a broad J. The Ausable takes its name from the shifting sands at its mouth. The Ausable River begins near Staffa and flows south to Ailsa Craig where it makes a wide arc to the west. The main tributaries include Black Creek, the Little Ausable River and Nairn Creek.

Physiography (Map 1-3)
The watershed is shaped by J-shaped till moraine ridges flanking plains of fine till. Glacial meltwater deposited the spillway skirting the Seaforth Moraine and formed a large outwash delta under today's Hay Swamp. Glacial lakes accumulated sand and clay plains over till and left linear beach remnants. Lake Huron eroded sand from shore bluffs to the north and deposited it to form the southern sand plain where lake winds shaped the extensive dune system that sheltered a large lagoon. Natural processes of coastal erosion and accretion continue today (Chapman and Putnam 1984; Donnelly 1994).

Topography
Ausable's till plains are almost level. The moraines are more rolling but rarely more than gently sloping. The undulating topography around Arkona supports orchards. The steepest slopes occur where streams dissect moraines, most notably the Ausable Gorge. The sand dunes of the Port Franks-Pinery area also have steep slopes, in sharp contrast to the adjoining level lagoon bed (Conservation Branch 1949).

Soils
The clay soils of the till plain and moraines are mainly Huron/Perth/Brookston series, and are high capability soils for agriculture. Imperfectly drained Perth and poorly drained Brookston dominate on more level areas; well drained Huron occurs on the moraine slopes. Soils in some spillway areas have developed on sands (Bookton, Berrien, Wauseon). The glacio-lacustrine clays extending up the river valley form the high capability Brantford/Beverly/Toledo catena. Heavy and wet Blackwell clay with thinning patches of muck sits on the old lagoon bed. The dunes are low fertility and low moisture holding Plainfield sands. Soil compaction is a common problem in the watershed. Much of the basin rates a severe water erosion risk given the soils and intensive land use. The many tile outlets and extensive channelization aggravate bank erosion (Snell and Cecile et al. 1995).

Surface Hydrology (Map 1-4)
The Ausable is 145 km long (ABCA 1985). The main stem and its major tributary, the Little Ausable, are both directed by the parallel moraines, both following the spillway pattern of their much larger post-glacial river ancestors, and both generally oriented in a J shape. Most tributaries enter from the outside of the J and tend to form short fan patterns as they flow off the moraine divide. When the Ausable finally breaches the broad Wyoming Moraine, it carves a gorge about 40 m deep, exposing fossil-bearing deposits. The river emerges first onto the sand plain of glacial Lake Warren, then down the Algonquin beach to the lagoon bed flats.

At European settlement, the river meandered northward through the lagoon flats to today's Grand Bend where, within sight of the lake, it made a "grand bend" to flow another 15 km parallel to the shore between the dunes before outletting near today's Port Franks. The sands there were unstable and shifting as was the river mouth. Picturesque small lakes that form part of the Port Franks Forested Dunes and Wetlands Complex are remnants of former channels (Donnelly 1994) and Mud Creek likely formed an Ausable tributary.

Even before forest clearance, the large volume of snowmelt and spring rains swelled the river system to much higher flows in the spring than in mid-summer. The flooding replenished the lagoon flats, which acted as a sediment trap and nourished large numbers of migratory waterfowl. By the 1870's, upstream land clearance had aggravated the natural flooding and as interest in settling and farming the lagoon flats grew, techniques to drain them and relieve flooding were sought. Between 1873 and 1875, a channel was excavated to divert the river straight through the dunes (known as 'The Cut') and to drain two of the three lagoon flats' lakes, Lake George and Lake Burwell (Donnelly 1984).

The Parkhill Creek watershed is cupped in the crook of Ausable's J and mirrors the Ausable on a smaller scale. Like the Ausable, other tributaries are predominantly from the outside of the J forming short fan patterns as they flow off the moraine divide. The main such tributary is Ptsebe Creek. The Parkhill was originally a tributary of the Ausable but after The Cut, the severed original lower Ausable channel became the lower extension of Parkhill Creek. In 1892, another constructed channel diverted Parkhill Creek straight to the lake at Grand Bend, cutting off the reach through the dunes. Today this reach, known as the Old Ausable Channel (OAC), is fed only by adjacent runoff and seepage through the sands as it flows very slowly southward into the modified Ausable outlet (Snell and Cecile et al. 1995). The OAC, no longer part of the Ausable or Parkhill rivers, is characterized by clear water and dense aquatic vegetation. Due to its lack of flow, the old river channel seems to be converting to a more pond like ecosystem that may eventually become less aquatic and more terrestrial. It has been identified as an important ecosystem in the Recovery for Species at Risk Strategy for the Ausable River (Killins 2006). Along the Old Ausable Channel, the tributaries are a set of parallel relatively straight creeks that resemble Shore Gullies and Streams crossing the same physiography.

In 1952 the Conservation Authority straightened, widened and deepened The Cut downstream west of Highway 21 to help deal with on-going flooding. The remaining lagoon, Lake Smith, was drained in the 1960s. Although these measures succeeded in reducing floods, the former lagoon area still retains some of this natural function; buildings and fields are occasionally inundated. Natural processes of ice jam flooding and unstable sands persist at the mouth (Snell and Cecile et al. 1995).

Prior to European settlement, Dr. William 'Tiger' Dunlop, Canada Company Warder of the Forest, noted there were so many streams that every farm would have one (Conservation Branch 1949). Although possibly a sales pitch, today's streams are fewer. The clay soils and level land made drain construction relatively easy and by 1949, the drainage extent had raised concerns about lowered summer flows and drying wells (Conservation Branch 1949). By 1981, municipal drains had multiplied over 10-fold (ABCA 1985) and by 1983 tile drainage was installed in approximately 60% of the watershed (Snell and Cecile et al. 1995). Response time to storms sped up, downstream flooding continued, summer base flows decreased, and upper tributaries went seasonally dry. Forest and wetland clearance aggravated all these problems (Snell and Cecile et al. 1995). Although drains can retard event runoff if they free up soil storage space, the effect is likely minimal in the Ausable's clay till soil. The efficient drainage network also contributes to water quality problems. It can move contaminants such as manure to the stream system (Wall et al. 1997); it increases sediment and nutrient loads, aggravates channel instability, raises temperatures, reduces wetland function and degrades fish habitat. Costs climb with channel maintenance. The Ausable has a history of enclosing headwater surface drains in some areas; for example, 38% of the Nairn system has been enclosed since 1960. Effects of reduced headwater functions in agricultural areas have had little study. Channel straightening can impair the capacity of headwater streams to reduce downstream nitrate concentrations; closed drains may have a similar effect (Veliz and Sadler-Richards 2005).

The wet clay soils in the Parkhill watershed encourage artificial drainage to the point where little natural watercourse remains. Between 1950 and 1979, channelizing, dredging, straightening, ditching, tiling and riparian clearing in the upper Parkhill accelerated runoff from storm events, leaving barely a trickle in the summer (ABCA 1979). A cold water stream noted in 1949 (Conservation Branch 1949) had lost that rating by 1979 (ABCA 1979) and was a possible casualty of the extensive alteration. Other consequences are destabilized streambeds and banks. Dislodged sediment and soil eroded from fields clogs ditches and rapidly collects in the Parkhill Reservoir (ABCA 1979). The 1979 report also warned of loss of wetland hydrological function if muck soils are cleared from the upper watershed.

Morrison Dam was completed in 1959 and supplied the vegetable canning company, a water taking that caused late summer quantity and quality problems downstream (ABCA 1985). A hydro-power dam above Rock Glen operated from 1908-1926 and was later removed to allow fish passage. The Parkhill Dam, built in 1969, augments low flows to aid farmers and decrease water quality problems (ABCA 1985). By 1991, 41 dams – some 19th century millponds – interrupted the Ausable and Bayfield systems, 19 located on streams with sensitive fish species (Veliz 2001).

Today's flow patterns show maximums in February to April coinciding with snow melt and heavy rains on frozen ground. Ice jams compound flood problems. A smaller flow peak occurs in November and December after fall rains. High evapotranspiration lowers summer flows (Shaus 1982). Intense thunderstorms, however, sometimes dump very high amounts of rain and cause localized summer flooding.

Mud Creek is a small stream that skirts the southwest boundary of the Ausable watershed. Its level agricultural upper basin has the extensively drained and cleared pattern of the Ausable basin. The lower watershed, however, crosses the heavily forested dune unit, much of which was Stoney Point First Nations land taken over for Canadian Forces Camp Ipperwash. The forest and natural sand filter improves water quality and volumes in the lower reaches. The creek outlets at Port Franks near 'The Cut'; the depositional shoreline is evolving and subject to flooding. Port Franks suffers increased flood risk from ice jams in both the Ausable and Mud Creek (Snell and Cecile et al. 1995).

The Ausable watershed is known to have a number of sinkholes (Map 3-7, Appendix D). These areas are defined as shallow semi-circular depressions where surface waters can access bedrock aquifers. Sinkholes are present in the West Perth headwater areas, and the area's stream-feeding shallow aquifers are vulnerable to contamination from surface water (Waterloo Hydrogeologic Inc. 2004). The Ausable Bayfield Conservation Authority conducted two studies in order to determine the impact of sinkholes on municipal water supplies: the Sinkhole Investigation for areas mainly within the municipalities of Huron East and West Perth, and the Sinkhole Extension Study. Sinkholes in the area were located and mapped, and two boreholes were drilled to classify the geological characteristics of a sinkhole.

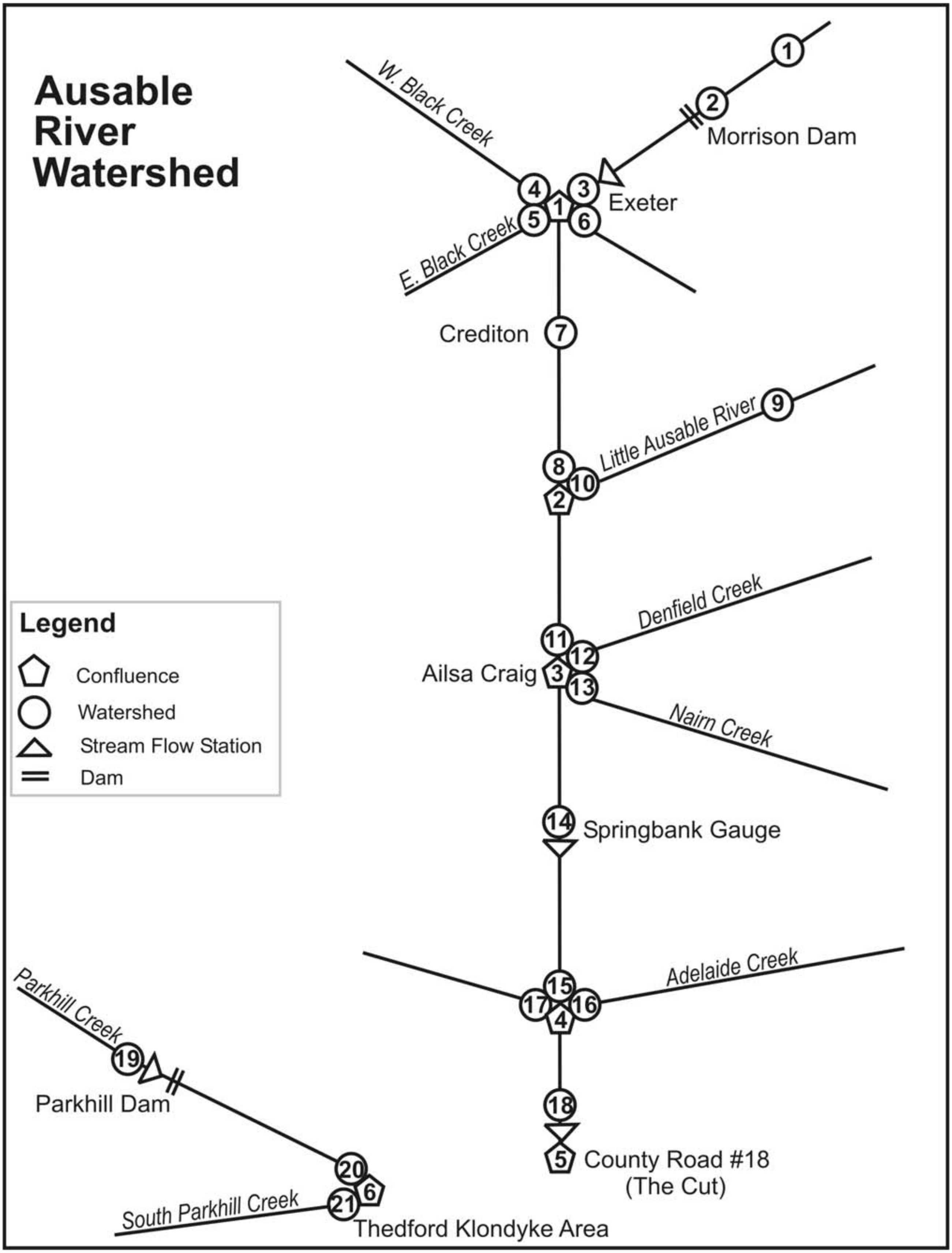

Figure 1-1: Basin Runoff Forecast Unit (BRFU) Model Schematic Representation of the Ausable River System

Bayfield (Figure 1-2)
The Bayfield watershed is 497 km^2 (Malone 2003), flowing east to west and entering Lake Huron at Bayfield. The basin has an almost rectangular shape pinched off at both the upper and lower ends.

Physiography
The Bayfield watershed crosses the same till moraines and till plain sequence as the Ausable watershed (see Map 1-3). It differs, however, in rising from one moraine further east, the Mitchell Moraine, and in having almost no influence of glacial Lakes Warren and Algonquin because of the watershed's very narrow shore plain extent. A major north/south spillway system splits and then flanks the Wyoming Moraine (Chapman and Putnam 1984).

Topography
Giancola (1983) described Bayfield watershed slopes as generally less than 2 % with steep slopes limited to the lower Bayfield and Bannockburn river valleys. Upstream banks have some moderate slopes as does the Trick's Creek and the kame area near Clinton.

Soils
Perth clay loam, an imperfectly drained soil on clay till, dominates much of the upper and middle portions of the watershed. On the moraines, the slight roll improves the drainage to develop well-drained Huron clay loam till soils. In the Clinton area, the till soils become siltier, developing Harriston silt loams in the well-drained areas. The kame near Clinton has some steep gravel Donnybrook soils; the spillway associated with Trick's Creek has developed well-drained Burford gravel outwash soils (Malone 2003; Snell and Cecile et al. 1995). The agricultural capability is high on most of the clay and silt till soils, slightly lower in poorly drained or more rolling areas. The sand and gravel soils – Burford, Gilford, and Donnybrook – are lower capability with limitations of low fertility and, in some cases, susceptible to drought. Alluvial soils occur in the lower Bayfield floodplain. Soil erosion likely increases in the more sloping moraine areas; the 1995 plan rates only a sub-watershed in the more rolling Wyoming Moraine as relatively high, which is a similar finding to Giancola (1983). Bonte-Gelok and Joy (1999) rate the basin 'moderate' for extent of poorly drained and imperfectly drained soils (44% in the Huron County portion).

Surface Hydrology (Map 1-4, Appendix D)
The Bayfield River is 65 km long, rising near Dublin and outletting at Bayfield with a gradient of 2.3 m/km (Malone, 2003). It contends with the same three moraines as the Ausable but skirts them northward rather than southward and is more prompt at breaching them. Despite headwaters further inland than the Ausable's, the Bayfield's more direct route results in a river less than half the length and a watershed less than half the area. The river's main tributary is the Bannockburn River; Trick's Creek, another tributary, is a cool/cold water system, which helps to maintain water quality and provides habitat for salmonids.

In the pinched-off upper Bayfield subwatershed, the Liffy, Cook and McGrath Drains meet in a glacial spillway to launch the Bayfield River. The narrow moraine basin divide directs the new river northwest until it breaks through into the east end of Bayfield valley's rectangle. From there, the general river direction is northwest across clay till plains, barely diverted by the moraine at Egmondville. Near Clinton, both the kame moraine and Wyoming till moraine block its northwest direction. The river turns to intercept and follow the major spillway south for a few kilometres before slicing westward through the Wyoming Moraine, the glacial Lake Warren beaches and coastal plain. There the lower Bayfield forms a wide, deep (as much as 50 m) and forested valley where high level terraces, old oxbows and isolated meanders resemble those in the lower Maitland (Malone 2003). Limestone outcrops are exposed in the lower reaches (George and Pfrimmer 1973). The rectangular shape of the watershed abruptly narrows to only the width of the deep river valley.

On the till plain, most streams have been converted to municipal drains. For the river and tributaries above Clinton, clearing, draining and low infiltration soils result in spring torrents and very low flows the rest of the year (George and Pfrimmer 1973). Many homes in Seaforth sit in the regional Flood Plain. Only Silver Creek and Hellgramite Creek have a permanent, though small, flow. In each case, flow possibly originates in small pockets of sand and gravel associated with eskers. The Bayfield's main flow contributions occur west of Clinton, some from the kame and Wyoming Moraine but most through the major spillway that splits the moraine. Trick's Creek is the main contributor. It flows down the spillway from the north with steady cold base flows. Bannockburn Creek originates in the Wyoming Moraine and follows the spillway northward, receiving flow from both units. Although permanent, it becomes low and weedy in the summer with most of its tributaries dry (George and Pfrimmer 1973).

At the Bayfield mouth, which is an active commercial harbour, ice jams or lake storms can cause flooding.

None of the watershed's eight dams – all private – create large reservoirs. The two ponds in Trick's Creek sub-watershed cover 6.2 ha; the remaining six total 2.8 ha. They alter flow, sedimentation patterns, temperature, and fish migration, but also offer recreation options (Malone 2003).

Tile drained land covers 49% of the watershed, a lower proportion than the more poorly drained soil found within the Ausable (Snell and Cecile et al. 1995).

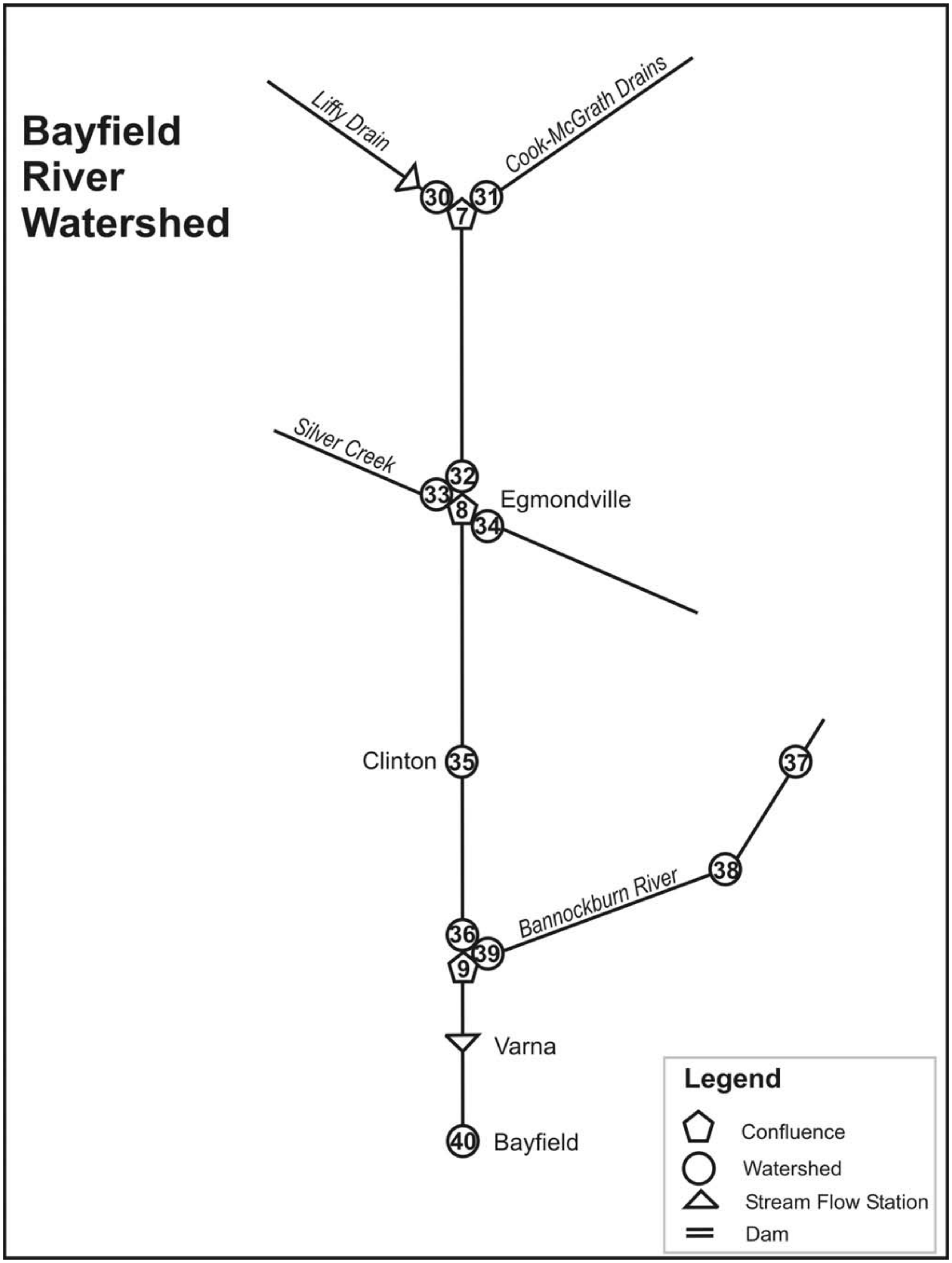

Figure 1-2: BRFU Model Schematic Representation of the Bayfield River System

Maitland (Figure 1-3)
The Maitland is 2572 km^2, the largest of the five main watershed units. It includes the South, Middle and Little Maitland River tributaries. The main stem can be divided into the North and Lower Maitland Rivers (see Map 1-4). The Maitland River is 150 km long and falls 235 m to Lake Huron at Goderich.

Physiography
Map 1-3 presents the physiography. Like the Upper Bayfield watershed, the oval shaped South Maitland basin is a clay-till plain crossed by three narrow north/south till moraines. The eastern Mitchell Moraine marks the headwater divide. The middle Lucan Moraine tapers off into a small kame ridge in the middle of the South Maitland basin. Just above its outlet, the South Maitland joins a branch of the same spillway that maintains Trick's Creek. The watershed's main distinction from the upper Bayfield is the broad band of hilly, coarse textured Wawanosh kame moraine. A large organic deposit is associated with the Hullett Marsh and several gravel eskers rise out of the clay till plains.

The main physiographic unit of the funnel-shaped Middle Maitland unit is the Teeswater drumlinized till plain. The upper reaches of the watershed flow off the Milverton Moraine onto a flat, wet, and clay-till plain with some extensive muck soils. At mid-basin an intricate spillway system interspersed with small kames is superimposed on the till plain. Several distinctive esker gravel ridges up to 15 m high cross the plain and provide valuable aggregate (Conservation Authorities Branch 1967).

The elongated Little Maitland watershed rises in the Dundalk till plain. It lies in a drumlinized till plain with a complex pattern of spillways. Two large organic soil-based wetlands bracket the valley in the lower end and two prominent eskers bisect the valley further upstream.

The North Maitland's north boundary is a series of kames and its eastern headwaters rise in the Dundalk till plain. Drumlins of the Teeswater Drumlin Field sprinkle the middle and lower watershed. The spillway pattern becomes increasingly dense down through the watershed to the point that large areas north of Wroxeter form complete spillways among the protruding drumlins. Several eskers and organic deposits occur throughout the system.

The Lower Maitland has a highly varied physiography. Upper areas include the drumlinized till plain with a network of drumlins and spillways. A broad kame band bisects the basin north-south just east of the wide Wyoming Moraine, itself bisected with the major spillway. The river outlet cuts through the shore sand plain below the Lake Warren beach (Chapman and Putnam 1984).

Topography
The topography generally increases from the relatively level till plains in the south and east to the steep kames in the north. The till moraines gently slope, the drumlins moderately slope in a rolling landscape and the kame moraines more steeply slope in an irregular pattern. Eskers have short steep sides; the valley slopes of the Lower Maitland are very high and steep. The Maitland River mouth at Goderich provides eastern Lake Huron's only deep harbour for large ships (Beecroft 1984).

Soils

Poorly drained Brookston clay dominates the soils of the level plains in the upper South and Middle Maitland watersheds. Elsewhere loamier associations and better drainage become more prevalent. Some kame soils and spillways have sandier series; eskers are gravely. Several large accumulations of organic soils occur in the basin. Bonte-Gelok and Joy (1999) measured the extent of poor and imperfect soil drainage in Huron County, rating South with the most (63%), followed in order by Middle, Little, North and Lower. Maitland soils are generally classed as high capability for agriculture. Lower ratings occur in the very wet areas, steeper slopes and stonier kames (Conservation Authorities Branch 1967). South Maitland and Lower Maitland have the worst soil erosion for the Maitland system (MVCA 1984).

Surface Hydrology

The Maitland River bends to the north and west side of the basin with the major tributaries flowing in from the southeast (see Map 1-4, Appendix D). The largest tributaries are the South Maitland and Middle Maitland Rivers. The South Maitland joins the Maitland downstream of Auburn. The Middle Maitland meets the main channel at Wingham immediately below the Middle Maitland's confluence with the Little Maitland.

The South Maitland River skirts the southern divide of the watershed; all its major tributaries join from the north, all flowing westward. Most cross the clay till plains; a few tributaries contribute from the kame moraine near the South Maitland outfall.

The upper South and upper Middle watersheds rate the most channel modification in MVCA (Steele et al. 1995). In the South Maitland basin, the indistinct upper river valley, extensive drainage and clearance and clay soils all contribute to flashy flows after storms and low stream levels at other times. Dikes reduce the Hullett Marsh's natural roles for filtering and flow modification. The river's runoff curve is higher than the Maitland average. The hydrology changes markedly, however, in the lower reaches, where the high percolation in the spillway and Wawanosh kame (B.M Ross no date) moderates flows. Eskers may offer some groundwater discharge to a few upper tributaries.

The wide fan of Middle Maitland headwater streams rises from the edge of the till plain that dominates the watersheds to the south and almost immediately enters the drumlinized till plain. The headwaters fall promptly to a level plain above Listowel; in the Boyle Drain even the headwaters are flat (Conservation Authorities Branch 1967). The stream valleys are indistinct in the level landscape where only eskers have any possibility for groundwater discharge. Mid-basin, the river course joins the spillway network. A few tributaries – all of which are short – enter downstream of Brussels; the major exception is the Little Maitland that joins the Middle Maitland just above its outlet at Wingham.

Flooding has long been a concern on the Middle Maitland. Reasons include: its headwaters topography of higher gradients that quickly flatten out, it receives large volumes of snow melt, rain occurson frozen ground, and that there are ice jams, extensive clearance and drainage. The close confluence of all the upstream tributaries may also be a factor. Extreme summer storms occasionally flood; the worst flood was from a freak storm in August 1883 (Department of Planning and Development 1954). Severe damage at Listowel was largely attributable to the dilapidated conduit carrying the river under the town (Department of Planning and Development

1954). A 1970 study (Crysler and Jorgensen 1970) linked agricultural drainage to Listowel's problems, given the conduit's limited capacity further restricted by sediment accumulation. The study proposed a plan for drain improvement, channel dredging, reservoir construction and conduit improvements. An 8-phase Listowel conduit project started in 1979 and opened in 1991 has prevented flooding in subsequent extreme events (MVCA Partnerships 2003). The watershed, however, still carries a substantial flood risk and recent studies recommend riparian planting and channel naturalization (MVCA 2004). Floods at Wingham result from its location at or near the confluence of the Middle, Little and North Maitland Rivers (Conservation Authorities Branch 1967).

The Middle Maitland watershed's heavy soil, extensive drainage and few coarse deposits all limit base flow. The Middle Maitland River joins the South Maitland in having the lowest base flow index of the MVCA and a higher than average runoff curve. For both metrics, the most extreme tributary is Boyle Drain (B.M. Ross no date).

Within a few kilometres of the Little Maitland River headwaters, the stream falls to the relatively level till plain and continues in a shallow spillway valley its remaining length (Conservation Authorities Branch 1967). Tributaries are well distributed. Artificial drainage is likely less extensive than in the more poorly drained South and Middle Maitland. Spillways and eskers may provide groundwater discharge. No reports of significant flooding were noted.

The North Maitland River's eastern headwaters flow across the till plain. Past Harriston, however, the main channel and most tributaries follow the spillway pattern. The north tributaries often originate from kames. Within a few kilometres, the headwater tributaries fall to the level till plain. At Harriston the valley is flat, shallow and swampy but west of the town, the river enters the Teeswater drumlin field. There the valley is deeper for 16 km with occasional banks up to 15 m high with remnants of old gravel terraces. This deeper valley has a gradient of 30 m in the next 26 km providing mill sites at Gorrie and Wroxeter. From there the valley becomes indistinct as it winds through spillways and among drumlins to Wingham (Conservation Authorities Branch 1967; B.M. Ross no date). The North Maitland's kames and spillways both discourage artificial drainage and provide steady groundwater discharge. The result is that the North Maitland River, with Nine Mile River, rates as the most pristine in the planning region. The Nine Mile's more permeable landscape results in a relatively high base flow index for the Maitland Valley region, a lower than average runoff curve (runoff potential) and a fairly high percolation rating (B.M. Ross no date).

The North Maitland watershed contains the only natural lake of any size in MVCA: Lakelet Lake is located near the north boundary and associated with the kame unit. Mid and lower North Maitland rates low channel modification for MVCA (Steele et al. 1995).

The Lower Maitland follows the major spillway through a narrow valley 8 to 30 m deep winding among drumlins and large areas of kame, then between the kame and Wyoming Moraine, before, like the Bayfield, chiselling a deep valley into the Wyoming Moraine to cross the shore sand plain. Within a few kilometres of Lake Huron, the valley is almost 50 m deep with steep banks and limestone exposed at the base (Conservation Authorities Branch 1967). The rock creates small falls and rapids that provided white water rafting as early as 1829 when Samuel Strickland enjoyed an expedition there "amazingly" (Beecroft 1984). Some elevated terraces in the lower valley are related to Lake Algonquin levels (James F. Maclaren 1977). At the mouth, ice jams or lake storms can cause flooding. High Lake Huron water levels – from both long term cycles and very brief wind-generated seiches – can influence the Maitland for 1-2 km upstream (Conservation Authorities Branch 1967).

The Lower Maitland has some major tributaries beyond the North, Middle, Little and South contributions. Blyth Brook flows in along a spillway off the drumlinized till plain and then through the kame unit. Sharpes Creek originates in the Saratoga Swamp, follows the deep spillway that splits the Wyoming Moraine and drops abruptly (30 m in the last 2 km) to the Maitland (B.M. Ross no date). Its dependable spring-fed flow powered three mills in Benmiller and is still vital to the village's tourist industry (Beecroft 1984).

By 1967, the Donnybrook gauge averaged 52% of its flow in March and April; 8% in June to September. The contrast is more extreme than average for Southwestern Ontario (Conservation Authorities Branch 1967) and later shifted slightly to 47% and 9% (B.M. Ross No date). The Lower Maitland's base flow index and percolation is rated fairly high in the planning region context (B.M. Ross no date) and artificial drainage is likely low, given the low extent of wet soils. In 2003, however, MVCA noted that since 1985, a shift to less snow and to more mid-winter melts had reduced base flow in the Maitland system (MVCA 2003).

The flooding, sand bar formation and ice created challenges for the Goderich harbour facilities to the point that in 1873 the river was diverted away from the piers (Beecroft 1984).

The 1967 Report on the Maitland system assessed no water issue (flooding, low flow, pollution, drainage, low groundwater, water supply, sedimentation, bank erosion) as extreme except for flooding at Listowel. The 1984 plan judged the worst flood damage in North Maitland (Harriston) and Middle Maitland (Listowel, Brussels). Most flooding extent has been in South Maitland, Boyle Drain of the Middle headwaters and the Middle Maitland's lower reach south of Wingham (MVCA 1984). In the 1970s, Wingham (Lowertown) sold flood plain area to the Maitland Valley Conservation Authority, but today there is not the type of funding available for Conservation Authorities to acquire land. In 1989 there were more than 600 buildings in flood susceptible areas, led by Harriston, Lucknow and Listowel, followed by Wingham, Brussels and Blyth. Harriston, Lucknow and Wingham had many undeveloped lots in flood-prone areas (MVCA 1989). In the 1990s, Listowel, one of the many centres in the Maitland where the river flows underneath the town, improved and increased its conduit's capacity to help with flooding issues.

Although there are slight changes that occur in the area designated as floodplain as new technologies become available, but the introduction of 'Generic Regulation' in May of 2006 did not change the areas designated as floodplain within the Maitland.

There are no large reservoirs in the watershed, but almost every community has a small one. Cumulatively, they offer some flood staging for minor events but little capacity for major ones. MVCA operates several old mill ponds. B.M. Ross (No date) found that in the previous 40 years, only two annual floods were not associated with snowmelt and frozen ground flooding. B.M. Ross also explained how in areas of low relief, even with drains, low level flooding can act as a form of storage and can lower peak runoff rates. The 1989 Conservation Strategy expressed concern about the extent of streams widened and deepened for outlet and about the associated loss of cleaning functions and lack of natural headwater reaches.

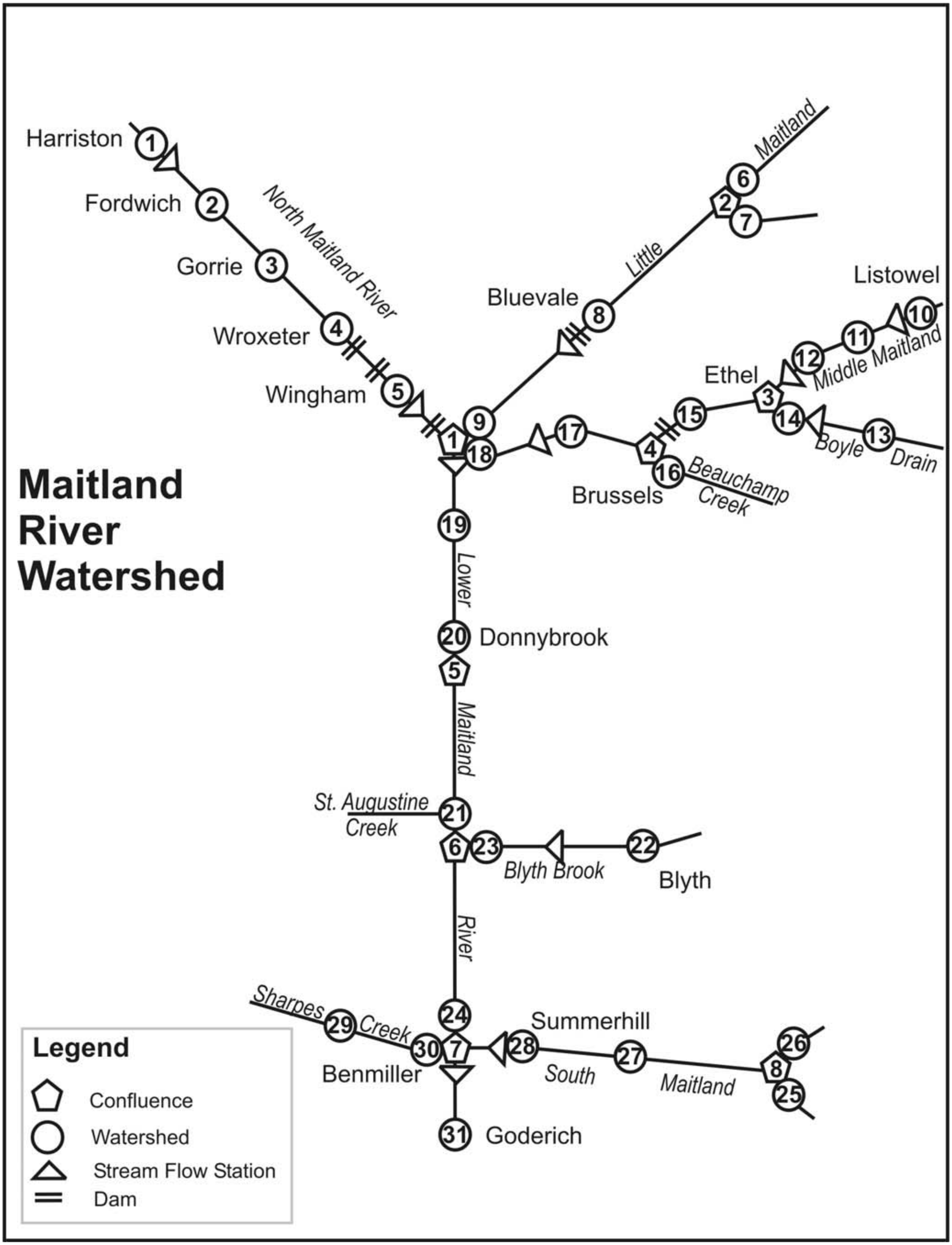

Figure 1-3: BRFU Model Schematic Representation of the Maitland River System

Nine Mile River (Figure 1-4)
The Nine Mile River watershed covers 243 km^2. It has a wide rectangular upper portion connected to the lake with a narrow "handle" that outlets into Lake Huron at Port Albert.

Physiography
The watershed headwaters are in the large Wawanosh kame moraine and much of the area is the Wyoming Moraine that abuts the kame to the west (see Map 1-3). This till moraine is split by the spillway that supports the major coldwater streams to the south, the closest being Sharpes Creek. The narrow lower part of the watershed crosses the glacial Lake Warren bevelled till plain below the Lake Warren beach (Chapman and Putnam 1984).

Topography
Slopes range from irregular steep areas in the kame to longer more moderate and gentle slopes on the till moraine to level topography on the bevelled till plain.

Soils
The upper watershed soils are coarse kame-associated series. Clay till series have developed on the till moraine and bevelled till plain. Sandy and gravely outwash soils occur in the spillway. The soils are generally well-drained; only 26% are poor or imperfect drainage (Bonte-Gelok and Joy, 1999). Upper Nine Mile is rated high soil erosion for MVCA (MVCA 1984 Plan).

Surface Hydrology (Map 1-4)
The headwaters rise in the Wawanosh kame. In Lucknow, Anderson Creek, Dickies Creek and Ackert Drain/Kinloss Creek join to form Nine Mile River and impose occasional flood damage (MVCA 1984). Below Lucknow, the river follows the spillway southwest across the Wyoming Moraine and over the glacial Lake Warren beach. There it turns west to flow straight to the shore across the bevelled till plain, carving down to lake level. The kames and spillways both discourage artificial drainage and provide steady cold groundwater discharge. The result is that the Nine Mile River rates the highest base flow index and the most pristine water quality in the planning region and supports a valuable trout fishery.

The River flows down the westward spine of the watershed; several short tributaries originate in the kame at the east divide and flow west to join the river in sequence. The Nine Mile River is rated low channel modification in the MVCA context (Steele et al. 1995).

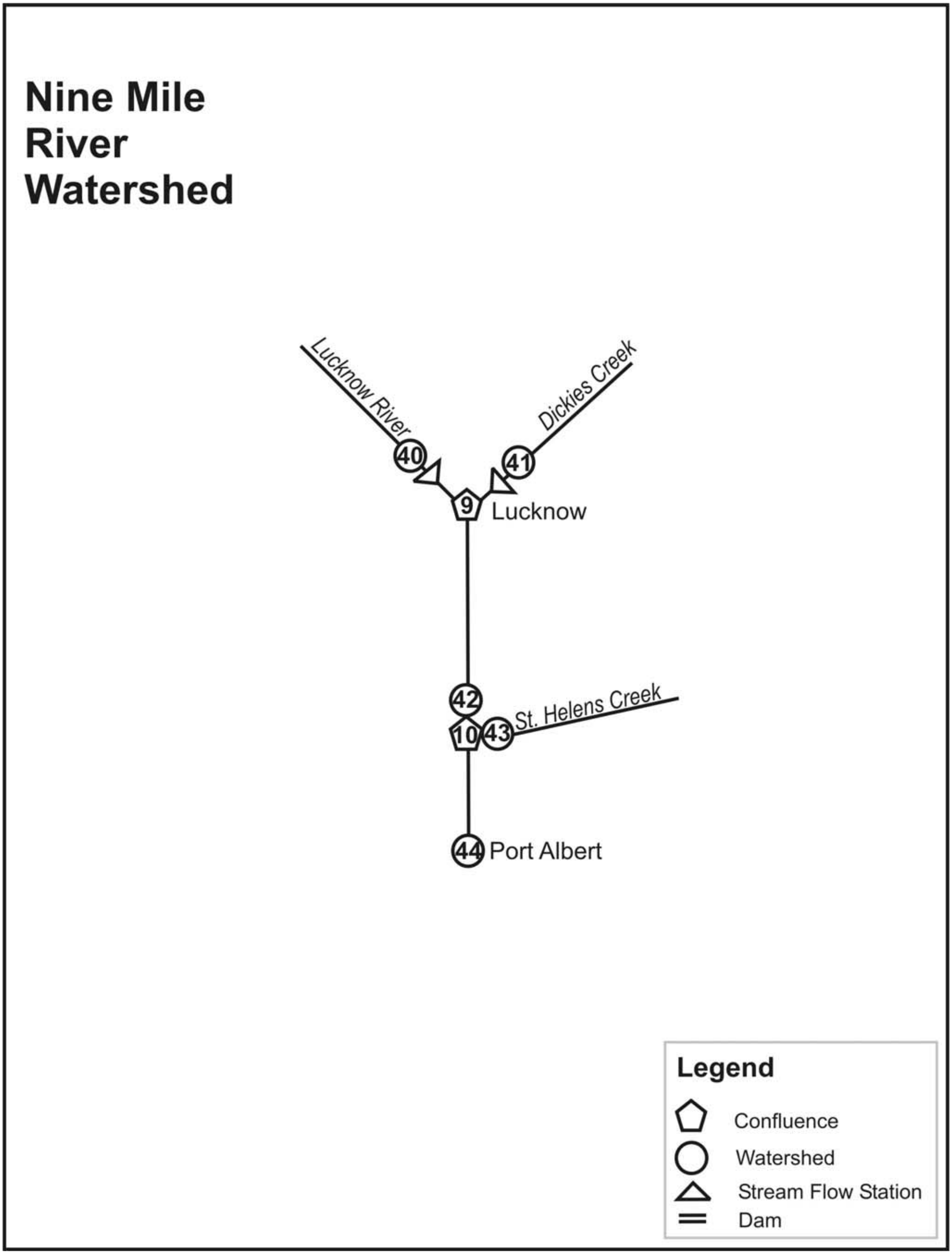

Figure 1-4: BRFU Model Schematic Representation of the Nine Mile River System

Shore Gullies and Streams

The total area of the shore gullies and stream watershed unit is 692 km^2. It includes the basins of all the short streams flowing into Lake Huron from just north of Grand Bend to Eighteen Mile River (see Map 1-1, Appendix D). They are numerous – the planning area has 742 streams that are greater then 10 metres flowing into Lake Huron (this number has removed channel types or pseudo nodes in its calculation). The basin of each stream tends to be narrow and most are parallel, flowing westward and carving down to lake level. The unit forms a very long narrow strip along the shore, interrupted only by the narrow outlet valleys of the larger basins.

Physiography

Headwaters originate on the west slopes of the Wyoming Moraine (see Map 1-3). The physiographic sequence westward to the lake is down the glacial Lake Warren beach and across Lake Warren's bevelled till plain that usually includes a narrow strip of sand plain (Chapman and Putnam 1984). As the streams approach the lake, they cut down as much as 20 m to form deep gullies to the shore.

The shore is actively eroding to form shore cliffs. Goderich breakwater to Kettle Point is a closed littoral cell for shoreline sand transport; those two extremes trap any sand from the north. Goderich to just north of Grand Bend contributes sediment to the cell's shoreline budget; Grand Bend to Kettle Point receives it. Over millennia (the pre-breakwater cell extended to Point Clark just north of the planning region) this process has eroded away the north bluffs and Lake Algonquin beach. On the other hand, in the accretion area to the south, the Algonquin Beach swings far inland behind the sand deposits and the geologically recent lagoon (see Map 1-3). Gully erosion of the shore streams between Goderich and Grand Bend also contributes sediment – 12% of the sand plain accretion (Snell and Cecile Environmental Research 1991).

The Goderich breakwater shortens the natural cell, reduces sand supply, thereby narrowing accretion beaches from their natural width. On-going bluff erosion is natural as these geologically young landforms evolve and is an essential supply to accretion areas and beaches. Structures like groynes that interfere with the sediment transport can have distant adverse effects (Baird and Associates 1994).

Topography

The watersheds are generally level with gently sloping headwaters off the Wyoming Moraine. The lakeshore is a very steep bluff which ranges from 20-22 metres in the north, and peaks around 28 metres around Goderich. As the gullies gouged down to lake level, they too created very steep banks.

Soils

Soils are predominantly the Huron/Perth/Brookston clay tills. Narrow strips of Burford, an outwash gravel, occurs at the Lake Warren beach line; Berrien, shallow sand over clay, marks the narrow sand plain that runs the length of the Lake Warren bevelled till plain. The clay tills are high capability soils; the Burford and Berrien have some low fertility and droughtiness limitations. The Shore Gullies and Streams unit rates high for proportion of poorly and imperfectly drained soils – 68% in the Huron County portion (Bonte-Gelok and Joy 1999). Besides the gullies themselves, the main erosion issue is the proximity of older cottages to the largely natural shoreline bluff erosion (MVCA 1989). Field erosion and compaction are also serious problems (Snell and Cecile et al. 1995).

Surface Hydrology
Samuel Strickland (circa 1830) noted the “fine spring streams” in the rolling land east of the lake (Beecroft 1984). Today they are largely agricultural drains. The streams follow the same physiographic sequence as described under Physiography above, generally flowing straight towards the shore. Few are long enough to have tributaries; Eighteen Mile River in the north has a small tributary, Boyd’s Creek.

Some gullies were present at settlement as steep shore ravines stabilized under forest cover. Human activities have extended them. Land clearance, accelerated drainage, tile outlets, channel straightening and cultivation to gully edge all contributed to their growth (Conservation Branch 1949).

The short narrow streams have very short reaction times to storm events. The lack of forest cover also accentuates the sharp hydrographs. The gullies generally drain so quickly that flooding is not an issue.

Ambitious plans to dig a canal from St. Joseph to Lake Erie stalled after construction of the St. Joseph dock in 1904 (Conservation Branch 1949).

Local surface water in the nearshore of Lake Huron has suffered degradation from intensification and seasonal shoreline development (Peach 2006). Some nodes have experienced a lot of growth: Goderich, Bayfield and Grand Bend are examples. Given the movement of water currents, the effects of intensification can have impacts in areas where there is little development.

1.3.2 Climate

The planning region’s mid-continent location immediately leeward of Lake Huron shapes its climate. In the Canadian context, its southern latitude favours it with a long growing season, surpassed in Ontario only by areas still further south. The lake moderates continental hot summers and cold winters. The result is a mean daily temperature of about 5.4 ^{o}C in the headwaters and 7.3 ^{o}C at the lake. North to south the gradient is less – Lucknow’s mean is 6.7 ^{o}C; Dashwood’s mean is 7.9 ^{o}C (Environment Canada 2005). In the Maitland, the pre-1967 frost-free period ranges from 154 days near the lake to 132 days inland (Conservation Authorities Branch 1967).

The planning region’s location also contributes to precipitation levels rated among the highest in the Great Lakes basin (Water Use and Supply Project 2004). The region is in the snowbelt off the lake and receives 200 to 270 cm snow annually (Environment Canada 2005). Precipitation is 840 mm to 1050 mm distributed throughout the year (B.M. Ross No date). The lake spawns streamers of intense, linear snow squalls that extend from Lake Huron across the planning region sometimes as far as Kitchener-Waterloo.

Location also causes variation within the region. The cooling effect of Lake Huron curbs the development of thunderstorms and lowers summer rainfall in a lake shadow area extending 10 to 20 kilometres inland. In contrast, a band from Grand Bend to Listowel sees many more summer storms as onshore winds from Lakes Huron and Erie converge. Precipitation also increases on the higher Wawanosh kame. The higher precipitation watersheds of the planning region are

Nine Mile River, Middle and South Maitland Rivers, Bayfield River and North Gullies (Water Use and Supply Project 2004). Sudden spring melts accentuated by rain on frozen ground can bring significant flooding. The area has the average level of drought probability for southern Ontario (ABCA 1979; ABCA 1985; Conservation Authorities Branch 1967; B.M. Ross No date).

A number of climatological stations have been developed through the years by the conservation authorities, primarily for the purposes of local flood forecasting. Environment Canada Climate Records include Atmospheric Environment Service (AES) stations at Blyth, Brucefield, Cromarty, Dashwood, Exeter, Lucknow and Wroxeter. Brucefield, Cromarty and Lucknow have since been closed. The total amount of precipitation received within the study area has risen slightly over the past 50 years and is discussed further in the Conceptual Water Budget for the Ausable Bayfield Maitland Valley Partnership. Appendix A lists the climate normals for AES stations from the period of 1971-2000.

1.3.2.1 Climatic and Meteorological Trends

Climate change is expected to bring warmer temperatures, higher evapotranspiration, lower lake levels, more flooding, low flows, more droughts, more intense storms and more erosion (Bruce et al. 2000). Already long, gentle rainfalls are yielding to shorter, more intense thunderstorms. A shorter lake ice season may increase snowfalls and expose the shore to strong winter storms. Climate change effects on water quality could include more runoff, erosion and pollution (MFX Partners 2002). Groundwater levels may gradually decrease. In southern Ontario, base flow decreases are projected to be most severe in the spring. Groundwater-linked management implications include: drilling deeper wells, designing sewage treatment plants for more extreme low flows, and promoting water conservation and efficient irrigation (Piggott et al. in press).

1.3.3 Groundwater and Hydrogeology

This section is derived from the county groundwater reports (Perth: Waterloo Hydrogeologic 2003b; Huron: International Water Consultants et al. 2003; Lambton and Middlesex: Dillon and Golder 2004: a,b; Wellington: Minto and North Wellington: Burnside 2001: a,b; Bruce: Waterloo Hydrogeologic 2003a).

Major Aquifers

Aquifers are formations that provide adequate drinking water when tapped by a well. Good aquifers can include sand, gravel and fractured limestone. Overburden aquifers are aquifers that occur in unconsolidated deposits above the bedrock. Confined overburden aquifers are protected from contamination by an overlying fine textured layer. Shallow unconfined aquifers can be associated with sand plains and spillways and, although less protected than confined aquifers, can be more productive (Dillon Consulting and Golder Associates 2004a).

The aquifer in the fractured and fissured limestone bedrock is by far the most significant drinking water aquifer in the planning region. Most area wells use the top few meters of the aquifer. The yields from units that occur in the planning region are generally among the best from bedrock in southern Ontario. Only the Hamilton Group in the extreme south fails to make that rating (Singer et al. 1997).

Overburden aquifers were tapped historically more than today and are less well documented than bedrock ones. Significant overburden aquifers in the planning region include:

- North Lambton/South Huron unconfined aquifer that exploits the beach and bay-mouth bar deposits of Lake Algonquin and Lake Nipissing as well as the more recent dunes between Grand Bend, Port Franks and Thedford. Wells are shallow, usually less than 15 m (Dillon Consulting and Golder Associates 2004a);
- The unconfined glacial Lake Warren beach sand and gravel north and south from Goderich;
- The confined to semi-confined and poorly understood Hensall aquifer;
- The Wyoming and Seaforth Moraines; and
- The kames and network of sandy outwash and spillway deposits that becomes more extensive to the north of the region.

Many smaller locally significant overburden aquifers occur throughout the area. In Lambton clays, some overburden wells acted as cisterns. They were highly susceptible to contamination and most have been replaced with municipal servicing from Lake Huron (Dillon and Golder 2004a). A number of users in the north part of the MVCA watershed, including Mennonites, often use shallow overburden wells. This can present a problem for Mennonites if a well becomes dry or contaminated, as they have no option to bore down to the bedrock.

The regional bedrock aquifer flow direction is generally from east to west. A steep hydraulic gradient east of Seaforth indicates karst features (International Water Consultants et al, 2003). A bedrock rise near Arkona directs groundwater flow northwest toward the Lake. Surface topography controls the flow in overburden aquifers (Golder 2000).

Overburden Thickness (R.74)

Overburden thickness (see Map 1-5) is an indicator of the bedrock aquifer's protection from contamination. The general trend is for deeper overburden to the west with the exception of the Thedford – Port Franks area. Shallow areas with little protection include the sinkholes in the Ausable and Bayfield headwaters, the Brussels area and the lower 17 km of the Maitland River.

Recharge and Discharge Areas

Groundwater flow maps indicate that the major bedrock groundwater systems originate east of the watershed. Local recharge areas include sinkhole areas in the upper Ausable and Bayfield watersheds and an area near Lucan with a very low bedrock water table. Till moraines and kames tend to have a moderate rate of recharge to the regional aquifers. Recharge in the Lambton clays is very slow; the area's freshwater aquifer at the bedrock contact is estimated to have been recharged thousands of years ago (Dillon Consulting and Golder Associates 2004a).

The Conservation Authorities used overburden and surface features to rate groundwater recharge potential rates highest in the Maitland watershed, intermediate in the Bayfield and lower in the Ausable, Nine Mile and Shore watersheds. Major exceptions to this trend are high recharge areas along the shore between Bayfield and Goderich and near Hay Swamp (Golder Associates 2000).

Discharge is strongest in the Ausable Gorge and lower Maitland. Bedrock discharge also occurs in the Port Franks area and in a bedrock trench that crosses the upper Maitland watersheds in a North/South direction. Some discharge from deep overburden takes place in the Nairn and Little Ausable sub-watersheds. Shallow overburden discharge occurs along some streams.

Because overburden discharge is often associated with spillways and kames, overburden springs are more prevalent in the northern watersheds (James F. Maclaren 1977).

1.3.4 Surface – Groundwater Interactions

Potential for infiltration depends on surface soil porosity, location in the watershed, land use, natural drainage patterns, degree of soil saturation and extent of each of depression storage, agricultural drainage and underlying impervious soils (B.M. Ross No date).

The most vulnerable aquifers are shallow unconfined ones that tend to occur in sand plains, spillways and kames – the overburden recharge areas (Golder Associates 2000). These poorly understood aquifers often influence streams but their effect on wells is unknown. Their coarser soils tend to have lower agricultural capability and more forest cover with its associated source water protection.

For bedrock aquifers, overburden depth and high clay content provide good protection across much of the planning region. Bedrock aquifer susceptibility tends to rise to the east where overburden thickness is least.

Very high susceptibility occurs in sinkholes, a feature of the Lucas Formation (International Water Consultants et al, 2003; Waterloo Hydrogeologic 2003b). Dissolution of the limestone creates a network of cavities and channels. If sediments collapse into the cavities, sinkholes form that directly link surface water with groundwater. Sinkholes occur in the Upper Ausable and Bayfield watersheds, Middle Maitland near Brussels and near the lakeshore west of Lucknow (International Water Consultants et al. 2003) and are indicated on Map 1-4, Appendix D. Most are less than 5 m deep and 9 m diameter; a large one in the bed of the Ausable River is 46 m wide and 122 m long (Waterloo Hydrogeologic 2003b). A detailed study in Huron East and Perth West found over 50 sinkholes draining over 800 ha. The two largest sinkholes receive water from municipal drains and transmit large amounts of water to the aquifer. Characterization of effects requires longer term monitoring (Waterloo Hydrogeologic 2004).

Surface-groundwater interactions are organized by watershed.

<u>Ausable</u>
High susceptibility is noted (Snell and Cecile et al. 1995; Donnelly 1994; Paragon 1986; Schaus 1982; Waterloo Hydrogeologic 2003b, International Water Consultants et al. 2003; Dillon Consulting and Golder Associates 2004: a,b) for:

- Sinkholes in the upper Ausable watershed (Waterloo Hydrologic Inc. 2004).
- The Dunes unit and extending into the Thedford Marshes. Malfunctioning septic systems could leak into the shallow groundwater;
- A small area in the Nairn Creek headwaters;
- Near Hensall where limited confining material protects the overburden aquifer;
- The spillway associated with the Hay Swamp, while half forested, still exposes a large area to surface – groundwater interactions. A landfill and composting facility are potential contaminant sources above the cold water stream section; and
- Staffa, on a susceptible kame.

Other interactions include:

- Base flow interference from Exeter area development and groundwater use by irrigation;

- Possible effects on the Little Ausable from a landfill, gravel pit, and Exeter's well; and
- Possible effects on the Ausable temperature and flow from gravel pits near Arkona;

Exeter will soon reduce its effects when it switches its water source from groundwater to a surface water intake in Lake Huron. Parkhill rates few susceptibility concerns.

<u>Bayfield</u>
Potential interactions (Snell and Cecile et al. 1995, International Water Consultants et al. 2003; Waterloo Hydrogeologic 2003b) include:

- Sinkholes in the Upper Bannockburn, mid-basin and Clinton;
- Possible well contamination below Clinton from Clinton's STP effluent: flagged by 1980 MOE Basin Study;
- Gravel pits and development effects on Trick's Creek; the lower Bayfield has a trailer park in the floodplain and potential landfill issues; and
- Gravel pits very close to the river affecting temperature and base flows.

<u>Maitland</u>
Interactions or potential interactions (MVCA 1984 Plan; Middle Maitland Initiative 2000; James F. Maclaren 1977; Steele et al. 1995; International Water Consultants et al. 2003; Waterloo Hydrogeologic 2003b; Burnside 2001: a,b; Beecroft 1984) include:

- The highest base flow contributions appear to be associated with spillways and kames in the lower Middle and upper Lower Maitland watersheds;
- Recharge to overburden does happen but no evidence connects it to bedrock aquifers. The few areas where the piezometric elevations are below the bedrock surface and therefore possibly, though not necessarily, unconfined and subject to recharge through the overburden are in the west end of the basin – Lower and South Maitland watersheds that tend be protected by thick overburden;
- Several areas have <3 m clay at the surface, and so there is some possibility of overburden recharge – the thinner the clay, the more likely the recharge;
- Trowbridge uses a localized overburden aquifer that should be protected. Middle Maitland may be recharging the overburden aquifer south of Trowbridge;
- A number of sinkholes are draining agricultural lands and could directly link surface contamination with the bedrock;
- In the early 1960s, Middle Maitland flow volumes were half baseflow. By 1970 the baseflow proportion had declined despite increasing precipitation. Upper watershed drainage, cropping and tillage practices that discourage recharge were blamed. The decline diminishes the system's ability to withstand drought and impacts aquatic life; a higher surface flow proportion raises sediment and pollution potential;
- The Middle Maitland River may also be interacting with the bedrock aquifer near Brussels;
- The upper North Maitland has a few vulnerable spots for surface-groundwater interactions, most along spillways and distant from any potential sources;
- Saratoga Swamp (Sharpes Creek watershed, Lower Maitland) is a discharge area for localized groundwater flow from the surrounding glacial overburden aquifers; and
- From Auburn to Goderich there are several areas where the river flows over bedrock and where either groundwater discharge or recharge may be occurring.

<u>Nine Mile</u>
Interactions or potential interactions (MVCA 1984; James F. Maclaren 1977; International Water Consultants et al. 2003; Waterloo Hydrologic 2003a) include:

- Lucknow has an overburden well that should have recharge area protection;
- High susceptibility spots for both overburden and bedrock susceptibility occur in the kame between Lucknow and Wingham;
- High base flow contributions appear to be associated with spillways and kames; and
- Recharge to overburden does happen but no evidence connects it to bedrock aquifers. In some areas the piezometric elevations are below the bedrock surface and therefore possibly, though not necessarily, unconfined and subject to recharge through the overburden. Its thick depth, however, provides protection.

<u>Shore Gullies and Streams</u>
Interactions or potential interactions (International Water Consultants et al. 2003; Waterloo Hydrologic 2003a; Donnelly 1994) include:

- Septic systems on the highly impervious clay can fail and result in beach postings. Near bluffs, contamination could seep laterally to emerge at lakeshore and gully slopes (Donnelly 1994). Some surface – groundwater interactions may also be occurring at bedrock exposures along Lake Huron (e.g., north of Goderich); and
- Recharge to overburden does happen but no evidence connects it to bedrock aquifers. In a few areas the piezometric elevations are below the bedrock surface and therefore possibly, though not necessarily, unconfined and subject to recharge through the overburden. Its thick depth, however, provides protection.

1.4 Natural Heritage

Terrestrial natural areas play important roles in source protection. They trap contaminants to cleanse surface and groundwater and are a vital link in the hydrological cycle. They also rely on clean, adequate water – generally from surface sources but sometimes from seepage areas and springs.

History
Generally across Southwestern Ontario after approximately 1850, clearance for agriculture, fuel wood, fencing and roads sharply reduced natural area extent. By the early 1900s forest cover had shrunk to below 10% of the Ausable watershed. A gradual recovery raised forest extent to 11.7% in 1947 (Conservation Branch 1949) and to 15% by 1983 (Stoll 1983). Many natural areas were doomed by their good agricultural capability. Areas remaining and recovering tend to coincide with soils of lower agricultural capability. The Dunes, Ausable Gorge, and Hay Swamp are prominent examples. Fragmented woodlot remnants in the "back 40" create a curious pattern that often runs perpendicular to tributaries, a relic of early settlement's attempt to make roads parallel to the major rivers (Conservation Branch 1949). The shift from livestock grazing benefits woodlots; 60 years ago almost all were pastured (Conservation Branch 1949) destroying the critical lower tiers. However, seed banks may have been depleted. Reforestation with very few species and without restoring the natural pit and mound microtopography creates forests that function far below their natural counterparts for both habitat and water protection roles.

Maitland natural areas have a history similar to the Ausable's. Early settlers marvelled at the lush forests and teeming fish (Beecroft 1984). Forest exploitation for roads, railroads, timber, fuel and fence posts peaked in the late 1800s. Much of Goderich and Colborne township forests fuelled the salt works (Beecroft 1984). In 1964, the Conservation Authority's jurisdiction was 12.6% woodland and plantation, and 4.3% scrubland (Conservation Authorities Branch 1967). An assessment of forest health in 2001 found over half the forest surveyed in fair or poor condition due to a lack of large trees, lack of marking, logging damage, lack of woody debris and disturbance levels. Alien species proved less of a problem than in other parts of Southwestern Ontario (Maitland Watershed Partnerships 2001). Modest losses continue: between 1984 and 1999, 256 ha were lost – most to agricultural land, some to aggregate and development.

In 1952, the Middle Maitland was 8% forest. The central level plain had many large hardwood swamps. Extensive mixed forest swamps in the upper Boyle drain had been reduced to wet thickets by fires, grazing and clearing. Grazing was found in 62% of the forest, destroying new growth. Fire was a menace – some had been deliberately set to burn off peat (Department of Planning and Development 1954). The watershed is now 11.2% forest cover.

In the last few decades, the planning region, like many other parts of southern Ontario, has seen some gains in immature forest extent as agricultural economics forces abandonment of marginal farmland. Since high capability soils dominate the area, however, the trend is far more subdued than in central or eastern Ontario (Larsen et al. 1997).

1.4.1 Wetlands and ANSIs

Wetlands can play very important hydrological roles; they can perform flow stabilization, water quality improvement and erosion control. Beecroft (1984) cites an instance of a creek once large enough to support sawmills disappearing after cedar swamp removal. The following paragraphs outline the evaluated wetlands within each watershed of the source protection planning region, but there remain a number of unevaluated wetlands. Calculated areas and percentages of wetland are derived from natural heritage studies.

Areas of Natural and Scientific Interest (ANSIs) are also included in this section. ANSIs are described as areas (land or water) containing natural landscapes or features which possess values related to protection, natural heritage, scientific study or education (Hanna 1984). ANSIs vary in significance (provincially or locally significant); it is important to remember that wetlands and ANSIs are not mutually exclusive.

Ausable

Documented wetland extent is at 1.52% (2,604 ha): 1.28% is swamp, 0.12% is marsh and 0.12% is unevaluated. The number mainly comprises Hay Swamp (a local ANSI) and a handful of very small areas. Hay Swamp is in the Upper Ausable watershed. It plays an important role in flood moderation, aided by roads and bridges across the direction of flow. The swamp improves water quality in the critical summer period and then releases nutrients in the fall and winter (Paragon 1986).

Lake Smith, its predecessors and associated marshes were part of the flood retention function of the Lower Ausable flats and also an effective sediment trap. The flats still have some flood storage capacity but not near the pre-Cut, pre-drainage volume. Wetland removal eliminated habitat and the only marsh between Walpole Island and Arran Lakes near Southampton, which is outside the planning region (Conservation Branch 1949). Today, although abandoned by most wildlife, tundra swans and other migratory waterfowl still alight before water is pumped out for the spring planting.

The landscape potential for wetland restoration is best in the Lower Ausable flats, Hay Swamp vicinity and Parkhill watershed's wet clay tills and wet sand plains (Snell and Cecile et al. 1995).

Within the Ausable River watershed, there are a number of ANSIs. The Ausable River Valley is a 1780 ha forested area near Arkona and is significant in its seepage for cold water. It was selected as a provincially significant ANSI for its large size, relative natural condition, and excellent diversity of habitats and landform types (Brownell 1984). The ANSI crosses two physiographic regions: the Horseshoe Moraines, where the river valley has cut deep through the moraine to the underlying bedrock, and the Huron Slope near Thedford, where there are sand plain deposits (Lindsay 1981). Broad-leaved species such as beech, sugar maple, red maple, red oak, basswood, white oak and bur oak dominate, and the area is habitat for the threatened Queen Snake (Lindsay 1981) and the threatened Eastern Hog-nosed Snake (Brownell 1984). A large amount of forest in the Ausable River Valley ANSI has been disturbed for timber removal (Brownell 1984). Other provincially significant ANSIs are the Staffa Kame complex, Pinery Provincial Park and the Port Franks Dunes and Wetland Complex.

Hay Swamp, a local ANSI, is 2,150 ha of swamp forests, scrub, and plantations. It is bounded by the Wyoming moraine on the north, west and south sides, till plain to the east, and is a wide, gentle spillway. The predominant tree species includes silver maple, white elm, black ash, cottonwood, white cedar, poplar and tamarack (ABCA 1984). Dashwood, another local ANSI, is located adjacent to Hay Swamp.

<u>Bayfield</u>

Documented wetland extent is very small – wetlands account for 0.59% of the watershed (294 ha): 0.48% swamp, 0.01% marsh and 0.10% unevaluated. Huron groundwater study maps indicate only Trick's Creek wetland plus three other very small wetlands (International Water Consultants et al. 2003). Trick's Creek wetland lines the creek along the spillway; the wetland benefits from the spillway's groundwater discharge and buffers the stream. Bayfield's main wetland restoration potential is in the eastern headwaters and the Big Drain watershed (Snell and Cecile et al. 1995).

Two ANSIs are located within the Bayfield watershed: the Bayfield River ANSI and the Bayfield North ANSI.

The Bayfield River ANSI is 850 ha of long, narrow, river valley that follows the river for 10 km, upstream of Bayfield. The ANSI is representative of floodplain wetlands with abandoned meander channels, oxbows and floodplain terraces (Klinkenberg 1983). The Bayfield River harbours a range of vegetation including floodplain, riverbank and valley wall communities (Hanna 1984). Due to the variation exposures along the valley slopes, there exists a variety of microclimates (Crins 1983). The uplands support deciduous forest (sugar maple, american beech, green ash, black cherry, ironwood) while the slopes support some coniferous species like eastern hemlock and white cedar. Twelve vascular plants considered to be rare in Ontario have been found in this ANSI (Crins 1983). Special features to this system include a deer yard and a migratory trout and salmon run (Hanna 1984).

The Bayfield North provincially significant ANSI is comprised of 273 ha of adjoining woodlots that are bisected by concession roads: Huron County Road 13, Orchard Line and the Bayfield Concession Road (Jalava 2004). It is located north of the Town of Bayfield, in close proximity to Lake Huron. The woodlots of the ANSI contain both upland (sugar maple, beech, and ash) and lowland (cedar, red maple, basswood, and dogwood) species, but generally represent upland woods (Hanna 1984). Stream corridors and small wetlands also make up part of the ANSI and the moist rich organic soils of the bottomlands support extensive meadow marsh-woodland mosaics (Jalava 2004). The area is mostly undisturbed, but some of the woodlands have been used for fuelwood and commercial timber production (Jalava 2004). Bayfield South, another locally significant ANSI, is also located within this watershed and runs parallel to Lake Huron.

<u>Maitland</u>
The Maitland watershed has the greatest amount of wetland both in area and in percent of overall land. The Maitland has a wetland extent of 5.48% (14,120 ha) broken down into 4.83% swamp, 0.06% marsh, 0.03% fen, 0.22% bog and 0.34% unevaluated. Little Maitland River joins the North Maitland River with the best distribution of wetlands in the watershed. Several wetlands buffer the Little Maitland River system. Most North Maitland wetlands are associated with tributaries rather than with the river.

The Middle Maitland watershed has an intermediate number of wetlands especially in the south including some that may moderate the flow and quality problems of Beauchamp Creek.

South Maitland has no wetlands in the upper and mid basin. The lower river flows through the diked Hullett Provincial Wildlife Area. Flow moderation and filtering services were likely important given upstream concerns but the dikes limit the interactions with the river and the wetland's role. A few small wetlands are scattered through the kame unit in the basin's west end. Most are along a tributary that joins the South Maitland from the north immediately above its confluence with the Maitland; their hydrological services benefit the Lower Maitland.

In the Lower Maitland, the spillway that discharges into Sharpes Creek also contributes to Saratoga Swamp which buffers much of the creek's length. Other concentrations of wetlands occur in the upper Blyth Brook watershed and along Hopkins Creek. Hopkins Creek is part of the same spillway unit as Sharpes Creek but across the Maitland; Hopkins Creek wetlands, like Saratoga Swamp, are discharge areas and buffer the creek.

The Maitland has a number of ANSIs which together make 4,572 ha: Holmesville, Winthrop and Kinburn are all provincially significant, while the Maitland River Valley, Anient and Pollard Tract, Blyth Area, Ethel Kame and Seaforth Esker are all locally significant. The Seaforth-West Wawanosh Moraines borders the Maitland and Bayfield River watersheds, and is provincially significant.

<u>Nine Mile River</u>
The upper area has a relatively high number of small wetlands including several buffering the river. Wetlands account for 13.54% (3,290 ha): 12.74% being swamp and 0.80% is unevaluated wetland. The Nine Mile also has 200 ha of ANSIs.

Shore Gullies and Streams

Like Bayfield, this watershed has a low number of wetlands. The wetland extent is 0.75% (519 ha): 0.68% is swamp and 0.07% is unevaluated. The major system is Saratoga Swamp that is at the headwaters of Boundary Creek.

The Eighteen Mile Shorecliff provincially significant ANSI of 30 ha is comprised of a 20 m high bluff that stretches 3 km along Lake Huron southward from the mouth of the Eighteen Mile River. Trembling aspen, balsam popular and cedar dominate the steep slopes with beach grass along the sand at the toe of the slopes (Hanna 1984).

1.4.2 Terrestrial

The current forest differs markedly from the original forest not only in extent but in form. Black cherry trees ten feet in diameter or hollow sycamores able to hold a dozen men in one tree base (Beecroft 1984) are long gone. Since its low point near the turn of the 20th century, the forest area is very gradually recovering as more marginal farmland is abandoned but many woodlots are immature, highly altered replacement forests (Larsen et al. 1999).

Forest diseases and pests have also taken a toll on the area's woodlots. The Hickory Bark Beetle has killed up to 80 to 90% of the trees in hickory woodlots. Recent droughts appear to have weakened the trees and increased their vulnerability while mild winters have not killed the insects' over wintering stage (ABCA 2004). The Emerald Ash Borer is an invasive species that has garnered recent headlines when it was found in the City of London in November 2006, but it has yet to some to the source water planning region. The larvae feed on the nutrient-rich cambium of the ash, which results in girdling the tree; the first signs to tell if the tree has the emerald ash borer are look at the health of the tree canopy and the presence of 'D' shaped holes in the bark. In its native system, the ash borer is not a pest as it is prey to parasitic wasps and birds. Other aggressive tree diseases and pests include the gypsy moth, beech bark disease, striped sumac leaf roller, fall webworm, bass leaf miner and European woodwasp (Tucker 2006).

Map 1-6, Appendix D, presents today's forest distribution.

Ausable

Stoll (1983) and Snell and Cecile et al. (1995) report that up to 20% of the Ausable watershed is woodland; however, recent calculations put the number at 14.5%. The Dunes unit is the major forested area. The Dune forests protect overburden recharge, stabilize the soil and support highly significant biological communities. Much of the remainder of Ausable's natural area buffers the main stem river from the extensive Hay Swamp at the headwaters to the slope protection in the Ausable Gorge. Forest also buffers the deeper part of the Parkhill valley and lower Ptsebe Creek. Few tributaries, however, benefit from riparian woodlands; the woodlot pattern tends to be scattered and perpendicular to the streams. Exceptions are the well-buffered lower Adelaide, lower Nairn and lower Little Ausable as well as a broken woodlot corridor along Parkhill's north/south sand plain. Current calculations estimate 811,239 m of linear riverine buffer.

The 1995 Watershed Management Strategy (Snell and Cecile et al. 1995) assessed extent of vegetated dunes, riparian extent, forested potential recharge areas, wooded headwaters and wooded steep slopes to rate the forest's water protection roles. Highest role loss has occurred in the headwaters, southeast tributaries, Hobbs-MacKenzie Drain, Decker Creek and the flats. The dunes area dramatically outscores the others in retained functions, followed by Ausable Gorge and Mud Creek. Many sub-watersheds show little natural area function. The flats and the mid reach between Ailsa Craig and Exeter have the least woodland.

Source data for all open watercourses was used to calculate the amount of linear buffer in each watershed. Woodlots were buffered by 30 metres and then identified onto streams. Where these streams were inside woodlot buffers, they were considered watercourses which had a riparian zone. In the Ausable watershed, there is 811 km of linear buffer.

<u>Bayfield</u>
The forest cover is low at 10% (Snell and Cecile et al. 1995). The upper watershed is barren; much of the forest is concentrated along the lower Bayfield valley below Clinton, as well as in the valleys of Trick's and lower Bannockburn Creeks. The vegetation found within the lower valleys helps stabilize slopes, moderate flows and improve water quality. The lack of forest in the mid and upper watershed aggravates an already un-moderated and unnatural drainage system and contributes to the wide gap in water quality and quantity between the two parts of the basin.

The 1995 Watershed Management Strategy indicated a high loss of natural area function relative to the ABCA for the upper and middle Bayfield River reaches and the adjoining Silver Creek sub-watershed, as well as for the Big Drain tributary of Bannockburn Creek. The rating for quality of remaining features singles out the Lower Bayfield, which includes an ANSI and diverse forest, as clearly the best terrestrial functioning sub-watershed in the basin. Of the remaining nine sub-watersheds, seven have very little natural area function – only Trick's Creek and the Middle Bayfield indicate even moderate roles.

<u>Maitland</u>
Natural areas cover 18.9% of the Maitland; forest – natural and plantation – covers 16.5% of the watershed. Little Maitland, North Maitland and Lower Maitland subwatersheds are above the average for natural areas with 19.3%, 21.3% and 26.8% respectively, while South has the least at 12.6%. The Maitland watershed has a total length of linear buffers of 1274 km.

<u>Nine Mile River</u>
The watershed has the highest proportion of natural area in the planning region – 32.6%. Natural forest is 25.0%, plantation is 1.8% and old field is 3.8%. Most of the stream system's banks are forest lined. The Nine Mile watershed has 222 km of linear buffer.

<u>Shore Gullies and Streams</u>
Forest cover is 11.2%. The highest concentration occurs in the gully basins immediately north of Bayfield. Further north, moderate percentages extend as far as Port Albert but dwindle to less than 10% beyond. The Gully watersheds north of Bayfield, led by Gully Creek, have good riparian cover, surficial recharge area cover, and slope protection (Snell and Cecile et al. 1995). Boundary Creek, south of Nine Mile River, has well forested headwaters associated with the Saratoga Swamp. Elsewhere, the main forest remnants occur on the narrow and shallow sand plain strip. The Shore Gullies and Streams watershed has 351 km of linear buffer. Table 1-5 presents percentages for the five watersheds within the source protection planning region determined through aerial photography from 2000.

Table 1-5: Watershed Natural Area Distribution for the Source Protection Planning Region

Watershed	Natural Area %	Natural Forest %	Plantation %	Old Field %	Distribution and Roles
Ausable	14.5%	13.6%	<0.1%	0.9%	-concentrations on Dunes unit -buffers along Ausable River from Hay Swamp to Ausable Gorge. -well buffered lower Adelaide, lower Nairn and lower Little Ausable.
Bayfield	10.8%	10.3%	<0.0%	0.5%	-very little natural area function only the Trick's Creek and Middle Bayfield subwatersheds have moderate roles. -forest concentrated along lower Bayfield valley below Clinton. -vegetation in valleys help to stabilize slopes, moderate flows and improve water quality.
Maitland	19.8%	16.9%	0.8%	2.1%	-some concentration on kames -Two large wetlands in Little Maitland subwatershed may have some flow moderation roles. -Maitland River, Blyth Brook and Sharpes Creek all well vegetated for most of their lengths
Nine Mile	32.6%	25.0%	1.8%	3.8%	-most of streams banks system are forest lined.
Gullies	13.9%	11.2%	1.2%	1.5%	-Gully subwatersheds have good riparian cover, surficial recharge are cover, and slope protection. -Boundary Creek has well forested headwaters

1.5 Aquatic Ecology

Pre-settlement rivers had more cold or cool water habitat maintained by springs and forest shade. Except for river bank erosion at meanders and gorges, complete ground cover minimized soil erosion and stream sediment. Flooding maintained the lagoon flats' marsh community.

Today, species sensitive to warm water or sediment are severely limited by land use activities, turbidity and sedimentation, increased temperatures and modified hydrology (Veliz 2001). Today's cold and warm water streams are distinguished on Map 1-6.

1.5.1 Fisheries

Ausable

Although the 1949 Report mapped a very limited extent of cold water streams and permanent flow, Veliz in 2001 reported even less cold water habitat. Although Veliz (2005) confirms 83 species – an impressive number for an agricultural watershed – most sites supported less than 10 species, a number suggesting poor water quality (Veliz 2001).

Reports of cold or cool water streams or associated species include:

- Upper part of Black Creek is cold water with resident trout (Veliz 2001) but the remainder of the creek is warm;
- Nairn Creek has sand and isolated gravel that historically supported cold water but very little is left. Veliz (2003) confirmed that low discharge and warm temperatures limit

trout. Out of 115 sites studied, six were cold, five had trout but only one of those five was cold. The best trout numbers were in warm water but with gravel, cover and continuous flow;

- A small tributary north of Ailsa Craig has cold water;
- Staffa headwater flow was historically cold and is still relatively clear with a gravel bed. It helps Morrison Reservoir support rainbow trout, smallmouth bass and largemouth bass (Veliz 2001).

Migratory trout and walleye are found in the main Ausable below Ailsa Craig. The Pinery's Old Ausable Channel, although warm water, is isolated from upstream water quality concerns and has been habitat for Rainbow Trout, Yellow Perch, Northern Pike and Largemouth Bass (Schaus 1984).

Although Veliz (2001) found some good cover and substrate on the main Parkhill Creek, water quality problems limit the fisheries (Schaus 1984). The reservoir becomes stratified; the upper warm layer concentrates the nutrients from agricultural runoff and encourages algae growth. Any fisheries are warm water only.

Mud Creek is not a major fisheries stream but the small lakes - Bio, Moon and L Lakes - near Port Franks have high significance for aquatic habitat (Snell and Cecile et al. 1995). A list of fish species found in the Ausable River Basin can be found in the <u>Fish Habitat Management Plan</u> for the ABCA (2001).

The Ausable also supports 26 species of freshwater mussels: 23 live species and fresh shells were found for three other species. Mussels act as living filters for aquatic environments, filtering up to 40 litres a day. Water is drawn across their inhalant siphon and is then passed across their gills to consume particles such as bacteria, algae and detritus. Unused nutrients are converted and expelled and are used by aquatic plants and benthic organisms.

In 2002 the Ausable River Recovery Team, a multi-agency team, was formed to implement a recovery strategy and ensure the continued survival of species-at-risk. The team has conducted several preliminary mussel surveys over the past five years to determine mussel abundance and distribution. In 2006, seven sites along the Ausable River were surveyed (Brinsley, Little Ausable, Ailsa Craig, Nairn, Highway 81, Rock Glen and Arkona): the most prevalent species found was the Threeridge (*Amblema plicata*) (Baitz et al. 2007 unpublished). A new species, the Pimpleback (*Quadrula pustulosa*) was also found in the watershed. Out of the six species-at-risk mussels found, the Kidneyshell (*Ptychobranchus fasciolaris*) was the most predominant. The Northern Riffleshell (*Epioblasma torulosa rangiana*) is globally rare and the only two populations in Canada occur in the Ausable and Sydenham rivers (Baitz et al. 2007 unpublished). This recently study also confirmed an isolated healthy population of Snuffbox (*Epioblasma triquetra*) at Arkona.

<u>Bayfield</u>
In 1973, George and Pfrimmer noted a gradual deterioration in water quality and decline of less tolerant salmonids. They blamed poor land use practices as well as domestic and industrial waste from Seaforth and Clinton. Lamprey control and introduction of Pacific Salmon by Michigan had restarted spring and fall runs of salmonids but only Trick's Creek showed any spawning success. Trick's Creek rated below-potential because of the dam and a poor fish ladder. George and Pfrimmer found good resident populations of Smallmouth Bass and

Northern Pike in the lower Bayfield and Bannockburn. The status of the river above Clinton was rated "deplorable" but, with proper management and good land use practices, capable of much improvement. Problems included intermittent flows, warm temperatures, eutrophication, erosion and sedimentation. The Conservation Authority assisted in rehabilitating cold water habitat in Trick's Creek in 1982.

In 1984, Schaus reported the lower Bayfield below Trick's Creek had a cool water fishery of considerable significance, noting Smallmouth Bass and Northern Pike as resident sport fish, and migratory Rainbow Trout in the spring and fall. Most headwater areas were rated warm water with resident species including minnows, Rock Bass, Sunfish, and suckers. Some streams supported resident Rainbow and Brook Trout.

In 2001, Veliz found 34 species with little effort. In the upper Bayfield, although mostly silty-clay tills and very low base flows, a few gravely areas had some cold water and others like Silver Creek had potential after riparian improvements. In the Lower Bayfield, gravel deposits – notably Trick's Creek – generated some of best cold water habitat in ABCA. Bannockburn's sands also supported some cold water tributaries.

In 2003, Malone confirmed 34 species. Low flow, warm temperatures and eutrophication may be limiting Bannockburn Creek's capacity to support sensitive species. The lower Bayfield continued to have much better water quality than the upper watershed with higher base flows, lower temperature and more dissolved oxygen – all greatly helped by Trick's Creek's flow. Trick's Creek continues to support resident Brook and Brown Trout. A comprehensive list of fish species found in the Bayfield River Basin can be found in the <u>Fish Habitat Management Plan</u> for the ABCA (2005).

<u>Maitland</u>

A 1963 survey found 42 fish species (Conservation Authorities Branch 1967). By far the most common were: Creek Chub, Hornyhead Chub, Common Shiner and Rainbow Darter. Very common but less widely distributed were: Rock Bass, White Sucker, Blacknose Dace, Bluntnose Minnow, Johnny Darter and Brook Stickleback. Trout were found only in the North and Lower Maitland basins, the basins with the most numerous cold or cool water systems. Sharpes Creek, a Lower Maitland tributary, had the best cold water flow. The Little, Middle and South each had small reaches of cool water. The majority of streams either dry up in summer or form stagnant pools suitable only for minnows, suckers and catfish.

The MVCA 1984 Plan indicates 21 cold water streams in a pattern very similar to the 1963 survey; most streams align with spillways and a few rise in kames or moraines. Base flow patterns, however, did not fully correspond to the cold water streams. Of all of the watercourses within the Maitland watershed, 37% are cold or cool with 23% lacking trout or salmon, and 14% having either trout or salmon present. 44% of the watercourses are warm water, with 35% having no top predators and 9% with top predators. 19% of the watercourses within the Maitland are intermittent.

<u>Nine Mile</u>

Of all of the watercourses within the watershed, 69% are cold/cool. Of this 69%, 35% have no trout or salmon present and 34% do have trout or salmon present. Of the rest of the watercourses, 6% are warm water with no top predators, and 25% are intermittent and are dry for at least three months of the year.

Shore Gullies and Streams

One of the most vegetated gully systems, Gully Creek, has cold water habitat and supports runs of migratory salmonids. Most gullies, however, have poor aquatic habitat; their highly variable flow has problems of erosion, poor water quality and no base flow. Of all of the watercourses, 23% are cold/cool, 34% are warm water and 43% are intermittent. Of the 23% cold and cool watercourse, 16% have no trout or salmon present and 7% do, while of the 34% warm watercourses, 29% have no top predators and 5% do.

Off-shore shallow areas and shoals correspond to fish spawning areas, as does the sand deposition area offshore of the Pinery and Port Franks. Offshore fish include Rainbow, Brown and Lake Trout; Coho, Chinook, and Pink Salmon; Freshwater Cod; Lake Whitefish; Chub; Smelt; and Alewife. Near-shore waters contain Yellow Perch, Walleye, Smallmouth Bass, Northern Pike and various pan fish. Commercial fisheries depend mainly on Whitefish and Yellow Perch with licensed fishermen out of Grand Bend, Bayfield and St. Joseph. Sport fisheries focus on Yellow Perch, Rainbow Trout, Brown Trout and Chinook Salmon in Lake Huron with docking at Bayfield, Grand Bend and Port Franks (Donnelly 1994)

1.5.2 Aquatic Macroinvertebrates

Narrow tolerance ranges of certain species of aquatic macroinvertebrates make them a valuable indicator of water quality. Although neither Conservation Authority participates in the Ontario Benthos Biomonitoring Network, both collect aquatic macroinvertebrate data, often using the BioMap protocol.

In the MVCA jurisdiction, from 1994 to 1999, 141 sites have had benthic macroinvertebrates collected to be used as bioindicators of aquatic health. Quantitative samples were collected with a fixed-area T-sampler and a qualitative sample was collected by selectively picking and available habitat types.

The samples were provided to a private consultant for identification to the species level where possible. Using the BioMAP protocol, a water quality index is determined based on the sensitivity values of the species found. Sensitivity values are assigned to a substantial number of species found in this area and range from a 1 (tolerant of warm water, sediment and nutrients) to a 4 (intolerant of warm water, sediments and nutrients). BioMAP has been criticized for being more of a reflection of stream temperatures than aquatic health, and it is planned to experiment with a Family Biotic Index to compare findings.

Ausable

A 2000 study (Veliz and Jamieson 2000) of benthic macroinvertebrates found the dominant taxa were chironomids, elmid beetles and aquatic worms typical of agricultural drains that have sediment and nutrient enrichment.

In 2001, Jamieson found relatively pollution intolerant Capniidae (Stonefly) along with Chironomidae (Midge Fly) as the dominant species in several sample sites including Mud Creek.

Nairn Creek had the best Family-Level Biotic Index but other indicators suggest good rather than excellent water quality.

<u>Bayfield</u>
A 1980 MOE Basin Study found only pollution tolerant species above Clinton. In Clinton some pollution-intolerant forms appeared. Lower Bayfield and Bannockburn Creek supported some intolerant taxa but less sensitive forms dominated. Trick's Creek offered a diverse, pollution intolerant community that indicates good water quality.

In 2000, Veliz and Jamieson found the most diverse site at Helgrammite Creek where clear water and a cobble/gravel substrate supported larvae of Mayflies and Caddisflies. Elsewhere the dominant taxa of chironomids, elmid beetles and aquatic worms were typical of agricultural drains that have sediment and nutrient enrichment. In 2001, Jamieson found Chironomidae (Midge Fly) dominant in the Bayfield at Clinton; Caenidae (Mayfly) at Bayfield and Capniidae (Stonefly) in the Bannockburn.

Since 2000, ABCA has been sampling 6 sites. In 2002, diversity was lowest for Silver Creek and highest for Helagrammite, but almost as good at the other four sites. Dominant taxa were: at the poor rated sites - Tubificidae (worms) at Liffey Drain, Hyalellidae (Side Swimmer) at Seaforth; at the fair rated sites - Chironomodidae (Midge Flies) at Silver Creek and Caenidae (Mayflies) at Bannockburn; at the good rated sites - Caenidae (Mayflies) at Varna, lower Bayfield, and Baetidae (Small Mayfly) at Helagrammite (Malone 2003).

<u>Maitland</u>
35% of the sites in the Maitland watershed were found to be unimpaired, with the proportion of unimpaired sites being the largest (60%) in the North Maitland (9/15). Next largest was the Lower Maitland with 42% (5/12), followed by the South Maitland with 37% (7/19), Little Maitland with 27% (4/15) and finally the Middle Maitland, where only 13% (2/16) of the sites were found to be unimpaired.

The different ratings for each of the branches are due to the varied amount of forest cover, gravel soils and landform which produce more stable flows and cooler water temperatures. The more unimpaired sites tended to the areas of higher forest cover and away from the till plain physiographic feature.

<u>Nine Mile River</u>
86% (6/7) of the sites in the Nine Mile watershed were found to be unimpaired due to the presence of sensitivity values of three and four for caddisfly, mayfly and stonefly insects. This watershed has cooler water temperatures, more forest cover and a more stable flow regime.

<u>Shore Gullies and Streams</u>
29% of the sites were unimpaired (2/7) which reflects the variable flow regime of this area and more clay soils. The streams with better ratings tended to be those ones with headwaters that touch the Wyoming Moraine. In 2001, Jamieson found Capniidae (Stonefly), a relatively pollution intolerant species, dominant in the Gully Creek site and Zurich Drain.

1.5.3 Species and Habitats at Risk

The presence of threatened or rare aquatic species can suggest unique habitat characteristics that should be considered in a source protection plan.

Ausable

The Ausable River, located on the northern fringe of the Carolinian Zone, supports unique aquatic biota and is one of the most biologically diverse basins of its size in Canada (Veliz, 2005). The aquatic community of the Ausable River includes 16 species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC): seven fishes, six mussels (Baitz et al. 2007 unpublished), and three aquatic reptiles. Because several of these species at risk are declining within the basin, a recovery team was formed in 2002. The Ausable River Recovery Team has conducted inventories of fish, mussels and reptiles, drafted a strategy and is now undertaking recovery actions to improve conditions for these species in the watershed (Veliz 2005).

Bayfield

Malone (2003) noted 21 rare species. Aquatic ones include Black Redhorse, Lake Chubsucker, Northern Brook Lamprey, as well as life stages of Queen Snake, Wood Turtle, Ashy Clubtail – a dragonfly, and Louisiana Waterthrush. Obligate wetland plants include: Hemlock Parsley (*Conioselinum chinense*), Beaked Spike-Rush (*Eleocharis rostellata*), and Hairy Valerian (*Valeriana edulis spp. Ciliata*).

Maitland

Natural Heritage Information Centre list of Committee on the Status of Endangered Wildlife in Canada (COSEWIC) aquatic or floodplain species found in the Maitland watershed includes: Least Bittern, Black Redhorse, Queen Snake, Wavy-rayed Lampmussel and a plant, *Arisaema dracontium* (Green Dragon). Central Stoneroller and Striped Shiner are listed but classified Not At Risk. The Maitland Valley also hosts the Wood Turtle. The Rainbow Mussel is yet to be listed under SARA, but is anticipated for 2007-2008.

Nine Mile

It is not known whether there are species at risk in the Nine Mile watershed.

Shore Gullies and Streams

For the Shorelines Gullies and Streams watershed, the American Eel and the Deepwater Sculpin have no status under SARA, but are designated by COSEWIC for future consideration for Schedule 1 listing. The Blackfin Cisco is listed as threatened under SARA, but is believed to be extinct.

Table 1-6 lists the various at-risk fish, mussels and aquatic reptiles found within the source water planning region.

Table 1-6: Species at Risk within the watersheds of the source protection planning region and their listing under SARA and SARO

Common Name	Scientific Name	Watershed	SARO	SARA
Fish				
Pugnose Shiner	*Notropis anogenus*	Ausable	END-NR	END, Schedule 1
Lake Chubsucker	*Erimyzon sucetta*	Ausable Bayfield	THR	THR, Schedule 1
Eastern Sand Darter	*Ammocrypta pellucida*	Ausable	THR	THR, Schedule 1
Black Redhorse	*Moxostoma duquesnei*	Ausable Bayfield Maitland	THR	THR, Schedule 2
Blackfin Cisco	*Coregonus nigripinnus*	Maitland	EXT	THR, Schedule 2
River Redhorse	*Moxostoma carinatum*	Ausable	SC	SC Schedule 3
Greenside Darter	*Ethostoma blennioides*	Ausable	SC	SC, Schedule 3
Bigmouth Buffalo	*Ictiobus cyprinellus*	Ausable	SC	SC, Schedule 3
Northern Brook Lamprey	*Ichthyomyzon fossor*	Bayfield	SC	SC, Schedule 3
Redside Dace	*Clinostomus elongates*	Shoreline	THR	SC, Schedule 3
American Eel	*Anguilla rostrata*	Shoreline	No status	No status, SC under COSEWIC
Deepwater Sculpin	*Myoxocephalus thompsonii*	Shoreline	THR	No status, SC under COSEWIC
Mussels				
Northern Riffleshell	*Epioblasma torulosa rangiana*	Ausable	END-NR	END, Schedule 1
Wavy-rayed Lampmussel	*Lampsilis fasciola*	Ausable, Maitland	END-NR	END, Schedule 1
Snuffbox	*Epioblasma triquetra*	Ausable	END-NR	END, Schedule 1
Kidneyshell	*Ptychobranchus fasciolaris*	Ausable	END-NR	END, Schedule 1
Rainbow mussel	*Villosa iris*	Ausable Maitland	No status	No status, END under COSEWIC
Mapleleaf	*Quadrula quadrula*	Ausable	No status	No status COSEWIC= THR
Aquatic Reptiles				

Eastern Spiny Softshell Turtle	*Apalone spinifera*	Ausable	THR	THR, Schedule 1
Queen Snake	*Regina septemvittata*	Ausable, Bayfield, Maitland	THR	THR, Schedule 1
Northern Map Turtle	*Graptemys geographica*	Ausable	SC	SC, Schedule 1
Wood Turtle	*Glyptemys insculpta*	Bayfield Maitland	END-NR	SC, Schedule 3

EXT=Extinct
END-NR=Not regulated under Ontario's Endangered Species Act (33)
END=Endangered
THR=Threatened
SC=Special Concern

1.5.4 Invasive Species

Some invasive species can affect water quality. Examples include the common carp and zebra mussel. The common carp was introduced to North America in the mid 1800s as a commercial fish. Because carp are omnivorous, they often eat the eggs and young of other fish and disturb sediment in a watercourse as they forage for food, thus disrupting the quality and clarity. The disturbance of sediment can discourage other fish from nesting in the area and can prevent aquatic vegetation from establishing which provides food to other fish.

Zebra mussels were first discovered in North America in 1988 and have since spread through the water system using the water currents during their planktonic larvae stage. Zebra mussels can affect water quality through their respiration and filtering by decreasing the amount of plankton, suspended sediments and dissolved oxygen and increasing the concentration of ammonia nitrogen and soluble phosphorous.

There is anecdotal evidence that the Round Goby has travelled as far upstream as the dam at Parkhill. The round goby is a bottom-feeding fish that is an aggressive feeder and breeder – producing more young for a longer period of time than other fish. The goby also establishes in prime habitat that is preferred by native fish. Little is known about the distribution of aquatic invasive species and is an identified data gap.

1.6 Human Characterization

Small nomadic bands may have followed caribou herds through a spruce forest landscape as long as 11,000 years ago (W. Fox in Beecroft 1984). Subsequent aboriginal use was based on hunting. By the late 1600s Chippewas settled in the area and developed a trade in flint found at Kettle Point. European settlement was deterred by Niagara Falls, the distance to the Nipissing route, poor river navigability and the Thedford Swamp. It was the Huron Road built by the Canada Company in 1828 that finally brought settlers to the area (Conservation Authorities Branch 1967; Beecroft 1984).

The relative remoteness discouraged industry and large cities while the rich soils encouraged agriculture. Agriculture remains a major economic mainstay of the community. It is only with the advent of the automobile that the tourism industry boomed (Butler and Hilts 1978) based on the allure of the Lake Huron shore. More recently, good roads and ready access to Canadian and US markets have encouraged industry beyond agricultural support and processing.

Provided documentation on human use was scant. Little of the documentation applied to the watershed boundaries of the planning region. In the following sections, Huron County data are used as most representative of the planning region (see Map 1-1).

1.6.1 Population Distribution

Both Conservation Authorities average 18 persons per kilometre squared in population density; a majority are rural residents. In the 2001 census, Huron County was 60% rural residents – more than any other Southwestern Ontario county (Statistics Canada 2002). Table 1-7 lists the planning region's towns and villages by watershed.

Table 1-7: Population Sizes and Densities of Towns and Villages within the Ausable Bayfield Maitland Valley

Town or Village	Watershed (* main)	Location in Watershed	Population	Population Density/km^2
Hensall	Ausable	Headwaters of Black Creek	1,194 [4]	746.3 [4]
Exeter	Ausable	Upper	4,500 [1]	914.2 [4]
Lucan	Ausable	Little Ausable	2,010 [4]	1,248.4
Ailsa Craig	Ausable	Mid	1,000 [2]	473.3 [4]
Arkona	Ausable	Hobbs-Mackenzie Drain	464 [4]	348.9 [4]
Thedford	Ausable	Decker Creek	755 [4]	379.4 [4]
Port Franks	Ausable*, Shore Streams	Mouth of Ausable and of Mud Creek		
Grand Bend	Ausable, Parkhill, Shore Streams*	Mouth of Parkhill	995 [4]	283.5 [4]
Parkhill	Parkhill	Mid	1,700 [2]	420.1 [4]
Seaforth	Bayfield, South Maitland	Silver Creek	2,500 [1]	914.4 [4]
Clinton	Bayfield, Lower Maitland	Boundary of upper and lower	3,000 [1]	764.0 [4]
Bayfield	Bayfield, Shore Streams	Mouth	830 [5]	317.8 [4]
Listowel	Middle Maitland*, Little Maitland	Near headwaters	5905 [4]	954.0 [4]
Brussels	Middle Maitland	Mid	1,143 [4]	589.2 [4]
Wingham	Middle Maitland, North Maitland*, Lower Maitland	Confluence of Middle and North so top end of Lower	3,000 [1]	1,187.2 [4]
Palmerston	Little Maitland	Near headwaters	2518 [4]	868.3 [4]
Harriston	North Maitland	Near headwaters	2034 [4]	600.0 [4]
Blyth	Lower Maitland	On Blyth Brook	952 [3]	440.6 [4]
Goderich	Lower Maitland*, Shore Streams	Mouth	7,500 [1]	961.4 [4]
Lucknow	Nine Mile	Mid	1136 [4]	576.6 [4]
Zurich	Shore Streams	Headwaters	850 [5]	924.7 [4]

[1] Dodds et al. 2005
[2] Peeters 2006
[3] Black 2006
[4] Statistics Canada 2002
[5] Municipality of Bluewater 2006

From 1951 to 1996, Huron County farm population decreased from 46% of the total to 18%, still much higher than the 3% proportion of farmers nationally (Huron County Planning and Development Department 2001). The recent rise in rural non-farm population results in non-farm population exceeding farm population in most townships (Bonte-Gelok and Joy 1999). The higher population growth areas have been in the south toward cities outside the basin (ABCA 1985).

1.6.1.1 Population Projections

Starting in the mid-1990s with the expansion of urban centres and the changing responsibilities of local and provincial governments, there was a movement of municipal restructuring and merging. Between the years of 1996 to 2001, the number of municipalities within Ontario decreased by 40%. Refer to Appendix B to see how the municipalities within the source protection planning region were restructured since 1996. Dates of approval for Official Plans and Zoning By-Laws are also listed; some municipalities have yet to consolidate the zoning by-laws of the various townships prior to municipal restructuring. Other municipalities do not have their own official plan and use that of their county, or have official plans for urban areas and use the county's official plan for rural areas.

<u>Huron County</u>
From 1951 to 1996, Huron County grew by 11,000, averaging 0.5% per year compared to Ontario's 2% per year. Between 1996 and 2001, however, Huron County population declined by 0.9%. The Ontario government projects that Huron County will grow at a modest rate: from a population of 59,701 in 2001 to 69,000 in 2031 (Dodds et al. 2005). The population fluctuates seasonally with summer cottagers and tourists.

<u>Middlesex County</u>
In the County of Middlesex's Official Plan (2006), the population of the county is estimated at 71,631 in 2001. The Official Plan attempts to forecast the growth of the county over the next 15 years to predict the required land use and infrastructure and predicts the population to be 71,502 in 2006, 75,399 in 2011 and 78,556 in 2016 (County of Middlesex Projections 2001-2026).

<u>Lambton County</u>
From 1961 to 2001, Lambton County grew by 52,011 averaging 1.4% per year (Lambton County Planning & Development Services 2002). Between 1991 and 2001, the population of Lambton County declined by 1.53%. In 2001, Statistic Canada estimated the population size at 126,971 (Lambton County Planning & Development Services 2002) and the County predicts a growth to 142,000 by the year 2016 (Lambton County 1998).

<u>Bruce County</u>
In the 1991 census, the population of Bruce County is estimated at 64,215 individuals. In the current official plan which uses a planning period until 2016, Bruce County predicts a population growth of 21,294 to a total of 85,509 (Bruce County 1999). Most of the growth will occur in primary, secondary and hamlet communities; it does not have a large regional centre within the county.

<u>Perth County</u>
The average annual growth rate in the County for the years between 1971 and 1991 was a modest 0.6% (Perth County 1997). As a rule, the populations increased significantly in the urban centres within the county, as compared to the rural areas. Between the years 1996 to 2016, the County predicts a growth rate of 1.25% and estimates that the population will be distributed 46% within the City of Stratford and Town of St. Marys, and 54% within the rest of the county (Perth County 1997).

<u>Wellington County</u>
The County of Wellington has projected its population on a five year basis starting in 2002 over a twenty-year time period. The projections are based on the assumption that 82% of the growth will occur in 15 urban centres: Arthur, Mt. Forest, Clifford, Harriston, Palmerston, Drayton, Moorefield, Belwood, Elora-Salem, Fergus, Rockwood, Erin, Hillsburgh, Aberfoyle and Morriston (Wellington County 1999). The county predicts a population of 83,000 in 2002, 89,500 in 2007, 96,500 in 2012, 102,500 in 2017 and 109,000 in 2022.

Table 1-8: Population projections for counties within the Ausable Bayfield Maitland Valley Region. All projected populations are from the Ministry of Finance, 2006.

County	Population (2006)	Population (2011)	Population (2016)	Population (2031)
Huron	61,600	62,300	63,500	67,930
Middlesex*	438,050	457,670	476,870	528,630
Lambton	132,200	132,390	142,000	136,470
Bruce	67,530	69,240	71,540	78,670
Wellington*	208,170	223,240	238,100	278,870
Perth	78,160	81,050	84,040	92,340

*Note: the projections for Middlesex County include the population for the City of London and the projections for Wellington County include the population for the City of Guelph.

1.6.2 Land Use

Land use (1980s) is presented on Map 1-7. Agriculture dominates the planning region. Small urban areas are scattered throughout the area. Cottage development has spread along the lakeshore. Forest concentrations occur in the Dunes, Ausable Gorge, the Lower Bayfield and Maitland Valleys and the major spillway and delta unit that include the Hay Swamp, Lower Bannockburn Creek, Trick's Creek and the Saratoga Swamp. There are a number of Conservation Areas, private campgrounds, and two provincial parks: The Pinery and Point Farms. Several gravel pits occur in the major spillway unit. Stoney Point First Nation, located outside of the source protection planning region, has reclaimed Ipperwash Range and Training Area. In 1989, the Maitland was 80% agriculture, 2% urban and 18% natural (MVCA 1989).

Potential land uses are presented on Map 1-8 to show Official Plan zoning; currently the map is an incomplete draft.

1.6.2.1 Existing Urban Development

The planning region is predominantly rural. All towns or villages in the planning region are listed in Table 1-7 in Section 1.6.1 and shown on Map 1-1. These towns and villages were all considered independent municipalities prior to the municipal restructuring and amalgamation which began in 1996. The largest is Goderich with a population of 7,500. Towns are scattered throughout the region and the urban footprint (which includes any town, village, hamlet or other grouping of houses) covers 1.42% of the Ausable watershed, 1.64% of the Bayfield, 1.41% of the Maitland, 1.94% of the Nine Mile and 2.28% of the Shorelines and Gullies watershed.

In the Bayfield Ward, shoreline development in Central Huron and Varna are considered urban, although Varna is a small residential community. Clusters of development within Stanley Ward and Central Huron are categorized as rural/recreational. These areas consist of a large number of permanent and seasonal residences, campgrounds and trailer parks. Rural areas are largely situated in Central Huron east of Highway #21 and north of County Road #13.

Some urban development is atypical of the extensive impervious surfaces associated with urbanization. Subdivisions such as Southcott Pines, Huron Woods and Beach O' Pines have greatly altered the dune ecosystem but maintained enough natural cover to minimize erosion and encourage infiltration in the highly pervious sands. The density of cottage development has allowed for more efficient water servicing, but has led to increased risks due to septic system use and failures.

The community of St. Joseph is unique in that there is a mixture of land use. It is comprised of 45% farms and 35% cottages. The cottages are connected to the pipeline from Port Blake, while the farms have private wells. All properties use septic systems in this area.

Other towns and communities serviced by municipal wells as listed in Section 1.6.3.5.1.

1.6.2.2 New and Projected Urban Development

Ontario's recent Greenbelt Plan and Places to Grow Policy does not apply to the planning region. The 2005 Provincial Policy Statement directs growth to existing urban areas and protects agricultural lands by discouraging lot creation (Ontario Ministry of Municipal Affairs and Housing, 2005).

1.6.2.3 Industrial / Commercial Sectors Distribution

As agricultural employment declines, industrial and commercial sectors have grown in importance. In 2002, Huron County employment in manufacturing and construction sectors outstripped all others (Statistics Canada 2002). Most manufacturers are small. The largest product categories are food related (farm feed supplies, food products and processing) and fabricated metal. Other major manufacturing categories include wood products, furniture, printing and publishing, and equipment – industrial, commercial, electric and transportation. Industries are well distributed in towns and villages throughout the region. In Huron County, the highest numbers occur in Goderich, Wingham and Exeter (Huron Manufacturing Association 2005) Goderich continues its long history of salt mining and port transport. The top five employers for Huron County in 2003 were Wescast Industries Inc., Volvo Motor Graders, Royal Homes Ltd., Nabisco Ltd., and Northlander Industries Inc (Huron County Planning and Development Department 2003).

Tourism is a major employment sector in the planning region. Lake Huron is the main attraction. The lakeside location has generated many business and activities for visitors and cottagers. Major tourist centres are Grand Bend, Bayfield and Goderich.

1.6.2.4 Trends in Industrial and Commercial Sectors

Manufacturing is the fastest growing sector of the Huron County economy both for business start-ups and job creation and has replaced farming as the largest generator of Huron's economy. A manufacturing strategic plan has initiatives to create economic development from within the area and to attract investment from outside (Huron Manufacturing Association 2005).

Tourism and its many associated businesses are also growing (Malone 2003). Cottage prices are climbing. As the cost of gasoline rises, the area's relative proximity to major population centres such as Toronto and Detroit may increase its attraction.

These growth trends buck the slight decline in population, possibly indicating a switch of employment out of farming.

1.6.2.5 Agricultural Sector Distribution

Significantly, the Maitland watershed has the highest livestock manure production/ha (7,610 kg/ha) in Canada, 10 times the national average. The Ausable Bayfield watershed was seventh at just over 4,000 kg/ha. Manure components showed similar patterns: Maitland was highest nitrogen in Canada at 48 kg/ha, while the Ausable Bayfield was sixth with 28 kg/ha. Maitland placed second for Phosphorus at 13 kg/ha and Ausable Bayfield was seventh with 8 kg/ha. Maitland ranked third nationally for total coliform bacteria and second for fecal coliform bacteria; in each case the Ausable Bayfield was at a lower ranking (Statistics Canada 2001).

Agricultural sector distribution is presented in Table 1-9. Cultivated lands include continuous row crops, corn systems, extensive field vegetables, grain systems, hay systems, mixed systems, orchards, vineyards and tobacco systems. Pasture lands include grazing systems, pastured systems and pastured woodlots. Lands which do not fall in one of these two categories include, but are not limited to, built-up urban lands, extraction sites, recreation sites, water, woodlots, and wetlands. Land that is either cultivated or pastured can also be described as prime or marginal; the two sets of categories are not mutually exclusive. Not all land is of either prime or marginal value and can be considered 'Non Marginal or Prime'.

Table 1-9: Agricultural Sector Distribution within the Ausable Bayfield Maitland Valley

Watershed	% cultivated	% pasture	% prime	% marginal	Cattle Density	Poultry Density	Swine Density	Livestock Unit Density
Ausable	78.04	3.87	91.67	2.54	M*	L*	H*	M*
Bayfield	84.23	1.60	97.23	0.99	M*	H*	M*	M*
Maitland	78.43	2.84	88.70	2.84				
Nine Mile	68.01	4.64	65.58	9.92	L*	L*	L*	L*
Shore Streams & Gullies	82.77	1.44	97.58	0.48				

*The ratings are from Bonte-Gelok and Joy (1999) and apply to Huron County portions only.

1.6.2.6 Trends in Agriculture

In 1996, Huron County housed approximately 240,000 livestock units: 405,000 hogs, 4.5 million chickens and 165,000 cattle (Huron County Planning and Development Department 2001). These numbers mark a decline in cattle since 1971 but an increase in poultry and swine for little change in total livestock units. In the same period, improved land area decreased while un-improved areas grew (Bonte-Gelok and Joy 1999).

Between 1996 and 1999, Huron saw a further 54% increase in hogs marketed per producer. Between 1996 and 2000, 391 building permits were issued for new or expanded barns to accommodate an additional 58,000 livestock units, and hogs accounted for 72%. In 1996, every municipality still averaged adequate area to accommodate the manure. But since then, intensity of production has risen dramatically and new barns are much larger (Huron County Planning and Development Department 2001). The 1996 to 2000 building permits for new or expanded barns showed some concentration in Bayfield, Middle Maitland, Little Maitland and North Maitland watersheds, but occurred in all other areas as well. Expansion was highest in former Stanley Township, south of Bayfield. Livestock density remains highest in the Maitland watershed (Huron County Planning and Development Department 2001).

Between 1961 and 1996, the number of farms in Huron County dropped by 38% and the average farm size grew 1.5 times (Huron County Planning and Development Department 2001), but Huron still has more census farms and farmland (3,260 and 711,525 acres, respectively) than any other district or county in the province (Huron Tourism Association no date). In Perth County, 90% of the land is classified as prime agricultural land (class 1, 2, 3), and the total number of farms recorded in the 1996 census was 2,832 (Perth County 2005).

In the longer term, the dominance of mixed farms noted in the 1949 Report gave way to a major expansion of row crops (corn and soy beans) in the following 25 years. Pasture receded to river valleys while livestock numbers and feedlots grew. The changes brought increases in artificial drainage, fertilizer use, manure production and spreading, manure spills, milkhouse wastes, cultivation to stream edges and clearing of marginal land. Rotations declined, woodland was cut and fields expanded, flash flows increased and both water and soil declined in quality (ABCA 1979; MVCA 1989).

1.6.2.7 Non Agricultural Rural Land Uses and Trends

The discussion focuses on land use relationships to drinking water source protection.

1.6.2.7.1 Aggregates

A 2004 Aggregate Resource Inventory Paper for Huron County notes all aggregate as sand and gravel; there is no bedrock-derived aggregate. Between 1998 and 2002, total production averaged about 2.8 million tonnes per year and the average since 1981 has been about 2.7 million tonnes per year. Most of the 169 pits are in the north and central parts of the County and associated with major spillways (e.g., Trick's Creek, Sharpes Creek, Nine Mile River) and eskers. Glacial lake beaches, sand plains and some coarser textured moraines can also provide aggregate. Goderich and Grey townships had the highest number of licensed pits in 2002. Many of the primary deposits can have potential conflicts with adjacent agriculture, wetlands, ANSIs and recreational uses (Dodds et al. 2005). The focus of exploitation on major spillways could raise concerns of potential interference with shallow overburden aquifers vital to wetlands and streams.

In the Draft Aggregate Resource Strategy Report (2005), Huron County followed the guidelines set out in the Draft Mineral Aggregate Resource Manual published by the Ministry of the Environment and performed a constraint mapping exercise. A constraint was considered of any social, economic and environmental features which may impact the ability of the mineral aggregate deposit to be extracted. Environmental constraints included, but were not limited to, areas with a 30 m buffer of a sinkhole, 120 m buffer of a locally significant wetland, 50 m of a locally significant ANSI and 50 m of a significant floodplain. Deposits with no or one constraint were recommended to be designated as Mineral Aggregates in the Municipal Official Plans. Deposits with two or three constraints are recommended not to be designated. Only deposits that are classified as primary or secondary by the Ministry of Northern Development and Mines were considered. In addition, several sterilizing features were identified, and it was recommended that deposits that were located at or adjacent to a sterilizing feature be discouraged. These features included landfills, provincially significant wetlands, provincially significant ANSIs and municipal wellhead capture zones.

Huron County's distance to markets makes it a small player on the provincial scale. Slow population growth and few new major infrastructure projects would indicate no dramatic increase in production in the short term. In the longer term, however, as resources closer to large urban markets deplete, Huron County may see a rise in production (Dodds et al. 2005).

1.6.2.7.2 Cottage Development

Over the last 60 years, a band of cottage development has spread along much of the Lake Huron shoreline. By 1993, Huron County shoreline townships had over triple the number of seasonal residents as permanent ones (Bonte-Gelok and Joy 1999). Some older areas built close to the eroding cliffs are now experiencing erosion threats from these natural processes. In some areas gullies are threatening to erode. Many cottages are also degrading water quality from malfunctioning septic systems. Many older cottages have expanded, exacerbating the erosion and septic system problems (Snell and Cecile et al. 1995).

In 1989, there were 1038 lakeshore residences with septic systems in ABCA and 1000 new single residences planned (Hocking et al. 1990). Many systems are now used well beyond their design as piped lake water supplies provide limitless volumes and conversions transform cottages into year-round residences.

Port Franks cottages suffer a number of stresses imposed by flooding made worse by ice jams, erosion – both natural and from boat wakes and sediment deposition. Some of these problems result from 'The Cut' creation; some have been made worse by upstream Ausable watershed processes of sediment loading and reduced flood retention due to land clearance, artificial drainage and marsh removal (Snell and Cecile et al. 1995). The dunes are unstable when disturbed and the lakes of the channels are sensitive and support significant plant and wildlife communities. The pressures of development including the septic systems in the porous sands are causing problems to both terrestrial and aquatic habitats.

Pressures for expansion of shore communities and cottage developments are especially severe near Grand Bend and on the coastal sand plain outside protected areas. Existing developments are serviced by the Lake Huron pipeline, and it is anticipated that the same will occur for future cottage development.

1.6.2.7.3 Forestry Operations

Conservation Authority properties undergo sustainable logging, and wood harvest is economically important for many landowners. No large-scale forestry operations exist in the area.

1.6.2.7.4 Protected Areas

The conservation lands, Crown lands, and other protected areas of the planning region are summarized in Table 1-10.

Table 1-10: Area of Conservation Lands (in hectares) within the Ausable Bayfield Maitland Valley

Watershed	Provincial Parks and Wildlife Management Areas (in ha)	CA Lands (in ha)	Other conservation Lands (Nature Conservancy, NGO Nature Reserve) (in ha)	ANSIs (in ha)
Ausable	2149	4093		7210
Bayfield	134	143		1325
Maitland	2061	1470	13	1563
Nine Mile	58	80		7915
Shore Streams & Gullies	233	135	35	410

1.6.2.7.5 Brownfields

The Ontario Ministry of the Environment (MOE) is currently compiling a list of brownfields for the province.

1.6.2.7.6 Landfills

There are a number of active and closed waste disposal sites within the source water protection planning region (Map 1-9).

The Waste Management Master Plan for the County of Huron (Stage 3 1997) identifies two existing landfill sites, Morris and Exeter, to have long term potential. There are 26 years of identified capacity, with a possibility of more capacity (up to 40 years) at these sites if a staged expansion program is granted by the MOE (CH2M Gore & Storrie Ltd. 1997). A potential new landfill site has been identified in Ashfield Township, but further work on this site will be postponed until the above two landfills have been optimized.

Bonte-Gelok and Joy (1999) documented waste water treatment plant lagoons and landfills for Huron County. From available data, they found little evidence of water quality issues from landfills, nor any relationship between treatment plants and water quality trends.

1.6.2.7.7 Oil and Gas

Oil, gas and brine wells are displayed on Map 1-10.

The following paragraph is an excerpt from the Lambton County Groundwater Study (2004):

"The two most sensitive areas where oil and gas wells are most likely to have an effect on the potable water aquifer are: a) the locations of wells where industrial wastes were historically injected into the Detroit River Group under pressure, and b) the historical oilfields, although natural factors have complemented the efforts of operators to abandon wells in the historic Devonian oilfields. The risk of migration of crude oil and sulphur water upward from the Devonian reservoirs into the potable water aquifer is considered to be relatively small. Unplugged wellbores in oil and gas wells pose the same risk as unplugged water wells, in that surface water may flow down the wellbore into the potable water aquifer. The density of wells drilled in the historical fields increases this risk."

1.6.2.7.8 Transportation

Because the area is rural and does not have a large city, most of the roads are county or local roads with the exception of four 'King's Highways.' Highway 21 begins at Highway 402 and heads north to Lake Huron, following the coast until Southampton where it then heads inland to Owen Sound. In the planning region, it connects the towns of Port Franks, Grand Bend, Bayfield, Goderich, Port Albert and Point Clark. Highway 4 runs north-south and connects Clinton on Highway 8, running through downtown London as Richmond Street, and then on to Port Stanley on the shores of Lake Erie. Highway 4 connects the towns of Clinton, Hensall, Exeter, Huron Park, Mooreville and Lucan within the planning area. Highway 8 runs northwest to southeast, connecting the towns of Goderich, Clinton, Seaforth then continuing outside of the planning area to Mitchell, Sebringville and Stratford before joining Highway 7 to Kitchener-Waterloo. Lastly, Highway 23 is a main artery through Perth County. It runs in a southwest-northeast direction beginning from Highway 7 at Elginfield, and connects the communities of Mitchell, Monkton, Listowel, Palmerston, Harriston and ends at the intersection of Highways 9 (to Walkerton) and 89 (to Mount Forest).

There are three minor airports located within the source water planning region: Centralia/Huron in Huron Park, Goderich, and Wingham. In the area there are also a number of train lines. Refer to Map 4-5: to see the locations of the train lines and the locations of salt storage. Transportation Issues are further discussed in <u>Chapter 4: Existing Threats Inventory.</u>

1.6.2.7.9 Wastewater Treatment
(Map 1-11)

Septic Systems
Impact on water depends on age, density, design, soil, illegal tile connections and use of lawn chemicals.

Septic system numbers for the different watersheds may be outdated. In the Ausable, Parkhill and Mud Creek areas, 4049 systems area estimated (Hocking - CURB 1989).
In the Bayfield area, 1450 are estimated, while in the Shore Streams and Gullies it is 1848 (Hocking - CURB 1989). The Bayfield area is rated as 'high density' by Bonte-Gelok and Joy (1999) and the highest density of the watersheds in Huron County goes to the Shorelines and Gullies. The Nine Mile has a low density (Bonte-Gelok and Joy 1999) and there is no information for Maitland.

Most of the documentation applied to systems built in heavy soils and was concerned with effects of malfunctioning on surface water quality. Cottages built on the shoreline sand plain, however, correspond to a major overburden recharge area and raise concerns for the shallow overburden aquifers.

The Huron County Health Unit has undertaken a septic system re-inspection program for the communities of Amberley Beach, Port Albert, Bluewater Beach, Black's Point, St. Joseph and Egmondville. The Health Unit targeted these areas because of the combination of high classification, history of sewage ponding, odour complaints, a history of poor-quality beach water for adjacent lakeshore communities; some of the communities volunteered for the program (Scharfe and the Ashfield-Colborne Lakefront Association 2005). In 2005, the Health Unit performed 174 re-inspections; 3 of systems had failed and needed to be replaced. For 2006, the number of re-inspections has exceeded the volume from 2005 and 2 systems required replacement. These numbers are conservative estimates of failures because it does not take into account the systems that failed, but could be repaired because the failure was due to a lack of maintenance. As well, the re-inspection program is currently of a voluntary nature, and landowners with known failed systems may be unwilling to contact the re-inspection program.

Stormwater Management

In addition to its regulatory role, the Conservation Authorities (CAs) are often called upon to provide support services in the review of development applications made under the Planning Act, generally being in the position as either having the required technical expertise or otherwise assuming the role as resource managers. With regard to stormwater management, the Conservation Authority generally acts in an advisory capacity to the local municipality. The Conservation Authority, generally, would encourage that suitable, effective stormwater management be implemented supporting a development proposal. The degree of stormwater management required will depend on the nature of the development proposal. Typically, change in land use will trigger the need for stormwater management. Development can take many forms and may proceed as a proposed plan of subdivision or condominium, may proceed by way of severance, or may involve a relatively small parcel of land such as in the case of an infill situation within an existing developed area.

Stormwater management may not be a requirement of the municipality in all cases. The decision to employ stormwater management may consider issues such as: size of area to be developed, density of the proposed development (consideration for resulting change or increase in percent imperviousness), proposed use, and assessment of the sensitivity of the natural environment to the impacts from development. Generally, at the request of the municipality, a site specific assessment would be undertaken by the Conservation Authority. At the request of the planning authority, being either the municipality or county, recommendations are provided by the CA in terms of specific requirements for stormwater management. In the case of a draft plan of subdivision or condominium, these recommendations typically would take the form of recommended conditions (with regard to SWM) to be fulfilled. These recommendations are associated with the approval of the plan prior to registration.

The "ABCA Stormwater Management Policies and Technical Guidelines, Final Report" (2004) sets out policies, criteria, and targets as guides towards the application of stormwater management within the ABCA's area of jurisdiction. Similar policy documentation has been adopted within the MVCA jurisdiction.

A certain degree of flexibility may be necessary in interpreting policy documentation and arriving at the best practices or otherwise criteria associated with stormwater management which should be applied to a given development proposal and the uniqueness of the surrounding natural environment.

Although the ABCA policy documentation does speak, in part, to water quality, policy generally dictates that stormwater quality control shall be provided in accordance with the guiding document from the MOE Management Planning and Design Manual (2003).

Both the ABCA and MVCA policy documentation encourages the use of lot level controls as best practices to be incorporated as first priority measures before the use of end pipe facilities such as stormwater management ponds. Provided that soils are suitably permeable, the use of onsite controls to promote the infiltration of surface runoff is encouraged where appropriate.

A stormwater management (SWM) plan, if prepared in accordance with the requirement of the CA, will generally demonstrate to the satisfaction of the CA that:

- Storm flows (surface and piped) are safely conveyed form the site to a suitable receiver;
- There will be no increase in flood risk onsite of offsite as a result of the development;
- Post development peak flows are controlled to pre-development levels;
- Erosion and sediment control is satisfactorily addressed (during construction and following development)
- Water quality objectives as set out by the MOE guiding documentation in terms of capture of suspended sediment are met (during construction and following development);
- Impact on the natural environment is duly considered

The stormwater management (SWM) plan may, in addition, address the following issues:

- Impact on water budget
- Consideration for thermal impact on the receiving watercourse
- Dissolved oxygen levels in the receiving watercourse as related to the support of life stage of fish (it is noted, ABCA policy documentation provides a target and does not set out strict criteria to be met);
- Phosphorous loading in the receiving watercourse (ABCA policy documentation provides a target and does not set out strict criteria to be met).

Both the ABCA and MVCA endorse the concept of an integrated approach to stormwater management through the planning process. The development of Watershed Plan(s), Master Drainage Plan(s) etc. which are endorsed by a municipality and address stormwater management needs at a community scale, regional scale, or on a watershed basis are encouraged. It is recommended that such plans be recognized within municipal land use plans such as the Official Plan or a Secondary Plan.

A municipality's Official Plan or Secondary Plan may make provisions for stormwater management. In such case, stormwater management requirements might be described as a statement of policy objectives. The policy/criteria is likely to be generic in nature and may not address in detail the specific stormwater management requirements which would be associated with a specific development proposal as would typically be addressed by a detailed stormwater management report.

1.6.3 Water Uses and Values

Groundwater uses are discussed in the county and township groundwater study reports (Huron: International Water Consultants et al. 2003; Lambton and Middlesex: Dillon Consulting and Golder Associates 2004 a & b; Wellington: Minto and North Wellington: Burnside 2001 a&b; Bruce and Perth: Waterloo Hydrogeologic 2003a & b). The reports present data by township or municipality and occasionally by Conservation Authority but never for watersheds within a Conservation Authority. Units vary, e.g., cubic metres per day in some reports and per year in others. Because data cannot be readily assembled to match planning region boundaries, Huron County is used to represent the area with reference to data from other counties where possible.

Livestock is the biggest water user. Domestic wells and municipal wells are other major uses but, over a township, their volumes of use rarely rival that for livestock. Aggregate washing also needs large amounts of water.

Groundwater is judged adequate to meet the area needs today and well into the future. Huron County withdrawals are conservatively estimated to be 17% of aquifer recharge. Wellington – Minto report estimated that about 1% of the infiltrated groundwater is used. Most is returned to the watershed although to more surficial systems.

The largest water use sectors are municipal, livestock watering, and rural domestic. Lesser uses include commercial and industrial sectors and recreation (Rush 2003).

1.6.3.1 Drinking Water Sources

Map 1-12 locates drinking water sources in the planning region. In towns, sources tend to be municipal wells; in rural areas most sources are individual or communal wells. Most wells are bedrock wells. For example, in Huron County, more than 80% of the wells reach bedrock (International Water Consultants et al. 2003). Overburden wells are concentrated in central and west Ausable with many shallow ones also at Port Franks and Grand Bend (Dillon Consulting and Golder Associates 2004a). Some municipal surface water systems are fed by Lake Huron and service nearby rural areas. Since the 1960s, Lake Huron pipelines have spread through Lambton County to the point that most areas are supplied and well drilling has almost ceased. In Lambton County within the planning region, only Arkona had municipal groundwater and it was replaced by Lake Huron supply in 2005. Subsequently, the wells in Arkona are slated for decommissioning in 2007. In Lambton Shores, however, 30% of the population is still self-supplied (Dillon Consulting and Golder Associates 2004a). Middlesex municipalities in the planning region have no public groundwater supply but some private wells (Dillon Consulting and Golder Associates 2004b). On the other hand, all Bruce County residents in the planning region use groundwater sources (Waterloo Hydrogeologic 2003a) and so do all of Perth County and Township of Wellington North residents (Rush 2003).

In 1989-1990, Lake Huron Water Supply at Grand Bend extended a pipeline north to Bayfield encouraging many cottages to switch from seasonal to year-round. This shift sparked concerns that septic systems could fail under the extra use.

Most MVCA residents, besides those living in the Town of Goderich and some other lakeside communities, use groundwater (MFX Partners 2002). A Huron County survey in 2000 found one-third of the wells above the drinking water guideline for bacteria and 10% above the guideline for nitrate (MVCA 2003). All larger towns have supplies exceeding requirements and problems are few (James F. Maclaren 1977).

Municipal wells

The groundwater studies document municipal well locations, volumes, potential contaminant sources and wellhead protection areas. Municipal well locations are listed in Table 3-1 in Chapter 3: Vulnerable Areas.

The only municipal wells that draw water from overburden aquifers are Hensall, Exeter, Trowbridge and Lucknow. In Huron, municipal wells supply about 30% of population including seasonal residents.

1.6.3.1.1 Communal Wells

In Huron County, public supplies taken from non-municipal wells are estimated at about 10% of the municipal supply. They occur in ten campgrounds and several small subdivisions (International Water Consultants et al. 2003).

1.6.3.1.2 Private groundwater supplies

Domestic wells are numerous. For example, in Huron County about 3,400 domestic wells supply approximately 45% of the population including seasonal residents. Well locations are mapped in the county groundwater studies (Huron: International Water Consultants et al. 2003; Lambton and Middlesex: Dillon Consulting and Golder Associates 2004 a & b; Wellington: Minto and North Wellington: Burnside 2001 a&b; Bruce and Perth: Waterloo Hydrogeologic 2003a,b). Each distinguishes depth range and bedrock wells from overburden ones. A residential shift from individual private wells to municipal wells is emerging as a trend.

1.6.3.1.3 Surface water intakes

Although most residents depend on groundwater, a substantial percentage uses water piped from Lake Huron. In Huron County, Lake Huron water supplies 24% of the population (International Water Consultants et al. 2003). Much of the planning region's Lambton and Middlesex areas also use Lake Huron water.

There are two intakes from Lake Huron in the planning region: the intake at Port Blake and the intake at Goderich. The intake at Port Blake (see Figure 1-5), just north of Grand Bend, services the City of London with a population of 350,000, located outside the planning region. It also supplies much of the population in the southern part of the planning region: the entire municipality of North Middlesex, the former Town of Lucan and part of the former Biddulph Township, Middlesex Centre (Denfield), the former Town of Strathroy and parts of the former Caradoc Township, Lambton Shores (most of Bosanquet Township as well as Parkhill, Thedford, Grand Bend and Port Franks), South Huron (Huron Part/Centralia, Exeter, Crediton, Dashwood) and Bluewater (the lakeshore villages from Bayfield to Kettle Point along Highway 21). Hensall will be added to this list in 2007/2008. It also serves the towns of Ilderton, Arva, Delaware, and Ballymote which are outside of the planning region. This intake services approximately 500,000 people.

The other lake intake within the source protection planning region is located at Goderich, supplies a population of approximately 7,500 people, and takes 900,000 gallons per day.

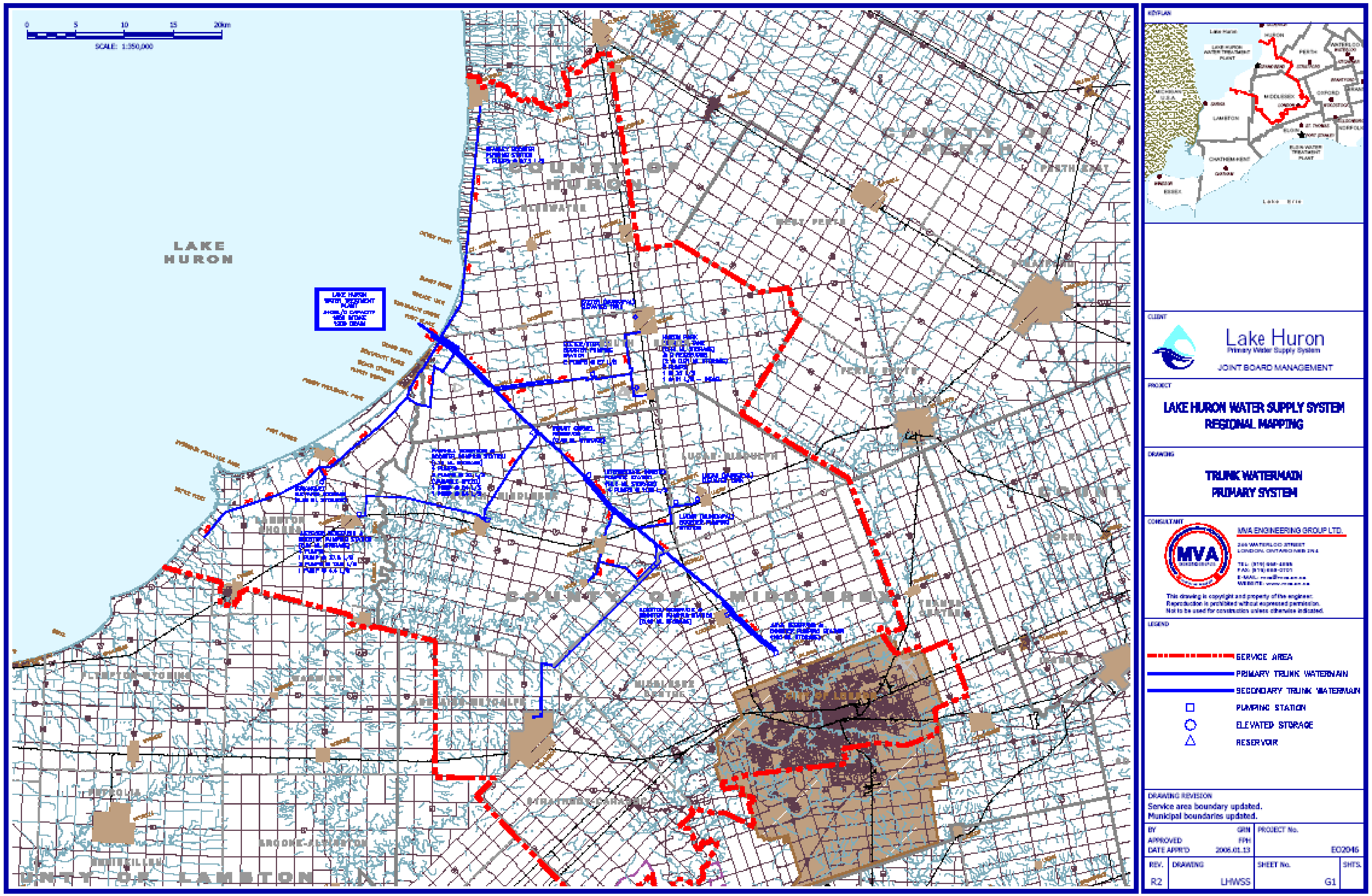

Figure 1-5: Lake Huron Water Supply Systems Map of Lake Huron pipeline serving the City of London and other areas of southwestern Ontario

1.6.3.2 Recreational Water Use

Recreation along Lake Huron is a major component of the planning region's economy and depends on good water quality for the highly popular beach use. In 1992, 750,000 people visited Pinery and Ipperwash Provincial Parks; on holiday weekends beaches are extremely busy (Hocking 1992). Point Farms Provincial Park is on the shore north of Goderich. Cottages line much of the region's shoreline and are interspersed with several private campgrounds. The larger harbours house marinas. Summer multiplies the population of the shoreline area and communities.

Inland recreational uses of water in the planning area include fishing, canoeing, and swimming. Picnic areas, campgrounds and trailer parks are associated with rivers and reservoirs (see Table 1-11, the list may not be comprehensive). Golf courses require water for irrigation. Huron County golf courses use about 240,000 m^3 of water/year (International Water Consultants et al. 2003).

Table 1-11: Trailer parks and campgrounds in the Ausable Bayfield Maitland Valley Region

Watershed	Campground/Trailer Park	Open*	Number of Sites	Sewage
Ausable	Birch Bark Tent & Trailer Park		148	Sewer outlet Dump station
	Elliott Park	Y	10 transient	No septics
	Great Canadian Hideaway	Y	215	
	Green Haven Trailer Park		130	Sewer outlets Dump station
	Harbour Side Family Trailer		170	Sewer outlets
	Klondyke Trailer Park		450	Sewer outlets Dump stations
	Pinehurst Trailer Park		193	Sewer outlets Dump station
	Pinery Provincial Park	Y	1000 campsites	Dump station Flush toilets
	Riverside Trailer Park		11	Sewer outlets Dump station
	Rock Glen Resort		200	Sewer outlets Dump station
	Rus-Ton Family Campground		242	Sewer outlets Dump station
	The Dunes Oakridge Park Ltd.		240	Dump station
Bayfield	Bluewater Golf Course and Campground	S	155 seasonal	Sewer outlets Dump station Flush toilets
	Wildwood by the River	Y	8 transient 270 permanent	Sewer outlets Flush toilets
Maitland	Auburn Riverside Retreat	S	65 transient 35 seasonal	Sewer outlets Flush toilets
	Blyth Recreation Campground	S	500 transient	No septics
	Falls Reserve Conservation	S	120 transient	Dump station

	Area		67 seasonal	Flush toilets
	Family Paradise Campground	S	55 transient 120 seasonal	Sewer outlets Dump station Flush toilets
	Pine Echo Camp	S	18 transient 145 seasonal	Sewer outlets Dump station Flush toilets
	Shelter Valley	S	28 transient 144 seasonal	Dump station
	Wawanosh Park Conservation Area	S	50 seasonal	Dump station No septics
	Wingham Trailer Park	S	30 transient 15 seasonal	Sewer outlets Dump station Flush toilets
Nine Mile	Happy Hollow	S	10 transient 90 seasonal	Sewer outlets Dump station Flush toilets
	Riverside Park	Y	10 transient 95 seasonal	
Shoreline Gullies and Streams	Birch Bark Tent and Trailer Park	S	20 transient 80 seasonal	Sewer outlets Dump station Flush toilets
	Kitchigami Family Campground	S	13 transient 77 seasonal	Sewer outlets Flush toilets
	Lake Huron Resort	S	125 transient 100 seasonal	Sewer Outlets Dump Station Flush toilets
	MacKenzie Tent and Trailer Park	S	30 transient 90 seasonal	Sewer Outlets Dump Station Flush toilets
	The Old Homestead	S	40 transient 210 seasonal	Sewer outlets Dump station Flush toilets
	Paul Bunyan Trailer Camp	Y	7 transient 375 seasonal/year round	Sewer Outlets Flush toilets
	Pine Lake Campground	Y	10 transient 429 seasonal	Sewer outlets Dump station Flush toilets
	Point Farms Provincial Park	S	216 transient	Dump Station Flush toilets
	Princess Huron Lakefront Trailer Park Resort	Y	10 transient 80 seasonal	Sewer outlets Flush toilets

Sources: Sarnia & Lambton County 2006 Travel Guide; 2006 Huron County Vacation Guide.
*S=Seasonal; Y=Year Round

Millponds, left over from the days of early settlement, are also an important part of recreation. They provide swimming areas to residents, as do decommissioned water-filled gravel pits (Rush

2003). Millponds also perform important ecological uses such as wildlife habitat, providing flow to streams in drier conditions, limiting flood control and being a source for groundwater recharge (Rush 2003).

1.6.3.3 Ecological Water Use

All ecosystems rely on water. Lake, river, stream, pond and wetland systems are particularly dependent.

Lake Huron is one of the biggest fresh water ecosystems in the world. Inland, the planning region has very little natural ponding; Lakelet Lake in North Maitland is the largest, well-buffered by forest. Several small millponds remain. Low summer stream flow prompted construction of reservoirs near Exeter and Parkhill. These lakes offer permanent habitat although their quality suffers from upstream agricultural inputs.

Groundwater from the surface overburden layer is critical to several important ecosystems. Groundwater provides cold water fish habitat, maintains wetlands, sustains base flow that supports aquatic habitat during droughts and contributes clear water to dilute pollution.

Stream habitat quality in the planning region generally improves from south to north. Physiography drives much of this trend; streams flowing through kames and spillways have much more access to the permanent and cold flows from near-surface groundwater aquifers than do streams on clay plains. Kames and spillways are also lower capability agricultural land than clay plains and support more forest, a form of natural infrastructure that protects water quality and quantity. Like forest, wetlands too are much more numerous towards the north, maintained by near-surface groundwater discharge and surface inflows. They both rely on water and protect it.

The Ausable River, located on the northern fringe of the Carolinian Zone, supports unique aquatic biota and is one of the most biologically diverse basins of its size in Canada (Veliz 2005). The aquatic community of the Ausable River includes 14 species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

1.6.3.4 Agricultural Water Use

Rainfall is essential to crops. For other water needs, agriculture in the planning region relies largely on groundwater and use by livestock operations is by far the greatest. Livestock operations use water for drinking, washing and cooling livestock, rinsing barns, mixing and spraying of pesticides or herbicides and for washing equipment. In Huron County's case, livestock use 4.8 million m^3 per year of which approximately 3 million m^3 is groundwater. Livestock use overshadows all others in Middlesex municipalities in the planning region. Huron County irrigation uses 1.2 million uses m^3 per year of which about 0.8 million m^3 is from groundwater. Surface water is used for irrigation in Black Creek sub-watershed near the Hay Swamp and in the Klondyke lagoon bed flats. Arkona area fruit operations require irrigation. Cattle – watering sometimes uses streams or dugouts. Streams and drains are outlets for tile drainage. Even in Lambton Shores where drinking water is largely supplied from Lake Huron and only 16% of the total water use is groundwater, groundwater provides two thirds of agriculture's water needs – largely for vegetable and fruit irrigation (Dillon Consulting and

Golder Associates 2004a). Greenhouse operations can use large volumes of groundwater. Exeter has seen recent greenhouse development and associated high groundwater use.

1.6.3.5 Industrial Water Use

Among industries, aggregate washing operations and Sifto Salt in Goderich use very large volumes of water, though the vast majority of this water is returned through drainage and infiltration. Food processing plants and golf course operations can also be large users. In Huron County, industry accounts for 37% of groundwater use most of which is aggregate washing. In the Perth portion of the planning region, the largest industrial user is Campbell Soup/Horizon Poultry in Listowel. The company uses five times the Perth portion's domestic use and exceeds the area's agricultural use. The two deep wells that the company owns provide 5,996 m^3 of water per day (Rush 2003).

1.7 Watershed monitoring strategies and programs

Water monitoring sites, both current and historical, are presented by type in Map 1-13. Table 1-12 summarizes current long-term monitoring by Conservation Authority.

Table 1-12: Long-term watershed monitoring programs within the Ausable Bayfield and Maitland Valley Conservation Authorities

Programs	ABCA	MVCA
Provincial Water Quality Network (monthly)	- started in 1960s - funding gap: 1996-2000 - 9 sites + 3 more in 2005	- started in 1960s - funding gap: 1996-1998 - 12 sites
Provincial Groundwater Monitoring Network- levels and water quality	- started in 2003 - 14 sites: 5 bedrock & 9 overburden	- started in 2003 - 11 sites
Stream Flows	- discontinuously by federal government since 1945 - CA started in 1982 with 4 sites - flood warning model started 1986	- discontinuously by federal government since 1945 - CA started in 1981 with 12 sites - flood warning model started 1981
Other monitoring	- 9 surface water sites by CA: started in 1982	- monitors snow bi-weekly at 17 sites

Sources: Malone 2003; ABCA 1985, 2004; Waterloo Hydrogeologic 2003b; Shaus, 1982; MFX Partners 2002

Monitoring data has also been collected throughout a number of shorter term programs. In 1981, following PLUARG's (Pollution from Land Use Activities Reference Group) recognition of the importance of agriculture to water quality, a survey of all farms in ABCA identified about 30% causing potential contamination from manure handling and storage. Over the next few years, several projects studied the problem in more detail and an awareness program was launched. A target sub-watershed program provided guidance on the effectiveness of remedial measures; from 1986 to 1993 the Desjardine Drain, upstream of Grand Bend (lower Parkhill watershed), provided data on water and effects of remedial measures (Hocking 1988, 1989, 1990 (with Schottroff), 1992, 1994, 1996). This study launched CURB, Clean Up Rural Beaches program. High bacteria concentrations were periodically closing popular downstream Lake Huron beaches. From 1991 to 1996 CURB was very active. In ABCA, CURB implemented more projects per unit area than in any of the 30 CURB jurisdictions and granted over $2.7 million on 811 project approvals. Although the bulk of the money went to manure handling improvements, repairs to domestic septic systems dominated project numbers as the importance of this contaminant source was realized. Monitoring included beaches and drains (Hocking 1988, 1989, 1990 (with Schottroff), 1992, 1994, 1996).

In the Maitland, surveys from 1986 to 1988 provided the basis for CURB plan. Modeling indicated that the three main sources of bacteria to Lake Huron beaches were faulty septic systems, winter spreading of manure and livestock access to watercourses. A target of 32% reduction in bacteria loads was set (Fuller and Foran 1989). Annual reports listed types of projects and bacterial concentrations at the beaches (e.g., Loeffler 1992). Maitland watershed had even more projects than ABCA. Like ABCA, septic systems received the most grants and manure storage the most funding but Maitland placed a higher emphasis on livestock-related projects (Loeffler 1999).

Following CURB, the next set of grants to assist Best Management Practices (BMPs) came through the Healthy Futures for Ontario program that was implemented on a CA/County basis. All programs are voluntary on the part of the landowners. It is not known how many landowners apply BMPs without grants nor the level of BMPs needed to reach target water quality levels. Grant levels have declined throughout the program.

Although County Health Units regularly monitor beaches for bacteria, their set schedule often missed the problem events (Hocking 1992, 1994, 1996). In a 1996/97 study, eight beaches and upstream drains were more intensively monitored to develop a rapid analysis method. Parkhill Reservoir exceeded the guidelines less often than any Lake Huron beach (Glaskin-Clay et al. 1996; EnviroMicrobial 1997).

Bonte-Gelok and Joy (1999) collected past water quality studies for Huron County and found them highly variable in parameters, timing and location of samples. Large amounts of historic data have been lost. Bonte-Gelok and Joy noted the number of water contaminant studies but were concerned about short spans and small extents. No comprehensive study of surface water contaminants had been done. Data were inadequate for correlations with potential contaminant causes and there was a lack of tracking of delivery from source to streams. They also questioned the small sample size that established the high estimate of faulty septic systems in the two Conservation Authorities.

Stream water quality in the planning region is dramatically worse during rain events but monitoring often misses the important but very sharp peak in concentrations. One solution is the use of aquatic macroinvertebrate indicators. Species reflect the stream's recent water quality history. Benthic monitoring began in 2000 (Malone 2003). ABCA alternates sampling headwaters and main channel stations on a bi-annual basis. Watershed report cards will use both benthic macro-invertebrates and water quality data (ABCA 2004).

Occasional short-term monitoring of water quality and aquatic biota results from events such as spills (Veliz 2005) or specific concerns. MOE's routine monthly water quality monitoring of the Maitland and Nine Mile Rivers found that concentrations of several heavy metals occasionally exceed Provincial Water Quality Objectives. A study sampling sediment, fish, crayfish and mussels, indicated the possibility of point sources in Listowel. The study also flagged PCB levels slightly above the International Joint Commission's aquatic life protection guidelines in fish at the river mouths but samples the following year fell below the guidelines (Zaranko 2001, 2003).

Golder Associates (2001) recommended sentinel well monitoring in Huron County. The 2002 results showed little seasonal variation and an annual sampling regime was recommended (Golder Associates 2003).

1.8 Water Quality

1.8.1 General Overview of Surface Water Quality

Form determines water quality and contaminant type. The upper lake location discouraged major settlement centres and the good soils encouraged agriculture – both row crops and livestock – to the point where the planning region rates the highest livestock and manure concentrations in Canada (Statistic Canada 2001). Contaminants are agricultural ones such as phosphorus, nitrates, sediment and bacteria. Pollutants associated with heavy industry are not a major problem.

Form also affects water volumes and resulting contaminant concentrations. The dominance of heavy textured soils – often poorly drained, cleared land and agricultural drains makes the whole region highly responsive to events. The main event is the spring thaw and associated rainfall. Flows peak in March and April and decline sharply the rest of the year. Smaller peaks follow storms at other seasons. Events flush high concentrations of accumulated sediments, nutrients and bacteria through the system to the lake.

Within this pattern, however, the variation in form across the region creates a north-south trend. The clay soil, poor drainage, drain density and lack of natural cover are all more prevalent in the south. Coarse-textured spillways and kames increase northward. Their lower agricultural capability encourages more natural cover and less built drainage. They support near-surface groundwater aquifers that discharge into the stream system. The result is a northward trend of increasing flows, decreasing concentrations but greater loadings. The stream water quality improves but the total amount of contaminants transported to the Lake Huron beaches increases; in effect, the travel time decreases. *E. coli* levels tend to increase downstream and at the northern beaches (Bonte-Gelok and Joy 1999; Hocking 1989).

The most productive clean cold water flow source is the major spillway splitting the Wyoming Moraine through the Bayfield, Lower Maitland and Nine Mile River watersheds. Streams through this feature (e.g., Trick's Creek, Sharpes Creek, Nine Mile River) are the most pristine of the planning region and the receiving waters of the lower Bayfield and lower Maitland Rivers benefit greatly from their input.

The form of the short shoreline gullies and streams determines their role. They represent the extreme of clay soils, drainage density and lack of natural cover in the planning region. They have additional factors. As streams carve down to lake level, gully erosion, a process encouraged by the intensive land use and tile drainage, increases sediment loads. Cottage density boosts septic system loading. The very short travel time to the shore limits in-course attenuation. Shore gullies are major contributors to shoreline contamination (Hocking 1989).

Non-agricultural sources of water contaminants can include snow dumps, landfills, food processing plants, industry, septic systems and golf courses. Although many sewage treatment plants have been upgraded, it is unknown whether older ones are causing contamination problems.

The major surface water contaminants of the planning region are:

Phosphorus: is a fertilizer which encourages algae growth. Once the algae die, they decompose, which consumes oxygen from the water. The reduced oxygen in the water can limit other aquatic organisms. Phosphorus is carried by sediment and originates from field erosion and faulty septic systems (Hocking 1989).

Nitrate: high levels can lead to blue-baby syndrome; after long exposure, adults can develop kidney and spleen problems (Statistics Canada 2001). Elevated nitrates can harm livestock and aquatic life. Nitrogen is a nutrient that encourages algae. Nitrates are highly soluble and can move into the shallow groundwater systems (MVCA 2000).

Sediment: it smothers stream life, blocking light and burying habitat. Non-point source field erosion is a major source.

Bacteria: *E. coli* does not affect stream life but is a risk to humans and livestock (MVCA 2000). Faulty septic systems and manure spreading are major sources (Hocking 1989).

Recent trends suggest phosphorus concentrations are decreasing, nitrates are rising, and fecal coliform is increasing in some areas (Bonte-Gelok and Joy 1999). In the last 20 years, Conservation Authority programs have raised farmer awareness of the issues; in 1984, many farmers were unaware of the severity of the problem (Balint 1984).

In an intensively used landscape such as the planning region, spills from agricultural and industrial operations are an on-going risk to streams and their biota.

Additional watershed-specific comments from the available reports are presented in Appendix C. Some reports are dated and many cover a limited area and time period. The most comprehensive report is the Bonte-Gelok and Joy (1999) survey of Huron County data.

1.8.2 General Overview of Groundwater Quality

The county groundwater study reports (Huron: International Water Consultants et al. 2003; Lambton and Middlesex: Dillon and Golder, 2004 a & b; Wellington: Minto and North Wellington: Burnside, 2001 a&b; Bruce and Perth: Waterloo Hydrogeologic, 2003a,b) conclude that the bedrock aquifer is generally well protected by the depth and fine texture of the overburden. Overburden wells typically have lower total dissolved solids, hardness, sodium, sulphate and iron levels but higher concentrations of dissolved organic carbon, chloride and bacteria. They also show greater occurrence of volatile organic compounds, pesticides and total petroleum hydrocarbons, although only trace to low levels. Nitrates were more likely in overburden wells but were very rarely above Ontario Drinking Water Standards (Golder 2001). The Provincial Groundwater Monitoring Network results indicate no concerns with pesticides, herbicides, fungicides, hydrocarbons or nitrate. The land use has not yet had any influence on the quality; only natural parameters like fluoride, hardness and iron are noted. Huron East is unique in adding uranium. Seaforth and Egmondville well water showed naturally elevated levels of radium-226, an element that can be removed with a water softener (Golder 2000). Singer et al. (1997) found many samples of poor natural water quality in all the bedrock units that are within the planning region. Commonly exceeded Provincial Drinking Water Objectives are total dissolved solids, sulphate and iron. The Hamilton Formation showed the highest proportion of instances for the whole set. Iron was often exceeded in all formations.

Caveats on the water quality assessments include the short data record, the lengthy residence time of contaminants in the overburden before they reach the bedrock, and the possibility of problems at private wells because of poor wellhead management (MVCA 2004). Chloride and sodium levels approach Ontario Drinking Water Standards aesthetic limit in the Thedford-Port Franks area groundwater (Dillon Consulting and Golder Associates 2004a). Areas with poorer well water quality (e.g., Stephen Township and Lambton County) are largely supplied with piped Lake Huron water. The 2002 results of sentinel well sampling program show little seasonal variation (Golder 2003).

Short circuits can directly and quickly contaminate aquifers. Access points potentially include sinkholes (see Map 1-5), non-commissioned wells, and rivers that have chiselled down to bedrock (e.g., lower sections of the Ausable, Bayfield and Maitland). The biggest threats of groundwater contamination are from agriculture (e.g., fertilizer or manure application near wells), road salt, landfills and hydrocarbon (fuel) storage (MVCA 2004). Depending on overburden depths and textures, improperly functioning or high density septic systems can contaminate groundwater (International Water Consultants et al. 2003).

Several township reports indicate that municipal wells could be susceptible to surface activities. All reports agree that shallow overburden aquifers – important contributors to streams and wetlands - are more sensitive than the bedrock aquifers.

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Appendix A: Climate Normals (1971-2000) Measures at Long-Term AES Stations in the Ausable Bayfield-Maitland Planning Region

CLIMATE STATION	CLIMATE STATISTIC	MONTH												
		JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**Annual**
Blyth	**Temperature**													
(6120819)	Daily Average (°C)	-7.5	-6.7	-1.7	5.5	12.3	17.3	20.2	19.1	15.1	8.8	2.7	-3.6	**6.8**
1971-2000	Standard Deviation	3.3	3.5	2.6	2.1	2.2	1.7	1.4	1.8	1.3	1.9	1.9	3.1	**1.3**
	Daily Maximum (°C)	-4.1	-2.9	2.5	10.1	17.9	22.9	25.9	24.6	20.1	13	5.8	-0.6	**11.3**
	Daily Minimum (°C)	-10.8	-10.5	-5.9	0.8	6.7	11.7	14.5	13.6	10	4.5	-0.5	-6.5	**2.3**
	Precipitation													
	Rainfall (mm)	24.9	22.9	39.1	68.4	89.8	85.1	72.7	105.9	115.4	89.2	80.7	40	**834**
	Snowfall (cm)	102.9	55.9	33.9	13.4	0.4	0	0	0	0	3.6	40.5	99.8	**350.4**
	Precipitation (mm)	127.8	78.8	73	81.8	90.2	85.1	72.7	105.9	115.4	92.8	121.2	139.8	**1184.3**
Brucefield	**Temperature**													
(6121025)	Daily Average (°C)	-6.4	-6.3	-1	6.2	12.6	17.2	19.6	19	14.9	9	3.2	-3	**6.8**
1971-1993	Standard Deviation	2.8	2.9	2.4	1.9	2	1.5	1.1	1.2	1.1	1.8	1.4	2.6	**1.3**
	Daily Maximum (°C)	-2.6	-2	3.5	11.4	18.9	23.4	25.8	24.9	20.4	13.6	6.6	0.2	**11.3**
	Daily Minimum (°C)	-10.1	-10.6	-5.6	1.1	6.4	10.9	13.4	13	9.4	4.3	-0.3	-6.2	**2.3**
	Precipitation													
	Rainfall (mm)	21.1	23.8	51.1	69.9	76.5	70.5	77	88.6	106.4	93	85.4	41.3	**804.6**
	Snowfall (cm)	66	39.4	23.5	4.8	0.1	0	0	0	0	1.3	19.1	47.4	**201.6**
	Precipitation (mm)	87	63.2	73.4	74.7	76.6	70.5	77	88.6	106.4	94.3	104.5	88.6	**1004.8**
Cromarty	**Temperature**													
(6141919)	Daily Average (°C)	-7.3	-6.9	-1.4	5.9	12.7	17.2	19.8	18.9	14.9	8.5	2.5	-4	**6.7**
1971-1991	Standard Deviation	3	3.2	2.7	2	2.3	1.5	1.2	1.4	1.3	2.1	1.8	2.9	**2.1**
	Daily Maximum (°C)	-4	-3.1	2.6	10.6	18.4	22.9	25.8	24.6	20.1	12.9	5.5	-1	**11.3**
	Daily Minimum (°C)	-10.7	-10.7	-5.4	1.2	7	11.4	13.8	13.1	9.5	4.1	-0.7	-7	**2.1**
	Precipitation													
	Rainfall (mm)	19.6	24	53.8	66	75.4	72.2	77.4	90.1	111.4	90.7	79.2	45.6	**805.5**
	Snowfall (cm)	84	54	33.8	12.7	0.6	0	0	0	0	3.7	30.3	71.6	**290.8**
	Precipitation (mm)	103.6	78	87.5	78.8	76	72.2	77.4	90.1	111.4	94.5	109.6	117.2	**1096.3**
Dashwood	**Temperature**													
-6121969	Daily Average (°C)	-5.6	-4.9	0.1	6.7	13.3	18.3	20.5	19.7	16	9.5	3.5	-2.5	**7.9**
1976 - 2000	Standard Deviation	2.8	3.1	2.4	1.7	2.1	1.6	1.3	1.3	0.9	1.6	1.6	2.8	**1.8**
	Daily Maximum (°C)	-2.5	-1.4	4	11.1	18.6	23.5	25.7	24.7	20.8	13.6	6.5	0.4	**12.1**
	Daily Minimum (°C)	-8.7	-8.3	-3.8	2.2	7.9	12.9	15.3	14.6	11.1	5.4	0.4	-5.3	**3.6**
	Precipitation													
	Rainfall (mm)	23.1	25.3	42.4	75.2	78.5	76.8	85.5	81.9	118.8	84.1	76.4	43	**811.1**
	Snowfall (cm)	49.4	32.6	19.4	4.6	0	0	0	0	0	1.3	18.3	48.5	**174.1**
	Precipitation (mm)	72.5	57.9	61.9	79.9	78.5	76.8	85.5	81.9	118.8	85.4	94.6	91.5	**985.2**
Exeter	**Temperature**													
(6122370)	Daily Average (°C)	-6	-5.7	-0.5	6.2	12.9	18	20.4	19.5	15.3	9.1	3.1	-2.9	**7.5**
1971 - 2000	Standard Deviation	2.7	2.9	2.5	1.8	2.1	1.5	1.2	1.3	1.2	1.7	1.6	2.7	**1**

	Daily Maximum (°C)	-2.4	-1.8	3.7	11	18.6	23.6	25.8	24.7	20.5	13.6	6.5	0.4	**12**
	Daily Minimum (°C)	-9.6	-9.7	-4.7	1.3	7.2	12.3	14.9	14.1	10.1	4.6	-0.3	-6.2	**2.8**
	Precipitation													
	Rainfall (mm)	25.9	20.7	43.4	73.5	77.3	77.7	84.9	85.7	114.5	84.8	74.9	42.8	**805.8**
	Snowfall (cm)	54.5	32.2	22.5	6	0.1	0	0	0	0	1.8	17.3	48.2	**182.7**
	Precipitation (mm)	80.4	53	65.9	79.5	77.4	77.7	84.9	85.7	114.5	86.5	92.1	91	**988.5**
Ilderton Bear Creek	**Temperature**													
(6143722)	Daily Average (°C)	-6	-5.1	0.2	7	13.6	18.7	21.1	20	16.1	9.7	3.4	-2.8	**8**
1971 - 2000	Standard Deviation	2.9	2.8	2.3	1.7	2.2	1.4	1.1	1.2	1.1	1.7	1.7	2.8	**2**
	Daily Maximum (°C)	-2.4	-1.2	4.4	12	19.4	24.6	27	25.7	21.3	14.3	6.8	0.4	**12.7**
	Daily Minimum (°C)	-9.5	-8.9	-4	1.9	7.6	12.8	15.1	14.3	10.7	5.1	0	-6	**3.3**
	Precipitation													
	Rainfall (mm)	28.2	27.1	51.5	79.1	87.6	85.4	82.3	96.1	97.5	74.7	76.1	43.8	**829.4**
	Snowfall (cm)	50.6	34.4	23.4	6.2	0	0	0	0	0	2.2	17.8	51.5	**186.1**
	Precipitation (mm)	78.8	61.5	74.9	85.3	87.6	85.4	82.3	96.1	97.5	76.9	93.8	95.4	**1015.5**
Lucknow	**Temperature**													
(6124700)	Daily Average (°C)	-6.7	-6.6	-1.7	5.7	12.3	16.8	19.5	18.8	14.6	8.5	2.7	-3.4	**6.7**
1971 - 1993	Standard Deviation	2.5	2.7	2.3	1.9	2	1.5	1.2	1.3	1.1	1.8	1.4	2.4	**1**
	Daily Maximum (°C)	-2.9	-2.1	3.2	11.2	18.9	23.2	25.7	24.6	20.1	13.2	6.2	0	**11.8**
	Daily Minimum (°C)	-10.5	-10.9	-6.5	0.2	5.8	10.4	13.2	13	9	3.7	-0.8	-6.7	**1.7**
	Precipitation													
	Rainfall (mm)	15.9	15.2	38.5	64	79	82.2	69.5	99.4	109.6	94.4	79.9	34.5	**781.9**
	Snowfall (cm)	111.2	67.6	32.8	11.4	0.3	0	0	0	0	3	26	86.6	**338.9**
	Precipitation (mm)	127.1	82.8	71.3	75.5	79.3	82.2	69.5	99.4	109.6	97.3	105.9	121.1	**1120.9**
Wroxeter	**Temperature**													
(6129660)	Daily Average (°C)	Temperature data not collected												
1971 - 2000	Standard Deviation													
	Daily Maximum (°C)													
	Daily Minimum (°C)													
	Precipitation													
	Rainfall (mm)	20.4	19	38.9	59.7	86.7	85.3	77.2	99.1	99.3	77.7	68.8	34	**766.1**
	Snowfall (cm)	64.6	36.8	23.6	6.2	0	0	0	0	0	1.1	23.7	54.8	**210.8**
	Precipitation (mm)	85	55.8	62.5	65.9	86.7	85.3	77.2	99.1	99.3	78.8	92.4	88.9	**976.9**

Source: Environment Canada's World Wide Web Site. Url of this page : http://www.climate.weatheroffice.ec.gc.ca/climate_normals/

Appendix B: Municipal Restructuring of the six counties within the source protection planning region (Ontario Ministry of Municipal Affairs and Housing 2006).

COUNTY	DATE OF OFFICIAL PLAN	PARTY MUNICIPALITIES	NEW MUNICIPAL NAME	NUMBER OF MUNICIPALITIES		DATE OF OFFICIAL PLAN	DATE OF ZONING BY-LAW
				BEFORE	AFTER		
Bruce	1997	county restructuring: (County plus 8 lower tier mun.) St. Edmunds, Twp/Lindsay, Twp./Eastnor, Twp./Lion's Head Vg. Amalgamation	Municipality of Northern Bruce Peninsula (Name change Gazetted Jan16/99)	28	9	county	2002
		Albemarle, Twp./Amabel, Twp./Wiarton, Town/ Hepworth, Vg. Amalgamation	Town of South Bruce Peninsula (Name change Gazetted Jan16/99)			2001	
		Arran, Twp./Elderslie, Twp./Chesley, Town/Tara Vg./ Paisley, Vg. Amalgamation	Municipality of Arran-Elderslie (Name change Gazetted Jan16/99)			urban-2004 rural-county	Chesley-1982 Elderslie-1984 Paisley-1982 Tara-1981 Arran-1994
		Greenock, Twp./Brant Twp./Walkerton Town - Amalgamation	Municipality of Brockton (Name change Gazetted Jan16/99)			county	Brant-1981 Greenock-1998 Walkerton-1992
		Mildmay-Carrick, Twp./Teeswater-Culross, Twp.- Amalgamation	Municipality of South Bruce (Name change Gazetted Jan16/99)			2004	Carrick-1985 Culross-1985
		Saugeen, Twp./Southampton,Town/Port Elgin, Town - Amalgamation	Town of Saugeen Shores (Name change Gazetted Jan16/99)			2000	2000
		Huron, Twp./Kinloss, Twp./Lucknow, Vg. - Amalgamation	Township of Huron-Kinloss			1999	2006 (draft)
		Bruce, Twp./Kincardine Twp./Kincardine, Town - Amalgamation	Municipality of Kincardine (Dec 22/99)			2006	2003
Huron	1997 (draft)	Stephen, Twp/Usborne, Twp/Exeter, Twn - Amalgamation	Municipality of South Huron	3	1	2003	2006 (draft)
		Goderich, Twp/Hullett, Twp/Clinton, Town - Amalgamation	Municipality of Central Huron	3	1	2003	Clinton-1985 Hullett-1987 Goderich-1984
		Hay, Twp/Stanley, Twp/Bayfield, Village/ Hensall V./Zurich, Village - Amalgamation	Municipality of Bluewater	5	1	2005	Hay-1987 Stanley-1985 Hensall 1987 Bayfield-1991 Zurich 1988
		Ashfield, Twp/West Wawanosh, Twp/Colborne, Twp - Amalgamation	Township of Ashfield-Colborne-Wawanosh	3	1	2003	2006 (draft)

		Morris, Twp/Turnberry, Twp - Amalgamation	Municipality of Morris-Turnberry	2	1	2006 (draft)	Turnberry-1987
		Brussels, V/Grey, Twp/McKillop Twp/Seaforth, Twn/ Tuckersmith, Twp - Amalgamation	Municipality of Huron East	5	1	2003 (draft)	2006
		Wingham, Twn/Blyth, V/East Wawanosh, Twp - Amalgamation	Township of North Huron	3	1	2004	Wingham-1992 Blyth-1991 E.Wawanosh-1987
Lambton	1998	Watford, Village/Warwick, Township - Amalgamation	Township of Warwick	2	1	1999	2000
		Dawn, Township/Euphemia, Township - Amalgamation	Township of Dawn-Euphemia	2	1	county	2002
		Arkona, Village/Bosanquet, Town/Forest, Town/Grand Bend, Village/Thedford, Village - amalgamation & annexation of part of Plympton, Township/Warwick, Township	Municipality of North Lambton (Amending Order - Gazetted June 26/99) (Amending Order - Gazetted Jul 01/00 Municipality of Lambton Shores (Name change)	5	1	2001	2003
		Brooke , Township/Alvinston, Village - Amalgamation	Municipality of the Township of Brooke - Alvinston (Amending Order - Gazetted Oct 2/99)	2	1	2000	2000
		Plympton, Township/Wyoming, Village - Amalgamation	Town of Plympton-Wyoming	2	1	2001	2003
		Petrolia, Town/Enniskillen, Township - Annexation	No Change			1999	2000
		Sombra, Twp/Moore, Twp - Amalgamation	Township of St. Clair	2	1	2003	2003
Middlesex	2006	Lobo, Township/London, Township/Delaware, - Township - Amalgamation	Municipality of of Middlesex Centre	3	1	2000	2005
		Lucan, Village/Biddulph, Township Amalgamation	Township of Lucan Biddulph	2	1	2003	2005
		Strathroy, Town/Caradoc, Township - Amalgamation	Municipality of Strathroy-Caradoc	2	1	2002 (draft)	Strathroy-1977 Caradoc-1987
		McGillivray, Twp/East Williams, Twp/West Williams, Twp, Parkhill Town/Ailsa Craig, V. - Amalgamation	Municipality of North Middlesex	5	1	2004	2004
		Adelaide, Township/Metcalfe, Township - Amalgamation	Township of Adelaide Metcalfe	2	1	2003	Adelaide-1997 Metcalfe-1994
		North Dorchester, Township/West Nissouri, Township - Amalgamation	Municipality of Thames Centre	2	1	2004	2006

		Ekfrid, Township/Mosa, Township/Glencoe, Village/Wardsville, Village - Amalgamation	Municipality of Southwest Middlesex	4	1	2007 (draft)	
Perth	1997	Logan, Township/Hibbert, Township/Fullarton, - Township/Mitchell, Town - Amalgamation	Township of West Perth Municipality of West Perth (name change) Effective December 20/00	15	5	1996	1999
		Wallace, Township/Elma, Township/Listowel, Town - Amalgamation	Town of North Perth			Listowel-1998 county	1999
		Mornington, Township/Ellice, Township/ North Easthope/South Easthope, Township/Milverton, - Village - Amalgamation	Township of Perth East			Milverton county	1999
		Downie, Township/Blanshard, Township - Amalgamation	Township of Perth south			county	1999
Wellington	1999	Erin, Township/Erin, Village - Amalgamation	Town of Erin	2	1	2004	2002
		Drayton, Village/Peel, Township - Amalgamation	Township of Mapleton	2	1	county	2000
		Two tier System (County plus 7 lower tier municipalities)		21	9	county	2001
		Palmerston,Town/Harriston,Town/Minto Township/ Clifford, Village - Amalgamation	Town of Minto				
		Mount Forest, Town/Arthur, Village/Arthur, Township/ West Luther, Township/Pt of Mapleton, Township/Pt of West Garafraxa - Amalgamation	Township of Wellington North (Name change Gazetted April 17/99)			1999	2001
		Fergus, Town/Elora, Village/Pt of West Garafraxa, Township/Pt of Nichol, Township/Pt of Pilkington Township, Pt of Eramosa Twp - Amalgamation	Township of Centre Wellington			2004	Elora-1995 Fergus-1995 W. Garafaxa-1984 Eramosa-1997 Nichol-1988 Pilkington-1996
		Guelph, Township/Pt of Eramosa, Township, Pt of Puslinch, Township - Amalgamation	Township of Guelph/Eramosa			county	1999
		Mapleton, Township/Maryborough, Township, Pt of Pilkington, Twp. Pt of Nichol Twp - Amalgamation	Township of Mapleton			county	2000

Appendix C: Watershed-Specific Summary of Surface Water Quality from Available Documents

Ausable

The trend within the Ausable watershed follows the planning region's north-south pattern of poorer quality to the south (Balint 1983; Schaus 1982; Snell and Cecile et al. 1995). An exception is The Pinery's Old Ausable Channel. Engineering benefited this reach by cutting it off from the polluted river systems and restricting its inputs to clean groundwater through the sands.

Water-taking in the Ausable can exacerbate the already low flows and increase contaminant concentrations.

'The Cut' has erosion problems from boat wakes, flooding and the non-natural design. Dredging creates fisheries concerns (Snell and Cecile et al. 1995).

Shallow beaches at Ipperwash and Port Franks suffer more bacterial problems than Grand Bend and the Pinery (Glaskin-Clay et al, 1996). Lake water has less chance to mix; again form is a factor.

Bonte-Gelok and Joy (1999) studied Huron County surface water quality and rated the Ausable High for fecal coliform concentrations and loadings; Moderate for nitrate concentration and loading; High for phosphorus concentrations, Moderate for loadings. It had poor water quality compared to the northern basins.

An example of a recent spill was an April 2005 discharge of 5000 L of chlorine into the river below Exeter. Over 20,000 fish died in the 5 km affected reach (Veliz 2005).

Parkhill

Parkhill's water quality is poor (Schaus 1982; Snell and Cecile et al. 1995; Bonte-Gelok and Joy 1999). Agriculture is the main contaminant source; clay soils, poorly drained soils, agricultural drainage, faulty septic systems, erosion and manure are all contributing factors (Balint and Thomas 1983; Ryan 1987). Parkhill Reservoir has a high sedimentation rate and problems of warm temperatures, bacteria, algae, carp and turbidity (ABCA 1979). A more extensive forest cover in Ptsebe Creek's watershed benefits that tributary. But high drainage density there and in the lower Parkhill tributaries off the Lake Warren Plain, encourages contaminant delivery.

Besides agriculture, potential contamination sources include the sewage treatment plants at Parkhill and Grand Bend and a landfill on the glacial lake beach.

Studies of effects of remedial measures in Desjardine Drain showed some improvement (Griffiths 1988, 1989), sometimes masked by other inputs (Hocking 1996). Long bacterial survival and growing antibiotic resistance combine with short travel times to continue concerns at downstream beaches.

Bayfield

The upper Bayfield resembles the Ausable in form and land use and suffers similar high levels of contamination and very low summer flows. The watershed's main distinction from the Ausable is a major spillway that adds a cold, clean, permanent base flow to the lower river via Trick's Creek and, to a lesser extent, via Bannockburn Creek. The input greatly improves the water quality of the lower Bayfield water quality over that of the upper reaches but also transports contaminant loads to the shore.

Besides agriculture, potential contaminant sources include faulty septic systems, sewage treatment plants (Clinton, Seaforth, Vanastra, Huronview) and landfills on permeable bases or valley brows.

Bonte-Gelok and Joy (1999) in their ratings for Huron County rate Bayfield High for fecal coliform concentrations and loadings; High for nitrate concentrations and loadings; Moderate for phosphorus concentrations and loadings.

Maitland River

Like the Bayfield, the downstream base flow contributions, led by those from the same spillway, help moderate upstream contaminant concentrations. The Maitland differs, however, in both its greater size and its extensive network of baseflow-contributing landforms and associated natural areas.

Like the Bayfield the main contaminant sources are septic system failure and manure (MVCA 1989). Effects are excessive algae, decreased oxygen, and degraded stream habitat and health threats. Since 1966, nitrate concentrations have increased to the point of harming aquatic life, while phosphorus levels have declined slightly (MVCA 2003).

South Maitland

The upper basin's clay plain generates high sediment and nutrient loads. Diking of the Hullett wetland has reduced its role as a filter and possible low flow contributor. The downstream kame probably contributes a small amount of base flow to the lower end. Bonte-Gelok and Joy (1999) in their study of Huron County rank South Maitland 'moderate' for fecal coliform concentrations and 'low' for loadings; 'high' for nitrate concentrations and 'moderate' for loadings; 'moderate' for phosphorus concentrations and loadings. Low flows give much of the river an impaired rating for ecosystem health (MVCA 2002). MVCA has targeted the watershed for water quality improvement (MVCA 2003).

Middle Maitland

In 1954, the Middle Maitland was dismissed as a "textbook example of the effects of dumping massive quantities of untreated sewage into an inadequate stream" (Department of Planning and Development 1954). Listowel was the obvious culprit; sources were both septic systems and industry. By 1967, many problems persisted (Conservation Authorities Branch 1967). The river became a priority for improvements. Today Listowel sewage treatment is much improved. But the same agricultural issues as in southern basins apply, especially after rain events. The upper parts of the Middle Maitland have the wet clay plains and extensive drainage that encourage delivery of contaminants to the streams. On-going projects with community partners are improving the situation. Projects include riparian plantings and a constructed wetland (MVCA 2003). Phosphorus concentrations have declined over the last 3 decades but still encourage excessive algae. Nitrates have increased; all sample sites were elevated beyond the health of stream life and livestock. *E. coli* levels showed no trends but jumped sharply after storms, often exceeding swimming guidelines (Middle Maitland Initiative 2000).

Bonte-Gelok and Joy (1999) in their Huron County study rated Middle Maitland 'moderate' for fecal coliform concentrations and loadings; 'moderate' for nitrate concentrations and 'high' for loadings; and 'high' for phosphorus concentrations and loadings.

Little Maitland

Little Maitland shows the moderation effects of the spillway network and slightly lighter soils. Bonte-Gelok and Joy (1999) rate Little Maitland 'low' for fecal coliform concentrations and loadings; 'moderate' for nitrate concentrations and 'low' for loadings; and 'low' for phosphorus concentrations and loadings. MVCA has targeted the area for water quality improvement (MVCA 2003).

North Maitland

Natural conditions in the North Maitland River support good water quality and healthy aquatic ecosystems (MFX Partners 2002). Sewage treatment at upstream towns improved the urban inputs. Agricultural inputs are diluted by baseflow contributions from the spillway network and kames, lighter soils, relatively extensive natural areas. The results are a rating of 'moderate' for fecal coliform concentrations and loadings; 'low' for nitrate concentrations and loadings; and 'low' for phosphorus concentrations and loadings (Bonte-Gelok and Joy 1999). Long-term trends are steady to decreasing phosphorus levels but rising nitrate concentrations. Loads increase during rainfall events (MFX Partners 2002).

Lower Maitland

The Lower Maitland collects all the flow from the above tributaries and adds its own. The watershed's natural conditions support good water quality and healthy aquatic ecosystems (MFX Partners 2002). Blyth Brook, like the upstream contributions, carries elevated phosphorus, nitrates and *E. coli* (Total Approach Initiative, 2000). But Sharpes Creek and likely, to a smaller extent, Hopkins Creek, pour cold permanent base flow into the Lower Maitland from the same major spillway that benefits the lower Bayfield.

The outcome is improved quality in the Lower Maitland while delivering the upstream loads to the lake. Bonte-Gelok and Joy (1999) rank Lower Maitland Low for concentrations of each of fecal coliform, nitrate and phosphorus, but 'high' for all their loadings. Long-term trends are steady to decreasing phosphorus levels but rising nitrate concentrations. As elsewhere, rainfall events carry the highest loads (MFX Partners 2002).

The 1967 Report (Conservation Authorities Branch 1967) notes some salt plant effluent near the mouth.

Nine Mile

The same spillway that feeds Sharpes Creek extends into Nine Mile River. That spillway and kame headwaters contribute baseflow to the creek. Natural area buffers help keep it cool and clean. The result is Nine Mile River is in good condition, meeting both nitrate and phosphorus targets (MVCA 2003). Bonte-Gelok and Joy (1999) rate Nine Mile River's nitrates and fecal coliforms 'low' for both concentrations and loadings.

Shore Gullies and Streams

The combination of heavy clay soils, gully erosion, numbers of septic systems and lack of natural cover all contribute to high contaminant concentrations. The short length and high drainage density efficiently delivers them to the lake. Bonte-Gelok and Joy (1999) rate Gullies south of Bayfield High for each of fecal coliform concentrations, nitrate concentrations and phosphorus concentrations.

Appendix D: Catalogue of Maps