Ausable Bayfield

Assessment Report

Amended March 26, 2024

Volume I – Text of Report

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DRINKING WATER SOURCE PROTECTION
Our Actions Matter

Ausable Bayfield
Maitland Valley
Source Protection Region

Ontario

Made possible through the funding support of the Government of Ontario

Assessment Report

Ausable Bayfield Source Protection Area

Summary of Report Approvals and Amendments

Version 1: Assessment Report, 2012

The initial findings and comments herein were approved by the Province of Ontario January 19, 2012. The Assessment Reports were prepared under the *Clean Water Act, 2006*; Ontario Regulation 287/07 – General; and the 2009 Technical Rules

Version 2: Updated Assessment Report, amended December 10, 2014

The Assessment Report was updated in 2014 to reflect threats verification work, revised mapping for consistency with the Source Protection Plan, and to address minor errors. The planned decommissioning of Carriage Lane and Harbour Lights systems was noted.

Version 3: Assessment Report, amended February 5, 2019

The Assessment Report for the Ausable Bayfield SPA was amended in 2019 under Section 34 of the *Clean Water Act, 2006* to include the following changes to well systems and to address minor errors:

- Add Varna Municipal Water Supply (formerly a non-municipal system)
- Remove Carriage Lane and Harbour Lights systems from the Assessment Report

A description of these water supply systems can be found in Chapter 4.

October 2023: The Assessment Report was updated under Section 51 of the *Clean Water Act, 2006* to remove the Zurich drinking water system

Version 4: Assessment Report, amended March 26, 2024

The Assessment Report and Source Protection Plan was amended March 26, 2024 under Section 36 of the *Clean Water Act, 2006*. Amendments were prepared using the 2021 Technical Rules. Sections of the Assessment Report that were not updated as part of this Section 36 amendment may refer to earlier versions of the Technical Rules.

The following provides a high-level summary of amendments:

Chapter 4:

- Removal of references to SGRA vulnerability scores
- Update risk assessment
- Reorganized maps and revised map numbers accordingly

Chapter 8: Outcomes

- Update section on threats and refer reader to Chapter 4 for details

Acknowledgements

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Note: In June 2014, the Ministry of Natural Resources (MNR) was renamed the Ministry of Natural Resources and Forestry (MNRF), and the Ministry of the Environment (MOE) was renamed the Ministry of the Environment and Climate Change (MOECC). In June 2018, the Ministry of the Environment and Climate Change (MOECC) was renamed the Ministry of the Environment, Conservation and Parks (MECP). The new and former names of both Ministries are used within this document.

AUSABLE BAYFIELD: CHAPTER 1

INTRODUCTION

TABLE OF CONTENTS

All the water that will ever be is, right now.

– *National Geographic*, October 1993

1.0 Introduction

Clean drinking water is essential to human health, the economy, and the environment. However, over the past decade there have been incidents, large and small, of drinking water contamination. This contamination results in illness, costly clean-up, public health actions, or expensive changes to drinking water systems. The drinking water tragedy which occurred in Walkerton in 2000 was a turning point in the Ontario approach to drinking water safety. As a result of the O'Connor Report from the Walkerton Inquiry, the Province of Ontario developed a program for protecting drinking water sources as part of a multi-barrier approach for clean safe drinking water. Protection of water at the source is the first barrier in the multi-barrier approach. That approach also includes barriers such as training, treatment, testing, and distribution.

Among many other actions, the Province passed the *Clean Water Act* in 2006. *The Clean Water Act, 2006* provides the legislative framework for drinking water source protection planning in Ontario. The intent of the Act is to ensure that Ontario's drinking water is safeguarded from contamination or depletion. To bring this about, the *Act* established source protection committees across the settled parts of the Province. The Source Protection Committee is required to complete three tasks, as outlined in the *Clean Water Act, 2006*:

- Write terms of reference to identify what work needs to be done and who is responsible to complete that work
- Compile assessment reports that bring together the science and technical information required to develop source protection plans
- Produce source protection plans that will outline measures necessary to reduce or eliminate the threats identified in the assessment report

The Ausable Bayfield Maitland Valley Drinking Water Source Protection Committee (SPC) issued formal Notice of Commencement of Source Protection Plan Policy Preparation in early 2011 to municipal administrators, First Nations, and to owners of properties where potential significant drinking water threats might exist.

The SPC provided notice on May 23, 2012 that drafts of proposed source protection plans were ready for public inspection and comment. The committee invited citizens to three public meetings, and one web and telephone conference, to review the drafts, ask questions, and make written comments. These public meetings took place in June of 2012.

The SPC approved Proposed Source Protection Plans on Tuesday, August 14, 2012. The Ausable Bayfield and Maitland Valley source protection authorities submitted the plans, along with public comments, to the Province of Ontario on Friday, August 17, 2012.

The committee provided notice on December 6, 2013 of revisions to Proposed Source Protection Plans. The source protection authorities submitted the revisions and the proposed plans to the Ontario Ministry of the Environment (MOE) following an advertised 46-day period of public comment beginning on December 6, 2013 and concluding on January 21, 2014.

The plans included polices that make use of implementation tools such as public education, incentives, municipal land use planning and bylaws, risk management plans and, in some cases, prohibition. They also included requirements for monitoring local progress on source protection. Municipalities are to be involved in implementing the source protection plans, in part through updates to their municipal official plans and zoning bylaws. The foundation for this plan is the assessment report, a science-based delineation of vulnerable areas and analysis of risks to drinking water sources.

1.1 Phases of Drinking Water Source Protection Planning

The source protection planning process is intended to continue over the long-term, similar to activities by the provincial government and municipalities under the Ontario *Planning Act*. Source protection is one component of watershed management, which involves the following steps: scientific research, planning, monitoring, and the evaluation of success. This Assessment Report is the culmination of five years of scientific research.

On the part of the Province, there has been a clear commitment to implement drinking water source protection planning immediately after the results of the O'Connor Inquiry were finalized. During the time that the Province was crafting the *Clean Water Act, 2006*, there was significant activity to prepare the way for source protection on a watershed basis:

- Expert panels were created to provide the government with technical and planning advice
- A white paper was written
- Funding was provided to conservation authorities to build capacity and put resources in place so that source waters could be protected
- Some of this capacity was built through ensuring the appropriate human resources existed locally within the conservation authorities
- Technical studies were undertaken to characterize the watersheds, understand the regional water budgets and gain a better understanding of municipal residential well fields

In 2007, the *Clean Water Act, 2006* was enacted. *Ontario Regulation 287/07* formalized the partnerships between Conservation Authorities to create 19 source protection regions. As well, it resulted in the creation of nineteen source protection committees charged with the preparation of terms of reference, assessment reports and source protection plans for their region or area. Chairs of these committees were provincially appointed and given a five-year time frame to complete the preparation of the documents. Committee members were locally appointed in keeping with the regulations.

Since the introduction of regulations in 2007, the Committee and staff have been ensuring that studies being prepared in support of the Assessment Report meet the regulation requirements. The results of these studies are the foundation for this report.

1.2 The Participants

Guiding the drinking water source protection process is the Source Protection Committee (SPC), which was established through the *Clean Water Act, 2006*. This Committee comprises a provincially-appointed Chair and local members representing a variety of viewpoints. The Committee not only works toward the identification of risks to drinking water, it also considers issues relating to water quality or quantity in vulnerable areas and implications to the Great Lakes in the context of the international agreements. The outcomes of this process are refined through an extensive consultation process. In the Ausable Bayfield Source Protection Area, the Source Protection Committee has benefitted by the input of seven local community working groups comprising stakeholders of various backgrounds. These working groups have been studying the science and regulated process for identifying risk. They considered many ideas pertaining to local water quality threats and provided feedback to the Source Protection Committee. In addition, each property within the two-year time-of-travel area, and 100-metre area, has been contacted by mail. The general public also had access to newspaper flyers, brochures, radio broadcasts, newsletter, and more.

Municipalities are key partners in the development and delivery of source protection planning. A municipal working group has provided insights to the Source Protection Committee throughout the development of the Assessment Report. In addition, the Chair and staff have made numerous presentations to municipal meetings, council meetings and had routine contact with the operators of municipal systems. **Appendix C** provides a synopsis of the consultation and meetings held to gather general comments and those specifically on the draft proposed Assessment Report for the Source Protection Committee to consider.

Municipalities included in the Ausable Bayfield Source Protection Area

- County of Lambton
    - Lambton Shores
    - Warwick
- County of Middlesex
    - Adelaide Metcalfe
    - Lucan Biddulph
    - Middlesex Centre
    - North Middlesex
- County of Huron
    - Bluewater
    - Central Huron
    - Huron East
    - South Huron

County of Perth
Perth South
West Perth

A number of other government ministries and bodies work closely with the SPC and staff to assist in the completion of the Assessment Report including:

Ontario Ministry of the Environment;
Ontario Ministry of Natural Resources;
Ontario Ministry of Municipal Affairs and Housing; and
Ontario Ministry of Agriculture, Food and Rural Affairs.

The local health units agreed that the Huron County Health Unit would be the primary contact for the SPC and have a liaison member attending the meetings.

Finally, the federal government has many interests in the source protection region. Environment Canada and Fisheries and Oceans Canada are federal organizations that have been or will be involved in the source protection planning process. As First Nations become involved, there may be interest from Indian and Northern Affairs Canada (INAC).

Adjacent source protection regions, specifically the Thames Sydenham Region, have been working cooperatively on the various aspects of the process to minimize discrepancies and work toward products that are compatible between regions.

1.3 Consultation Requirements

A fundamental principle for drinking water source protection is consultation with stakeholders. In addition to the stakeholder engagement described above, the SPC undertook a formal consultation on the draft proposed Assessment Report in accordance with the *Clean Water Act, 2006* and *Ontario Regulation 287/07*. A detailed description of the formal consultation is outlined below and examples of notices and letters can be found in **Appendix C**.

Formal consultation was initiated on January 5th, 2010 with a Draft Proposed Assessment Report being published on the Ausable Bayfield Maitland Valley Drinking Water Source Protection (ABMV DWSP) website (see **Appendix C** for an example of the Internet posting). In addition to the draft being posted on the Internet, copies of the Draft Proposed Assessment Report were made available at both the Maitland Valley and the Ausable Bayfield Conservation Authority administrative offices for public inspection on January 5th, 2010. A newspaper notice indicating the details of the consultation were placed in the following weekly publications and other media sources (an example of the notice can be found in **Appendix C**):

1. The Middlesex Banner
2. The Exeter Times-Advocate
3. The Lakeshore Advance

4. The Huron Expositor
5. The Clinton News-Record
6. The Parkhill Gazette
7. The Wingham Advance-Times
8. The Listowel Banner
9. The Minto Express
10. The Lucknow Sentinel
11. The Goderich Signal-Star
12. The North Huron Citizen
13. The Mitchell Advocate
14. The Citizen (Blyth)
15. The Focus News Magazine
16. The Rural Voice

Additionally a copy of the notice was sent for posting at each of the public libraries, and (where possible) at municipal offices located throughout the source protection region.

A letter, including the notice was sent by registered mail to: the Clerk of each municipality listed in the Terms of Reference, the Chief of Bands of First Nations, the Chair of all neighbouring SPCs, and every person established under the Great Lakes Water Quality Agreement (GLWQA), Lake-wide Management Plans (LaMPs), and Remedial Action Plans (RAPs). Examples of these letters, along with the mailing lists are included in **Appendix C**. A letter was also sent to every person engaging in activities that are or would be a significant drinking water threat listed in the Assessment Report (AR). An example of this letter is included in **Appendix C**.

Six public meetings were held (three in each SPA) on the Draft Proposed Assessment Reports in Bayfield (Thursday, January 21, 3-5 p.m. and 6-8 p.m.), Wingham (Wednesday, January 27, 3-6 p.m.), Blyth (Thursday, February 18, 4-6 p.m.), Zurich (Thursday, February 25, 3-6 p.m.), Grand Bend (Saturday, March 6, 10 a.m – noon, and 1-3 p.m.), and Palmerston (Saturday, March 6, 10 a.m – noon, and 1-3 p.m.). The meeting on March 6th was also presented as a webinar and teleconference to accommodate seasonal residents and others who could not attend in person.

The final step in the consultation process was to post the Proposed Assessment Report on the DWSP website and advertise that final comments could be forwarded to the Source Protection Authorities. This was done on May 4th, 2010. See **Appendix C** for an example of the Internet posting, notice, and sample letters sent to the Clerk of each municipality and the Chief of Bands of First Nations. Mailing lists for these groups are also in **Appendix C**.

1.4 Scope and Purpose of the Assessment Report

The main purpose of the Assessment Report is to prioritize drinking water issues and threats within the vulnerable areas that are described in Chapter 4. This information will assist the community, led by the Ausable Bayfield Maitland Valley Source Protection

Committee, to prepare the source protection plans. Drinking water threat activities, conditions and issues that are prioritized in this document will likely be the subject of extensive discussion during the development of the Plan.

The Assessment Report also serves as a summary of technical findings. For more detailed findings about a specific location, the reader is invited to reference the individual technical reports, each of which are listed in the References section and are held by the Ausable Bayfield and Maitland Valley Conservation Authorities at their respective administrative offices (Exeter and Wroxeter)

The *Clean Water Act, 2006* establishes the following minimum objectives for the Assessment Report:

a) Identify all the watersheds in the source protection area

b) Characterize the quality and quantity of water in each watershed

c) Set out a water budget for each watershed, which describes how water enters and leaves the watershed and describes the groundwater and surface water flows in the watershed and how water is used

d) Identify all significant groundwater recharge areas and highly vulnerable aquifers that are in the source protection area

e) Identify all surface water intake protection zones and wellhead protection areas that are in the source protection area

f) Describe the drinking water issues relating to the quality and quantity of water in each of the vulnerable areas identified under clauses (d) and (e)

g) List activities that are or would be drinking water threats, and conditions that result from past activities and that are drinking water threats

h) Identify the areas where an activity listed under clause (g) is or would be a significant drinking water threat, and the areas where a condition listed under clause (g) is a significant drinking water threat

This Assessment Report includes detailed local information in support of each of the above objectives.

The ensuing chapters provide the details on each of these topics as required by the legislation, regulations and technical rules. Chapter 2 delineates the Ausable Bayfield Source Protection Area and provides an overview of the watersheds, the physiography, human geography, and interactions of humans on the landscape (objectives A and B). The next chapter (Chapter 3) provides a water quantity stress assessment which is based on a synopsis of the water budget reports (conceptual, Tier 1, Tier 2) (objective C and part of D). The Water Quality Risk Assessment is contained in Chapter 4 (objective D, E and F). This chapter identifies the sources of drinking water in the area and provides details on defined vulnerable areas (objective H). Furthermore, the chapter identifies the high risk activities, issues and conditions which could contribute to source water contamination (objective G). Chapter 5 provides local thinking on adaptation to climate change. The next chapter (Chapter 6) identifies future research needs. The seventh chapter provides an over view of how the Source Protection Committee has considered the Great Lakes in their deliberations. A final chapter is a summary of key findings that the Source Protection Committee should take under consideration when formulating the source protection plans.

The Assessment Report comprises three volumes. Volume 1 is the text and tables. Volume 2 is the book of maps for the report. Volume 3 is the appendices. **Appendix A** is the Table of Drinking Water Threats organized by vulnerability score and type of vulnerable area. This has been done so that the reader can view a particular location on a map and determine the type of vulnerable area. Once the type of vulnerable area is determined, the vulnerability score can be located. With these two pieces of information, the reader can then establish what types of circumstances would generate significant, moderate, and low threats in that area. **Appendix B** contains the glossary and **Appendix C** is the record of public consultation.

AUSABLE BAYFIELD: CHAPTER 2

WATERSHED CHARACTERIZATION

Table of Contents

List of Tables

2.0 Watershed Characterization

The Watershed Characterization uses existing information to summarize the watershed's fundamental natural and human-made characteristics, their status and trends. For a more detailed report, see the full watershed characterization posted on the ABMV DWSP website at: www.sourcewaterinfo.ca.

2.1 Watersheds in the Ausable Bayfield Source Protection Area

The Ausable Bayfield Source Protection Area is a level, fertile agricultural area with a high concentration of livestock. It has limited upstream natural areas and extensive artificial drainage. Located within the Ausable Bayfield Source Protection Area are forested river gorges and a highly significant dune ecosystem. The Ausable Bayfield Source Protection Area comprises two watersheds: Ausable and Bayfield, as well as numerous small watercourses outletting to Lake Huron, known as the Gullies (**Map 2.1**). The Ausable basin is further divided into the following subwatersheds; Parkhill Creek, Mud Creek and Dune area (**Map 2.2**). The total watershed area is 2,440 km^2 with a population of approximately 45,000. The population density is 18.44 people per km^2.

Ausable
The Ausable watershed forms in a broad 'J' shape and residents living in the area use either groundwater or Lake Huron as their drinking water supply. Bedrock aquifers tend to be protected by deep overburden deposits while shallow aquifers are more susceptible to contamination. Sinkholes are present in the West Perth headwater areas, and the watershed area's stream-feeding shallow aquifers are vulnerable to contamination from surface water. Hay Swamp is the only major remaining natural wetland filtration area. Forest in the Ausable Gorge helps prevent erosion, and the fragile dune network between Highway 21 and Lake Huron contains much of the last Old Savanna woodland in North America. Very few cold water streams exist in the Ausable watershed but cold water is partially present in Black Creek, Nairn Creek, and a tributary north of Ailsa Craig. The Ausable River is one of the most biologically diverse basins of its size in Canada with the watershed featuring 83 fish species and 24 species of freshwater mussels. Although the area supports less wildlife than when Lakes Burwell and Smith were intact, it remains a stopping point for tundra swans and other migratory waterfowl in early spring.

Bayfield
The Bayfield watershed is rectangular in shape with water flowing from east to west, meeting Lake Huron at Bayfield. The residents of the Bayfield watershed obtain their drinking water from either groundwater supplies or directly from Lake Huron. Aquifers in the watershed, particularly shallow ones, are susceptible to contamination from sinkholes present in the Huron East headwater areas. The upper watershed has little natural vegetation to filter contaminants from rain and snowmelt runoff and clay soils accelerate runoff flows. Downstream of Clinton most stream banks are forested and the wetland near Trick's Creek filters contaminants. Trick's Creek and Bannockburn River, which gain

water from shallow aquifers, raise the water quality of Bayfield River. Trick's Creek contains some of the best cold water habitat in the watershed. The lower Bayfield Valley gorge supports a large, rich forest, which represents a valuable legacy of pre-settlement ecosystems.

Shore Gullies and Streams

Several short streams flow into Lake Huron between Grand Bend (Ausable Bayfield SPA) and the Eighteen Mile River (Maitland Valley SPA). Most of these streams are parallel and are about 6 to 8 kilometres in length. The streams' clay soils, straightened channels and steep near-shore gradients increase the pace of storm runoff. While vegetation is generally too sparse to provide adequate filtration in this area, a notable exception is Gully Creek, which has more forest cover and reaches coarse glacial deposits rich in groundwater. Erosion occurs at the shore cliffs, the sediment from which is transported south by coastal processes, and reinforces the dune system beyond Grand Bend. Erosion is a natural process but human activity may slow or speed the process. Most residents in this area draw water from a combination of Lake Huron and deep bedrock wells. The area's septic systems are facing higher demand due to the conversion of seasonal cottages to permanent residences. Septage contaminants have the potential to reach Lake Huron through clay soils that are insufficient for filtration.

2.2 Overview of Physical Geography

2.2.1 Watershed Descriptions

Ausable River

The Ausable River begins near Staffa and flows south to Ailsa Craig where it makes a wide arc to the west before flowing into Lake Huron at Port Franks. The basin has a total area of 1,233 km^2.

Physiography

The watershed is formed 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, near Arkona. The sand dunes of the Port Franks-Pinery Provincial Park area also have steep slopes, in sharp contrast to the adjoining level lagoon bed of what once were Lake Smith and Lake Burwell (Conservation Branch 1949).

Soils

The clay soils of the till plain and moraines are mainly Huron/Perth/Brookston series, 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 from 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

The Ausable River 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.

Historically the river meandered northward through the lagoon flats to today's Grand Bend. Within sight of the lake the river made a 'grand bend' to flow another 15 km parallel to the shore between the dunes before outletting near today's Port Franks. 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. The Parkhill Creek 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 through the dunes, 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 is characterized by clear water and dense aquatic vegetation.

Mud Creek is a small stream that skirts the southwest boundary of the Ausable watershed. 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. These areas are defined as 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).

Bayfield

The Bayfield watershed is 497 km^2 (Malone 2003), flowing east to west and entering Lake Huron at Bayfield.

Physiography

The Bayfield watershed crosses the same till moraines and till plain sequence as the Ausable watershed. 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 flood plain. Soil erosion likely increases in the more sloping moraine areas; the 1995 Watershed Management Plan (Snell and Cecile 1995) 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

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, a cool/cold water system, helps to maintain water quality and provides habitat for salmonids.

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 River watershed (Snell and Cecile et al. 1995).

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. 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. 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 Port Blake 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 source protection 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. 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 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 in height 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, eroding shoreline bluff (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 open municipal drains. Few are long enough to have tributaries. Some gullies were present at settlement as steep shore ravines stabilized under forest cover. Human activities have extended them. Land clearance, accelerated overland 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.

<u>Lake Huron</u>

Local surface water in the nearshore of Lake Huron has suffered degradation from intensification of seasonal shoreline development (Peach 2006). Some settlement nodes have experienced substantial growth: 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. Looking towards the future, lower lake levels that result from anthropogenic changes may bring increased pressure for development at the beach level of the shoreline. Without development, ideally the lower lake level would allow vegetative succession to occur and better dune stewardship (Donnelly 2006).

2.2.2 Natural Heritage

Map 2.3 depicts the location and types of natural vegetative cover in the AB SPA and **Table 2.1** lists the percentage of land coverage of each.

Table 2.1 Location and types of natural vegetative cover and the percentage of land coverage of each

Type of Vegetative Cover	Area in km^2	% Coverage in SPA
Wetlands	63.85	2.60
Natural Area		
Corridor	0.29	0.01
Forest	293.35	11.94
Hedgerow	0.17	0.01
Old field regenerating	2.08	0.08
Old field/plantation	2.44	0.10
Orchard	1.78	0.07
Plantation	0.38	0.02
Totals	**300.49**	**12.24**
Riparian		
Corridor	0.29	0.0120
Forest	21.85	0.8896
Hedgerow	0.04	0.0017
Old field regenerating	0.72	0.0292
Old field/plantation	0.34	0.0138
Orchard	0.02	0.0010
Plantation	0.004	0.0002
Totals	**23.26**	**0.9474**

Source: MNR's NHIC dataset

2.2.3 Aquatic Ecology

Pre-settlement rivers had more cold or cool water habitat maintained by springs and forest shade. 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 aquatic habitats are distinguished on **Map 2.4.**

2.2.3.1 Fisheries

<u>Ausable</u>
Although Veliz (2005) confirms 83 species of fish – 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. Pinery Provincial Park'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 (Killins 2008).

Although Veliz (2001) found some good cover and substrate on the main Parkhill Creek, water quality problems limit the fisheries (Schaus 1984). The Parkhill 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). The Ausable also supports 26 species of freshwater mussels: 23 live species and fresh shells were found for three other species.

<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 the State of 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 a private dam and a poor fish ladder. George and Pfrimmer (1973) 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. 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.

<u>Shore Gullies and Streams</u>
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 results in 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)

2.2.3.2 Aquatic Macroinvertebrates

Narrow tolerance ranges of certain species of aquatic macroinvertebrates make them a valuable indicator of water quality.

<u>Ausable</u>
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.

Bayfield

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.

Shore Gullies and Streams

Twenty-nine per cent 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.

2.2.4 Species and Habitats at Risk

Table 2.2 lists the various at-risk fish, mussels, aquatic reptiles, insects, vascular plants and birds that are on the Species at Risk in Ontario (SARO) List and are found within the Ausable Bayfield SPA.

Table 2.2 Species at Risk within the watersheds of the AB SPA and their listing under SARO

Common Name	Scientific Name	Watershed	SARO
FISH			
Pugnose Shiner	*Notropis anogenus*	Ausable	END
Lake Chubsucker	*Erimyzon sucetta*	Ausable Bayfield	THR
Eastern Sand Darter	*Ammocrypta pellucida*	Ausable	THR
Black Redhorse	*Moxostoma duquesnei*	Ausable Bayfield	THR
River Redhorse	*Moxostoma carinatum*	Ausable	SC
Bigmouth Buffalo	*Ictiobus cyprinellus*	Ausable	SC
Northern Brook Lamprey	*Ichthyomyzon fossor*	Bayfield	SC
Redside Dace	*Clinostomus elongates*	Shoreline	END
Grass Pickerel	*Esox americanus vermiculatus*	Ausable	SC
American Eel	*Anguilla rostrata*	Shoreline	END

MUSSELS			
Northern Riffleshell	*Epioblasma torulosa rangiana*	Ausable	END
Wavy-rayed Lampmussel	*Lampsilis fasciola*	Ausable	END
Snuffbox	*Epioblasma triquetra*	Ausable	END
Kidneyshell	*Ptychobranchus fasciolaris*	Ausable	END
Rainbow mussel	*Villosa iris*	Ausable	THR
Mapleleaf	*Quadrula quadrula*	Ausable	THR
AQUATIC REPTILES			
Eastern Spiny Softshell Turtle	*Apalone spinifera*	Ausable	THR
Queen Snake	*Regina septemvittata*	Ausable, Bayfield	THR
Northern Map Turtle	*Graptemys geographica*	Ausable	SC
Wood Turtle	*Glyptemys insculpta*	Bayfield	END
Blue Racer	*Coluber constrictor foxii*	Ausable	END
Spotted Turtle	*Clemmys guttata*	Ausable	END
Butler’s Gartersnake	*Thamnophis butleri*	Ausable	THR
Eastern Hog-nosed Snake	*Heterodon plathirhinos*	Ausable	THR
Five-lined Skink	*Eumeces fasciatus*	Ausable	SC
Milksnake	*Lampropeltis triangulum*	Ausable	SC
INSECTS			
Karner Blue	*Lycaeides melissa samuelis*	Ausable	EXT
Frosted Elfin	*Callophrys irus*	Ausable	END
VASCULAR PLANTS			
Bluehearts	*Buchnera americana*	Ausable	END
Cucumber Tree	*Magnolia acuminate*	Ausable	END
Drooping Trillium	*Trillium flexipes*	Ausable	END
Heart-leaved Plantain	*Plantago cordata*	Ausable	END
Showy Goldenrod	*Solidago speciosa*	Ausable	END
Dense Blazing Star	*Liatris spicata*	Ausable	THR
Dwarf Hackberry	*Celtis tenuifolia*	Ausable	THR
False Rue-anemone	*Enemion biternatum*	Ausable	THR
Goldenseal	*Hydrastis candensis*	Ausable	THR
Broad Beach Fern	*Phegopteris hexagonoptera*	Ausable	SC
Green Dragon	*Arisaema dracontium*	Ausable	SC
Riddell’s Goldenrod	*Solidago riddellii*	Ausable	SC
Tuberous Indian-plantain	*Arnoglossum plantagineum*	Ausable	SC
BIRDS			
Acadian Flycatcher	*Empidonax virescens*	Ausable	END
Loggerhead Shrike	*Lanius ludovicianus*	Ausable	END
Northern Bobwhite	*Colinus virginianus*	Ausable	END
Prothonotary Warbler	*Protonotaria citrea*	Ausable	END
Hooded Warbler	*Wilsonia citrina*	Ausable	THR
Cerulean Warbler	*Dendroica cerulea*	Ausable	SC
Louisiana Waterthrush	*Seiurus motacilla*	Ausable Bayfield	SC
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Ausable	SC

EXT = Extirpated
END=Endangered
THR=Threatened
SC=Special Concern
Source: Ausable Bayfield Conservation Authority database

2.3 Water Quality and Quantity

2.3.1 General Overview of Surface Water Quality and Quantity

The surface water quality in the Ausable Bayfield Source Protection Area reflects traditional rural non-point source issues of nitrogen, phosphorus, and bacteria. More urban contaminates such as chloride and copper are not present in concentrations above the Provincial Water Quality Objective (PWQO).

The dominance of heavy textured soils – often poorly drained, cleared land and agricultural drains makes the whole area highly responsive to hydrologic 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. The lower agricultural capability encourages more natural cover and less built drainage. These soils 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).

In the region, 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) 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. 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).

Potential sources of non-agricultural 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.

Spatial trends of current water quality are represented in statistical graph form in **Table 2.3**. Thirty water quality sites are compared for nitrate, total phosphorus and *E. coli* by grouping all data collected in the years 2001-2005. **Maps 2.5, 2.6 and 2.7** show the estimated *E. coli*, nitrogen and phosphorous concentrations respectively across the planning area.

Recent trends suggest phosphorus concentrations are decreasing, nitrates are rising, and fecal coliform is increasing in some areas (Bonte-Gelok and Joy 1999). Nitrates exceed Ontario Drinking Water Standards (ODWS) which is more evident in the headwaters of the Bayfield and Little Ausable. In the last 20 years, Conservation Authority programs have raised landowner 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.

For more detailed information on water quality and quantity in the AB SPA, please see Chapter 3: The Water Budget.

Table 2.3 Nitrate, total phosphorus and *E. coli* concentrations at current water quality monitoring sites in the Ausable Bayfield Source Protection Area

Watershed / Site	Years	Nitrate as N (mg/l)					Total Phosphorus (mg/l)					*E.Coli* (cfu/100ml)					
		n	median	25th	75th	max	n	median	25th	75th	max	n	median	geomean	25th	75th	max
Bayfield River																	
Upper Bayfield																	
Dublin	03-05	26	9.91	2.82	11.50	20.30	26	0.056	0.027	0.099	0.978	25	600	441	163	1325	4700
Silver Creek	05	8	3.71	2.80	6.38	9.15	8	0.018	0.014	0.024	0.094	8	157	111	70	255	320
Seaforth	03-05	26	7.01	1.76	9.36	17.60	26	0.026	0.017	0.04	0.144	26	385	323	150	660	2300
Lower Bayfield																	
Bannockburn	03-05	26	5.48	3.10	8.15	13.10	26	0.028	0.017	0.061	0.218	26	211	355	123	1000	50000
Steenstra	03-05	21	10.40	7.81	11.55	14.00	21	0.046	0.024	0.07	1.08	18	260	165	100	820	8200
Varna	01-05	60	6.70	3.28	9.30	14.40	60	0.03	0.016	0.053	0.611	26	71	105	28	210	10000
Parkhill Creek																	
Upstream Parkhill	03-05	26	6.07	2.60	9.50	14.30	26	0.082	0.048	0.113	0.401	26	175	171	80	410	2800
Downstream Parkhill	03-05	26	4.81	1.53	7.22	11.10	26	0.115	0.08	0.136	0.249	25	200	180	74.75	427.5	2600
Ausable River																	
Main Branch																	
Staffa	03-05	26	8.11	6.96	9.12	12.40	26	0.025	0.015	0.034	0.057	26	780	623	250	1600	7300
Exeter	01-05	41	6.73	3.43	9.00	14.30	41	0.101	0.059	0.16	1.17	25	200	120	68	290	720
Springbank	03-05	26	4.96	2.43	8.67	10.70	26	0.068	0.05	0.1	0.277	26	135	138	70	300	1600
Thedford	01-05	40	4.92	2.41	7.37	12.50	40	0.048	0.036	0.096	0.388	26	125	136	53	240	24000
Ausable Tributaries																	
Black	01-05	41	6.55	4.82	8.18	13.50	41	0.046	0.028	0.072	0.23	26	755	933	510	3800	11000
Nairn	03-05	26	4.75	3.86	7.06	11.40	26	0.019	0.011	0.029	0.088	26	185	130	51	380	1100
Decker	01-05	41	5.14	0.23	9.27	17.80	41	0.049	0.033	0.079	0.172	26	170	167	73	490	17000
Little Ausable																	
Huron Park	04-05	29	7.83	2.78	11.13	16.50	29	0.048	0.026	0.07	0.503	27	280	321	105	697.5	67000
Lucan	01-05	41	6.57	0.13	9.63	15.70	41	0.029	0.022	0.05	0.228	26	74.5	77	31	180	1700
Shoreline Watersheds (north to south)																	
Boyd	01-05	51	5.18	0.51	7.55	13.00	21	0.03	0.015	0.039	0.085	51	230	213	70	609	9500
Eighteen Mile	01-05	62	3.72	1.10	5.80	9.79	31	0.028	0.018	0.042	0.143	62	256	226	76	540	7700
Kintail	01-05	63	0.50	0.10	4.27	11.30	33	0.13	0.039	0.221	0.333	63	240	208	62.5	688	17000
Kerrys	01-05	99	3.60	1.67	6.35	13.10	55	0.027	0.018	0.061	0.36	97	280	244	86	712.5	12000
Kingsbridge	01-05	57	5.07	0.20	7.13	13.50	30	0.09	0.034	0.144	0.327	57	480	536	207.5	1550	17000
Griffins	01-05	69	1.60	0.20	6.92	19.40	39	0.106	0.038	0.163	0.501	68	569	544	210	1610	20000
Midhuron	01-05	61	2.10	0.20	6.78	13.90	33	0.067	0.032	0.168	0.721	61	240	269	88.5	835.5	5500
Boundary	01-05	77	2.81	0.54	4.42	13.50	33	0.041	0.028	0.086	0.6	77	360	314	100	857.5	11000
Bogies	01-05	63	2.87	0.34	5.83	11.00	33	0.03	0.019	0.047	0.253	63	105	146	49.25	397.5	42000
Allans	01-05	63	4.30	3.15	5.89	12.10	33	0.027	0.018	0.041	0.708	61	170	213	97.75	472.5	39000
Zurich	03-05	19	5.18	3.35	6.87	13.20	26	0.036	0.025	0.071	0.197	26	274	236	87	610	22000
Desjardine	03-05	25	4.30	0.44	7.85	14.00	25	0.034	0.018	0.044	0.145	25	110	156	45.75	570	25000
Port Franks	03-05	26	5.85	0.20	12.20	21.00	26	0.056	0.039	0.097	0.201	26	110	117	55	220	2000

Some sites have not been sampled for the entire period. Refer to the Years column.

The watersheds have been ordered from north to south, sites within each watershed ordered from upstream to downstream.

(light yellow) result exceeds the CCME Guideline of 2.93 mg/l nitrate as N, or the PWQO of 0.03 mg/l of total phosphorus or 100 cfu/100ml for *E.coli*

(orange) result exceeds the Ontario Drinking Water Standard of 10 mg/l nitrate as N

Source: ABCA water quality database

2.3.2 General Overview of Groundwater Quality and Quantity

The county groundwater reports (Huron: International water Consultants et al. 2003; Lambton and Middlesex: Dillon and Golder, 2004 a & b; Perth: Waterloo Hydrogeologic, 2003 a & 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 serious influence on the quality; only natural parameters like fluoride, hardness and iron are noted. 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 Water Quality Objectives are total dissolved solids, sulphate and iron. 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 the Technical Support Document for Ontario Drinking Water Standards, aesthetic objectives 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, non-decommissioned wells, and rivers that have chiselled down to bedrock (e.g., lower sections of the Ausable and Bayfield). The biggest threats for 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 municipal 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. A summary of overall water quality for the important overburden and bedrock aquifers in the Ausable Bayfield Source Protection Area is included below in **Tables 2.4 and 2.5**, respectively.

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. Most groundwater withdrawals are returned to the watershed although to more surficial systems.

For more detailed information on water quality and quantity in the AB SPA, please see Chapter 3: The Water Budget.

Table 2.4 Summary of water quality for overburden aquifers in the Ausable Bayfield Source Protection Area

Aquifer	Location	Water Quality	Key Issues
Wyoming	Just east of Lake Huron shoreline and runs in a north south orientation	Good	Fluoride Iron Sodium Trace presence of nitrates
Hensall	Directly below and in the vicinity of the community of Hensall	Moderate	Bacteria Nitrates Iron
Holmesville	Runs the length of the planning region in a north south orientation	Good	Hardness Iron contamination Trace presence of nitrates
North Lambton	Northern part of Lambton County adjacent to Lake Huron	Moderate	Iron Hardness Widespread presence of nitrates Evidence of significant salt contamination
Seaforth	Within the Seaforth moraine	Poor Evidence of high susceptibility to contamination via surface water	Bacteria Hardness Iron Widespread presence of nitrates Trace presence of hydrocarbons and pesticides

Source: Watershed Characterization 2006

Table 2.5 Summary of water quality for bedrock aquifers in the Ausable Bayfield Source Protection Area

Aquifer	Location	Water Quality	Key Issues
Lucas	Subcrops throughout a large portion of the planning region.	Moderate to Good	Fluoride Iron Hardness Localized evidence of salt contamination Radionuclides
Dundee	Subcrops throughout southwestern portion of SPA and overlies the Lucas formation	Good	Fluoride Iron Hardness Sodium Localized evidence of salt contamination
Hamilton	Very small area on the farthest southern and western limit of SPA	Poor Highly variable	Fluoride Hardness Iron contamination Evidence of significant salt contamination

Source: Watershed Characterization 2006

2.4 Overview of Human Geography

2.4.1 Human Characterization and Settlement Areas

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, largely based on the allure of the Lake Huron shore (Butler and Hilts 1978). More recently, good roads and ready access to Canadian and US markets have encouraged industry beyond agricultural support and processing.

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 the non-farm population exceeding the 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). **Map 2.8** shows the areas of settlement for the Ausable Bayfield Source Protection Area.

2.4.2 Population Distribution and Density

Four counties and 12 municipalities lie entirely or partly within the Ausable Bayfield Source Protection Area (**Map 2.9**) The AB SPA averages 18 persons per kilometre squared in population density; the majority of which are rural residents. In the 2006 census, Huron County was 60% rural residents – more than any other Southwestern Ontario county (Statistics Canada 2007). **Table 2.6** and **Map 2.10** show the population and population density for each municipality that lies within the AB SPA.

Table 2.6 Municipal Population and Population Density for the AB SPA

Municipality	Population	Population Density (per km^2)
Huron County	*59,325*	*17.5*
Bluewater	7,120	17.1
Central Huron	7,641	17.1
Huron East	9,310	13.9
South Huron	9,982	23.5
Middlesex County	*422,333*	*127.3*
Middlesex Centre	15,589	26.5
Adelaide Metcalfe	3,117	9.4
Lucan Biddulph	4,187	24.8
North Middlesex	6,740	11.3
Perth County	*74,344*	*33.5*
Perth South	4,132	10.5
West Perth	8,839	15.3
Lambton County	*128,204*	*42.7*
Lambton Shores	11,150	33.7
Warwick	3,945	13.6

Source: Statistics Canada 2007

2.4.3 Land Use

Agriculture dominates the Ausable Bayfield Source Protection Area with small urban areas scattered throughout. Cottage development has spread along the lakeshore. Forest concentrations occur in the Dunes, Ausable Gorge, the Lower Bayfield Valley and the major spillway and delta unit that include the Hay Swamp, Lower Bannockburn Creek and Trick's Creek. There are a number of conservation areas, private campgrounds, and one provincial park: Pinery Provincial Park. Several gravel pits occur in the major spillway unit. The Chippewas of Kettle and Stony Point First Nation have reclaimed Ipperwash Range and Training Area. No reserves as defined under the *Indian Act* are located in the AB SPA.

Federal lands located in the Ausable Bayfield Source Protection Area are presented on **Map 2.11**. They include the DND site at Stony Point, the Department of Fisheries and Oceans, and Public Works.

2.4.4 Urban Development

The AB SPA is predominantly rural and any towns and villages located in the area were all considered independent municipalities prior to the municipal restructuring and amalgamation which began in 1996. Towns are scattered throughout the area 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, and 2.28% of the Shorelines and Gullies watershed.

Ontario's recent *Greenbelt Plan and Places to Grow Policy* does not apply to the AB SPA. 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).

2.4.5 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. 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.

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

2.4.6 Agriculture Sector Distribution

Ausable Bayfield has the ninth highest livestock manure production/ha in Canada, at around 6,000 kg/ha. In terms of manure components Ausable Bayfield was sixth in Canada for nitrogen with approximately 36 kg/ha, and fifth for phosphorus with approximately 10.8 kg/ha (Statistics Canada 2006).

Cultivated lands in the AB SPA include continuous row crops, corn systems, extensive field vegetables, grain systems, hay systems, mixed systems, orchards, and soy and edible beans. 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.

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 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. Hogs accounted for 72%. In 1996, every municipality still had 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 the Bayfield watershed, but occurred in all other areas as well. Expansion was highest in former Stanley Township, south of Bayfield.

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 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 2832 (Perth County 2005).

The most recent census conducted in 2006 showed that there were 142,816 cattle, 711,745 pigs, and 5.2 million chickens in Huron County (Statistics Canada 2006). However, a major downturn in the hog industry over the last few years has meant a substantial decrease in in the number of pigs in the county.

2.4.7 Aggregates

An aggregate resource inventory paper for Huron County (Ontario Geological Survey 2004) 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 (outside of the AB SPA) and associated with major spillways and eskers. Glacial lake beaches, sand plains and some coarser textured moraines can also provide aggregate. 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.

Huron County's distance to markets makes it a small supplier 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).

2.4.8 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 cliffs are now experiencing erosion threats from natural processes. In some areas gullies are threatening to erode cottage foundations. Malfunctioning septic systems are also degrading water quality. Many older cottages have expanded, exacerbating the erosion and septic system problems (Snell and Cecile et al. 1995).

In 1989, there were 1,038 lakeshore residences with septic systems in ABCA and 1,000 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 and nearby 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 channels to Lake Huron 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. Most developments are serviced by the Lake Huron pipeline, and it is anticipated that the same will occur for future cottage development.

2.4.9 Landfills

The Waste Management Master Plan for the County of Huron (CH2M Gore & Storrie Ltd. 1997) identifies one existing landfill site, Exeter, to have long-term potential in the AB SPA. There are 26 years of identified capacity, with a possibility of more capacity (up to 40 years) at this site if a staged expansion program is granted by the MOE (CH2M Gore & Storrie Ltd. 1997).

Bonte-Gelok and Joy (1999) documented wastewater 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.

2.4.10 Oil and Gas

According to the Ontario Oil, Gas and Salt Resources Library, the AB SPA has a record of 336 wells (records dating back to early 1900’s). Presently listed as active are nine natural gas wells, six oil wells and nine natural gas storage wells (Ontario Oil, Gas and Salt Resources Library 2010). 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."

Some concern has been raised about the storage of natural gas in pools located near Zurich, Tipperary, and Bayfield. However, further research needs to be done in order to determine whether this is a potential threat to drinking water in these areas as natural gas is not cited as a drinking water threat under Section 1.1 of Ontario Regulation 287/07.

2.4.11 Transportation

Because the area is rural and does not have a large city, most of the roads are county or municipal roads with the exception of the 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 AB SPA, it connects the towns of Port Franks, Grand Bend and Bayfield. Highway 4 runs north-south and connects to Highway 8 at Clinton. Highway 4 continues through downtown London, and then on to Port Stanley on the shores of Lake Erie. Highway 4 connects the towns of Clinton, Hensall, Exeter, Huron Park 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).

Spills along these highway corridors have been raised as a concern by the SPC. However, more research is required to determine how to quantify this as a threat. This may be included in an updated version of the Assessment Report.

There is one minor airport located within the AB SPA: Centralia/Huron in Huron Park. In the area there are also a number of short line railway lines (mostly used for fertilizer, grain and salt).

2.4.12 Wastewater Treatment

Septic Systems

Impact on water depends on age, density, design, soil, and illegal tile connections.

Septic system numbers for the different watersheds may be outdated. In the Ausable area, 4,049 systems are estimated (Hocking – CURB 1989). In the Bayfield area, 1,450 are estimated, while in the Shore Streams and Gullies the estimate is 1,848 (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.

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 which included the communities of St. Joseph and Egmondville within the AB SPA. The Health Unit targeted these areas because of the combination of high classification, history of sewage ponding, odour complaints, or a history of poor-quality beach water for adjacent lakeshore communities. Some of the communities also volunteered for the program (Scharfe and the Ashfield-Colborne Lakefront Association 2005). In 2005, the Health Unit performed 174 system re-inspections, three of which had failed and needed to be replaced. For 2006, the number of re-inspections has exceeded the volume from 2005 and two 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.

Municipal Wastewater/Storm Sewers

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, 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.

The ABCA Stormwater Management Policies and Technical Guidelines, Final Report (Stantec 2009), sets out policies, criteria, and targets as guides towards the application of stormwater management within the ABCA's area of jurisdiction. The ABCA endorses 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 cases, 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.

In many municipalities where municipal wastewater and storm sewers are in place, storm water bypasses and overflows by cross connections are an issue. Discharge of chlorine and ammonia from wastewater into Lake Huron is also an issue that has been discussed through various site specific studies.

Many of the more urbanized areas of the SPA contain municipal or communal systems that collect and treat sewage and wastewater. Although most of these sewage treatment systems provide primary and secondary treatment and disinfection, the discharge from these systems can cause an increase in microbial release into the surrounding environment. In addition, sewage treatment by-passes and overflow that occur during times of heavy rains and snow melt, cause an overflow of microbial load to by-pass the treatment facility and flow into neighbouring watercourses. For further information on the frequency of municipal bypasses, refer to MOE's Spills Action Centre.

The Municipalities of Lambton Shores, Bluewater, and South Huron, are participating in the Grand Bend and Area Sanitary Sewage Servicing Master Plan to provide municipal sewage services to the area. This has been due to the fact that malfunctioning septic systems, and discharges from the Grand Bend Sewage Treatment Facility have been adversely affecting groundwater and surface water in this region (Dillon Consulting 2000).

2.5 Overview of Interaction between Physical and Human Geography

2.5.1 Drinking Water Sources

In towns in the AB SPA, the main source of drinking water tends to be the pipeline connected to Lake Huron; 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 individual 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). 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 Shores, however, 30% of the population is still self-supplied (Dillon Consulting and Golder Associates 2004a). Middlesex municipalities have no public groundwater supply but have some private wells (Dillon Consulting and Golder Associates 2004b). On the other hand, all of Perth County residents use groundwater sources (Rush 2003). In 1989-1990, Lake Huron Primary Water Supply System 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.

All drinking water systems located in the AB SPA, and the area served by each system, are shown in **Map 2.12**. The locations of monitoring wells in the AB SPA are shown on **Map 2.13**. Drinking water systems (DWS) are also listed in **Table 2.7** by system number, system classification, address, and number of users served by each system. Where cells in the table appear blank, the data is missing. The pumping rates for the maximum annual, average annual and monthly average pumping rates for all large municipal residential drinking water systems are listed in **Table 2.8**.

2.5.1.1 Municipal Wells

In Huron, municipal wells (Zurich, Brucefield, and three north of Bayfield) supply about 5% of the AB SPA's population including seasonal residents.

2.5.1.2 Communal Wells

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

2.5.1.3 Private Groundwater Supplies

Domestic wells are numerous. In Huron County about 3,400 domestic wells supply the population, including seasonal residents. A residential shift from individual private wells to municipal wells is emerging as a recent trend. It is estimated that there are 16,000 individual wells in the Source Protection Region (Gutteridge and Innes 2008). However, the majority of these wells are outside of the AB SPA.

2.5.1.4 Surface Water Intakes

The majority of residents in the AB SPA use water piped from Lake Huron. There is one intake from Lake Huron in the Ausable Bayfield Source Protection Area, the Lake Huron

Primary Water Supply System (LHPWSS). The LHPWSS is located just north of Grand Bend and services approximately 305,000 people in the City of London, located outside the source protection region. It also supplies much of the population in the southern part of the planning region: most of the 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 Thedford, Grand Bend and Port Franks), South Huron (Huron Park/Centralia, Exeter, Crediton, Dashwood) and Bluewater (the lakeshore residents from Bayfield to Port Blake along Highway 21 and Hensall). It also serves the communities of Ilderton and Arva which are outside of the planning region. This intake services approximately 350,000 people.

2.5.2 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. Although the SPA has very little natural ponding inland, several small millponds remain. Low summer stream flow prompted construction of reservoirs near Exeter and Parkhill. These lakes offer permanent habitat although the 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).

2.5.3 Agricultural Water Use

Rainfall is the main water supply for crops in the SPA, but groundwater is used for all other agricultural needs, particularly livestock operations. 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, livestock uses 4.8 million m^3 per year of which approximately 3 million m^3 is groundwater. Livestock use overshadows all other uses in Middlesex municipalities also. Huron County irrigation uses 1.2 million m^3 per year of which about 0.8 million m^3 is from groundwater. Agricultural water usage was developed based on 2006 census data for the subwatersheds following methodology developed by de Loë (2001). 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, and cattle watering sometimes use 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.

2.5.4 Industrial Water Use

Among industries, aggregate washing operations use very large volumes of water, though the vast majority of this water is returned through all types of 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.

Table 2.7 Drinking Water System Classification and Users Served in the Ausable Bayfield Source Protection Area

DWS Number	Drinking Water System Name	Classification	Address	Population Served
Township of Adelaide Metcalfe				
260010478	Adelaide – W.G. MacDonald Public School Well Supply	SNMNRS	29059 School Road, Strathroy, N7G 3H6	
Municipality of Bluewater				
220007748	Harbour Lights Development Well Supply	Decommissioned	17 Harbour Court, Bayfield, N0M 1G0	50
220001469	Zurich Well Supply – Well #1	LMRS	50 Main St., Zurich	1000
220001469	Zurich Well Supply – Well #3	LMRS	50 Main St., Zurich	1000
260007036	Carriage Lane Well Supply	Decommissioned	4 Carriage Lane, Bayfield, N0M 1G0	40
260020956	R252 The Old Homestead Limited Trailer Park Well Supply	NMSRS	35248 Bayfield River Road	
260019630	Varna Well Supply	LMRS (2017)	Lot 19, Conc. BRN, Stanley Ward	100
260019643	Wildwood Campground Well Supply	NMYRRS	76735 Wildwood Line	
260022035	Paul Bunyan Trailer Camp Limited Well Supply	NMYRRS	75559 Lidderdale St., Bayfield, N0M 1G0	380
260030121	R252 Stanley Complex Well Supply	SMNRS	38594B Mill Rd., Varna	
260010322	Huron Centennial Elementary School Well Supply	SNMNRS	39978 Centennial Rd., RR1, Brucefield	420 students
260061724	R252 The Little Inn of Bayfield Well Supply	SNMNRS	26 Main Street North, Bayfield, N0M 1G0	
260061737	R252 Martha Ritz House Well Supply	SNMNRS	27 Main Street North, Bayfield, N0M 1G0	
Unassigned	Admiral Restaurant	SNMNRS	5 Main St., Bayfield	
Unassigned	Bayfield Marina	SNMNRS	33 Long Hill Rd., Bayfield	
Unassigned	Bayfield Marine Service	SNMNRS	20 Fisherman’s Wharf Rd., Bayfield	
Unassigned	Bayfield River Cottage & Marina Colony Inc.	SNMNRS	19 Fisherman’s Wharf Rd., Bayfield, N0M 1G0	
Unassigned	Bed and Breakfast 2	SNMNRS	18 Hwy. 21, Bayfield	
Unassigned	The Docks	SNMNRS	76559 Hwy. 21	
Unassigned	Clair On The Square B & B	SNMNRS	12 The Square, Bayfield	
Unassigned	Goshen United Church	SNMNRS	74396 Goshen Line	
Unassigned	Harbour Lights Marina	SNMNRS	Chart House Hill, Bayfield	
Unassigned	Harry’s	SNMNRS	6 Main St., Bayfield	
Unassigned	Kerr’s Campground	SNMNRS	38979 Centennial Rd.	

DWS Number	Drinking Water System Name	Classification	Address	Population Served
Unassigned	Knox Presbyterian Church 4	SNMNRS	2 Main St., Bayfield	
Unassigned	Lakeview Conservative Mennonite Church	SNMNRS	73394 Bronson Line	
Unassigned	Magnolia B & B	SNMNRS	38906 Mill Rd. (County Rd. 3)	
Unassigned	New Orleans Pizza	SNMNRS	2B Hwy 21, Bayfield	
Unassigned	Pub & Eatery	SNMNRS	1B Hwy. 21, Bayfield	
Unassigned	Roman Catholic Church of The English Martyr’s	SNMNRS	27 Louisa St., Bayfield	
Unassigned	Rosie's Ice Cream Shoppe	SNMNRS	25 Main St., Bayfield	
Unassigned	The Albion Hotel	SNMNRS	4 Main St., Bayfield	
Unassigned	The Art See Café	SNMNRS	19 Main St., Bayfield	
Unassigned	The Bean Bag	SNMNRS	14 Main St., Bayfield	
Unassigned	The King’s Bakery & Tea Room	SNMNRS	24 Main St., Bayfield	
Unassigned	The Little Inn of Bayfield	SNMNRS	29 Main St., Bayfield	
Unassigned	The Paschen Farm B&B	SNMNRS	Bronson Line, Zurich	
Unassigned	The Red Pump Restaurant & Gift Shop	SNMNRS	21 Main St., Bayfield	
Unassigned	The Spa	SNMNRS	13 The Square, Bayfield	
Unassigned	Trinity Anglican Church 5	SNMNRS	10 Keith Cres., Bayfield	
Unassigned	Varna United Church	SNMNRS	75820 Parr Line (Country Rd. 31)	
Unassigned	Woodland Drive In	SNMNRS	17 Mill Rd., Bayfield	
Municipality of Central Huron				
220008284	S.A.M. Well Supply	LMRS	23 Albert St., Clinton, N0M 1L0, PO Box 400	12
220008293	Vandewetering Subdivision Well Supply	LMRS	23 Albert St., Clinton, N0M 1L0, PO Box 400	22
220001539	Clinton Well Supply	LMRS	23 Albert St., Clinton, N0M 1L0, PO Box 400	4500
260035191	R252 Shelter Valley Campground Well Supply	NMSRS	36534 Huron Rd RR 2, Clinton, ON, N0M 1L0	
260007075	Pine Lake Campground Well Supply	NMYRRS	77794 Orchard Line, Bayfield, ON	
260009360	Huron Condominiums #1 Well Supply	NMYRRS	Lot 1 & 2 Bayfield Concession, Bayfield	50
260021775	Bluewater Golf Course Well Supply	NMYRRS	77416 Bluewater Hwy., Lot 40, Conc. 2, Goderich	
260029861	Lighthouse Cove Campground Well Supply	NMYRRS	77719 Bluewater Hwy, Bayfield, N0M 1G0	
260030719	Five Seasons Mobile Homes Well Supply	NMYRRS	RR2, 35791 Bayfield River Rd.	
260074516	Northwood Beach Well Supply	NMYRRS	77307 Bluewater Hwy., Bayfield, N0M 1G0	40

DWS Number	Drinking Water System Name	Classification	Address	Population Served
260027833	Camp Glenhuron Lawson Well Supply	SNMNRS	77683 Bluewater Hwy.	
220007640	Dundass Well Supply	NMYRRS	Lot 39, Concession 1, Goderich	17
Unassigned	Bayfield Berry Farm	SNMNRS	77697 Orchard Line	
Unassigned	Bayfield Village Inn Inc.	SNMNRS	34777 Bayfield River Rd., Bayfield, N0M 1G0	
Unassigned	Deer Park Lodge	SNMNRS	76803 Hwy. 21	
Unassigned	Lakefront B&B	SNMNRS	77793 Lane of Pines, Bayfield, N0M 1G0	
Unassigned	McLean Manor	SNMNRS	77610 Whys Line	
Unassigned	Middleton Place Cottages	SNMNRS	35449 Bayfield River Rd., Bayfield, N0M 1G0	
Unassigned	Naftel House B&B	SNMNRS	78169 Bluewater Hwy	
Unassigned	Pleasant Pheasant B&B	SNMNRS	35389 Bayfield River Rd.	
Unassigned	St. James Church, Anglican	SNMNRS	77397 Tipperary Line	
Unassigned	Stone Garden Estate B&B	SNMNRS	39341 Vanastra Rd., Clinton, N0M 1L0	
Municipality of Huron East				
220007604	Brucefield Well Supply	LMRS	1 London Rd., Brucefield, N0M 1J0	175
220001511	Seaforth Well Supply	LMRS	Huron East	3000
260074451	Heritage Estates Mobile Home Park Well Supply	NMYRRS	75049 Hensall Rd., Seaforth, N0K 1W0	38 homes
260014144	St. Columban Sep. School Well Supply	SNMNRS	44106 Line 34, RR2, Dublin, ON, N0K 1E0	
260050726	R252 Seaforth Golf Course Ltd. Well Supply	SNMNRS	42990 Front Road, Seaforth, N0K 1W0	
Unassigned	Kate’s Station Restaurant	SNMNRS	76988 London Rd.	
Unassigned	St. Andrews United Church 12	SNMNRS	40046 Kippen Rd.	
Unassigned	St. Andrew's United Church	SNMNRS	6 Hwy. 21, Bayfield	
Municipality of Lambton Shores				
260031434	Camp Dahinda Well Supply	SNMNRS	8659 Rock Glen Road, Arkona, Ontario	
260046865	R252 Rock Glen Conservation Area Well Supply	SNMNRS	8680 Rock Land Road, Arkona, N0M 1B0	
Township of Lucan Biddulph				
Unassigned	St. Patrick’s Church	NMNRS	Richmond St. at Roman Line	
260020839	The Crest Centre Well Supply	SNMNRS	13570 Elginfield Rd., Lucan, N0M 2J0	
Township of Middlesex Centre				
260049777	Camp Kee-Mo-Kee Well Supply	SNMNRS	9581 Glendon Drive, Komoka, N0L 1R0	
Municipality of North Middlesex				

DWS Number	Drinking Water System Name	Classification	Address	Population Served
260057057	R252 Harmony Woods Recreation Club Well Supply	NMSRS	33825 Harmony Road, Parkhill, N0M 2K0	
Unassigned	Malibu Restaurant 2	SNMNRS	316316 London Rd.	
Township of Perth South				
260015795	Ryan Residential Homes Well Supply	SNMNRS	Perth South	
Municipality of South Huron				
210000791	Lake Huron Primary Water Supply	LMRS	South Huron	350,000
260038467	R252 Kirkton/Woodham Community Centre Well Supply	SMNRS	70497 Perth Road 164, Kirkton, ON N0K 1K0	
260045136	R252 Ironwood Golf Well Supply	SNMNRS	70969 Morrison Line, Exeter, N0M 1S0	
260066378	R252 Emmanuel Baptist Church of South Huron Well Supply	SNMNRS	40007 Kirkton Rd., Hwy 4, Centralia N0M 1K0	
Unassigned	B B Gas Bar	SNMNRS	70005 Rd. 164 (County Rd. 23), Woodham	
Unassigned	Country Haven B & B	SNMNRS	69900 Hern Line (County Rd. 11)	
Unassigned	Exeter Golf Club	SNMNRS	40374 Hwy. 6, Morrison Line	
Unassigned	Thames Rd. Elimville United Church	SNMNRS	71209 Elmville Line	
Unassigned	The Shall 'B' in B & B	SNMNRS	39973 Crediton Rd., N0M 1K0	
Unassigned	Zion United Church 1	SNMNRS	41592 Park Rd.	
Municipality of West Perth				
260007933	R252 Quality Meat Products Well Supply	LNMNRS	P.O. Box 38, Dublin, N0K 1E0	
260063284	R252 Denneny's Grill Well Supply	LNMNRS	7349 Line 34, Dublin, N0K 1E0	
260032175	R252 Cromarty Ball Park Well Supply	SMNRS	West Perth	
260032214	R252 Logan Shop Well Supply	SMNRS	West Perth	
260032227	R252 Staffa Hall Well Supply	SMNRS	West Perth	
260032253	R252 Dublin Pavilion Well Supply	SMNRS	West Perth	
260032266	R252 Brodhagen Community Centre Well Supply	SMNRS	West Perth	
260014196	St. Patrick's Sep. School Well Supply	SNMNRS	3928 Perth Rd. 180	

LMRS – Large Municipal Residential System
SMRS – Small Municipal Residential System
LMNRS – Large Municipal Non-Residential System

DWS Number	Drinking Water System Name	Classification	Address	Population Served

SMNRS – Small Municipal Non-Residential System
NMYRRS – Non-Municipal Year-Round Residential System
NMSRS – Non-Municipal Seasonal Residential System
LNMNRS – Large Non-Municipal Non-Residential System
SNMNRS – Small Non-Municipal Non-Residential System
Source: Databases provided by MOECC and Health Units

Table 2.8 The Maximum Annual, Average Annual and Average Monthly Pumping Rates of Surface Water Intakes and Wells that are Part of the System

Source: Well System Annual Inspection Reports

DWS Number	Drinking Water System Name	Max. Annual Pumping Rate (m3/day)	Avg. Annual Pumping Rate (m3/day)	Year of Avg. Monthly Pumping Rates	Avg. Monthly Pumping Rate (m3/day)											
					Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
220007748	HARBOUR LIGHTS DEVELOPMENT WELL SUPPLY	80	36	2013	24	27	30	34	47	50	59	55	34	24	20	22
220001469	ZURICH WELL SUPPLY - Well #1&3, combined	428	308	2013	315	310	297	301	319	310	329	329	313	284	296	295
260007036	CARRIAGE LANE WELL SUPPLY	82	23	2013	15	14	13	15	25	30	47	49	20	17	15	16
220008284	S.A.M. WELL SUPPLY	15	8	2013	10	11	9	8	7	8	8	7	6	6	8	11
220008293	VANDEWETERING SUBDIVISION WELL SUPPLY	16	8	2013	10	11	9	8	7	8	8	7	6	6	8	11
220001539	CLINTON WELL SUPPLY	2581	1649	2013	1746	1873	1727	1650	1612	1629	1653	1531	1546	1676	1565	1579
220007604	BRUCEFIELD WELL SUPPLY	94	48	2013	44	42	43	45	57	56	50	51	48	47	46	47
220001511	SEAFORTH WELL SUPPLY - TW1	208	79	2013	130	91	82	51	87	89	87	83	52	65	63	68
220001511	SEAFORTH WELL SUPPLY - PW1	926	271	2013	241	268	203	273	393	354	266	342	282	336	278	269
220001511	SEAFORTH WELL SUPPLY - PW2	1505	775	2013	896	884	795	900	832	842	770	760	788	657	573	607
210000791	LAKE HURON PRIMARY WATER SUPPLY	219900	132300	2013	125000	125000	116500	124900	137000	142500	150400	149500	141600	128400	120800	126000

Source: Well System Annual Inspection Reports

References

Author	Title	Date	Purpose
Ausable Bayfield Conservation Authority	*Watershed Plan Summary*	1985	A handy summary to assist plan implementation
Baird and Associates	*Consideration for Shore Protection Structures*	1994	To provide technical guidance on re-engineered shoreline protection
Balint, David S.	*Analysis of the Manure Management – Water Quality Program of the Ausable-Bayfield Conservation Authority*	1984	To build on earlier studies by more ground truthing and an education program
Beecroft, M.	*Windings: A History of the Lower Maitland River. Maitland Conservation Foundation, Maitland Valley Conservation Authority*	1984	Provide historical information on the Maitland River
Bonte-Gelok, Shelly and Douglas M. Joy	*Huron County Surface Water Quality Data Study*	1999	To collect available water quality information, identify trends and causes, and incorporate the data into a GIS
Butler, R.W. and S.G. Hilts	*Patterns of Land Use and Change on the Lake Huron Shore, Bosanquet Township, Ontario*	1978	To provide background papers for a geographer's field trip
CH2M Gore & Storrie Ltd.	*County of Huron Waster Management Master Plan: Stage 3 Report, Solid Water Management Master Plan Preliminary Draft.*	1997	A detailed plan for the future of waste management in Huron County
Chapman, L.J. and D.F. Putnam	*Physiography of Southern Ontario*	1984	To document the physiography
Conservation Authorities Branch, Department of Energy and Resources Management	*Maitland Valley Conservation Report*	1967	A detailed description as a basis for management recommendations
Conservation Branch, Department of Planning and Development	*Ausable Valley Conservation report 1949*	1949	A detailed description as a basis for management recommendations
de Loë, R.	*Agricultural and Rural Water Use in Ontario*	2001	Provided methodology for estimating water

			usage based on the number of livestock for a given area
Dillon Consulting Ltd.	*Municipal Class Environmental Assessment (EA). Study for Municipalities of Lambton Shores, Bluewater, and South Huron.*	2000	Provide information on water quality in the area.
Dillon Consulting Ltd. And Golder Associates Ltd.	*Lambton County Groundwater Study. Ontario Ministry of the Environment.*	2004a	To develop a characterization of the regional aquifer and a strategy for groundwater protection
Dillon Consulting Ltd. And Golder Associates Ltd.	*Middlesex-Elgin Groundwater Study. Ontario Ministry of the Environment.www.Thamesriver.org/Groundwater/Groundwater_study_report*	2004b	To develop a characterization of the regional aquifer and a strategy for groundwater protection
Donnelly, P.	*Shoreline Management Plan 1994*	1994	Develop policy to reduce or eliminate storm damage on shore development
Donnelly, P.	*Email Interview dated November 29, 2006. Lake Huron Centre for Coastal Conservation.*	2006	Provide context on future development around Lake Huron
Giancola, Jim	*Soil Erosion Study: Ausable River and Bayfield River Watersheds. Technical Report #3*	1983	To produce a map of potential soil erosion by sub-watershed
George, J. and B. Pfrimmer	*The Bayfield River Stream Survey. Ausable Bayfield Conservation Authority*	1973	The report reviews potential for sports fishery and determines management options to improve it.
Golder Associates Ltd.	*Report on Groundwater Resource Assessment County of Huron Ontario. County of Huron, Department of Planning and Development.*	2000	Provide water quality and quantity data for groundwater sources in Huron County
Golder Associates Ltd.	*Groundwater Quality Assessment: Huron County Groundwater Study. County of Huron, Department of Planning and Development.*	2001	Provide water quality and quantity data for groundwater sources in Huron County
Golder Associates Ltd.	*2002 Sentinel Well Monitoring Program: Huron County Groundwater Study. County of Huron, Department of Planning and Development.*	2003	Data from groundwater monitoring program with analysis trends
Gutteridge, A. and D. Innes	*Well Record Improvement Project, Phase Two, 2007 Summary. ABCA*	2008	Provide information on the number and location of private wells

			in the ABMV planning region
Hocking, Doug	*Rural Beaches Strategy Program: Target Sub-Basin Study Report April, 1988 to March 1989*	1989	To reduce bacteria contamination and monitor improvements
Hocking, Doug	*Clean Up Rural Beaches (CURB) Plan for the Lake Huron Beaches in the Ausable Bayfield Watershed*	1989	To understand sources as a basis for a remedial plan
Hocking, Doug and Jackie Schottroff	*Rural Beaches Strategy Program: Target Sub-Basin Study Report April, 1990*	1990	To document 4th year of study: monitor water quality past demo farms and Bayfield system
Huron County Planning and Development Department	*Intensive Livestock Operations and Manure Management: Huron County Interim Control Study. Report for Discussion.*	2001	Provide statistical information on the status of farming operations in Huron County
International Water Consultants Ltd., B.M. Ross and Associates Ltd. and Waterloo Numerical Modelling Corp.	*County of Huron Groundwater Assessment and Municipal Wellhead Source Protection Study. Ontario Ministry of the Environment.*	2003	To develop a characterization of the regional aquifer and a strategy for groundwater protection
Jamieson, E.	*Benthic Monitoring Program Fall 2001: Ausable Bayfield Conservation Authority*	2001	To document water quality in ABCA main rivers using benthic macroinvertebrates as indicators.
Killins, K.	*A Management Plan for the Old Ausable Channel Watershed*	2008	Provide fisheries information on the OAC.
Maitland Valley Conservation Authority	*Maitland Conservation Strategy*	1989	To focus management on causes of resource problems
Maitland Valley Conservation Authority	*MVCA Municipal Groundwater Workshop Materials. CD.*	2004	Provide context on the status of groundwater quality and quantity
Malone, Patty	*Bayfield River Watershed Report*	2003	Summary of existing information to raise awareness of watershed
Middle Maitland Initiative	*Water Sampling Results - 2000*	2000	To report water quality and trends to public
Oil, Gas and Salt Resources Library	*www.ogsrlibrary.com accessed on Apr. 4, 2010*	2010	Provide data on oil, gas and salt wells in the SPR.

Ontario Geological Survey (Ministry of Northern Development and Mines)	*Aggregate Resources Inventory of Huron County; Southern Ontario*	2004	To provide an inventory on the aggregate resources in Huron County.
Ontario Ministry of Municipal Affairs and Housing	*Provincial Policy Statement.* http://www.mah.gov.on.ca/Page10679.aspx	2005	To provide policy on future development in Ontario
Peach, G.	*Phone Interview: Hardening of Lake Huron shoreline. Lake Huron Centre for Coastal Conservation.*	2006, Nov. 23	To report on Lake Huron shoreline status
Perth County	*County of Perth: Perth County Statistics.* http://www.countyofperth.on.ca/about_perth_county	2005	Census information for Perth County
Rush, R.	*Maitland Valley Characterization Report. Guelph Water Management Group.*	2003	Summary of existing information on areas within Maitland Valley
Scharfe, P. and the Ashfield-Colborne Lakefront Association	*Huron County Health Unit Septic Reinspection Program, Phase 1. http://www.northwesthuron.com/*	2005	Identify the status of private septic systems in Huron County
Schaus, Barbara	*Water Quality and Quantity of the Ausable Bayfield Conservation Authority*	1982	To define a base level to either maintain or improve
Schaus, Barbara	*Fish and Wildlife Management Inventory: Ausable Bayfield Conservation Authority. Watershed Plan Technical Report # 7*	1984	To provide background for the watershed plan
Singer, S.N., C.K. Cheng and M.G. Scafe	*The Hydrogeology of Southern Ontario. Volume 1. Ontario Ministry of Environment and Energy.*	1997	Provide data on the quality of water in bedrock aquifers in the planning region
Snell and Cecile Environmental Research	*Ausable Bayfield Conservation Authority Watershed Management Strategy*	1995	Identify priority sub-watersheds for CA programs
Snell and Cecile Environmental Research	*Shoreline Management Plan: Environmental Review Component Goderich to Kettle Point*	1991	Environmental considerations for the Shoreline Management Plan
Stantec	*ABCA Stormwater Management Policies and Technical Guidelines, Final Report*	2009	Sets out policies, criteria, and targets as guides towards the application of stormwater management.

Statistics Canada	*A Geographical Profile of Manure Production in Canada*	2001	To profile manure production across Canada
Statistics Canada	*Population Counts, 2001. http://www12.statcan.ca/english/census01/products/standard/popdwell/Table-UR-D.cfm?T=1&PR=35&SR=1&S=1&O=A*	2002	Provincial census data
Statistics Canada	*Population Counts, 2006. http://www12.statcan.ca/english/census06/data/popdwell/Table.cfm?T=302&PR=35&S=1&O=A&RPP=25*	2007	Provincial census data
Veliz, M. and E. Jamieson	*Benthic Monitoring Program Fall 2000: Ausable Bayfield Conservation Authority*	2000	To document water quality in ABCA headwaters using benthic macroinvertebrates as indicators.
Veliz, Mari	*Fish Habitat Management Plan*	2001	To document current fisheries, opportunities and strategies for improvement
Veliz, Mari	*Cold Water Fish Habitat Management in the Nairn Creek Sub-Basin*	2003	To examine habitat to propose recovery strategies
Waterloo Hydrogeologic Inc.	*Grey and Bruce Counties Groundwater Study*	2003	To develop a characterization of the regional aquifer and a strategy for groundwater protection
Waterloo Hydrogeologic Inc.	*Perth Groundwater Study*	2003	To develop a characterization of the regional aquifer and a strategy for groundwater protection

AUSABLE BAYFIELD: CHAPTER 3

WATER BUDGET

Table of Contents

List of Tables and Figures

3.1 Summary of Conceptual Water Budget Results

The goal of any water budget is to characterize, as accurately as possible, the fluxes of water through the hydrologic system one is attempting to define. In order to do this, a basic understanding of the processes and components within the area and the flow between specific components of that cycle must be understood. This process of developing a basic understanding of the processes and components of the hydrologic cycle and developing a methodology for quantifying and correcting these fluxes is referred to as a conceptual water budget. Such a conceptual Water Budget was completed for the Ausable Bayfield Maitland Valley Source Protection Region (2007) and the summary of the pertinent aspects of that report are presented for the Ausable Bayfield Source Protection Area (SPA), below.

3.1.1 Description of Region

The Watershed Description (2006) provides an overview of how physiography, topography and soils generally influence the surface hydrology of the source protection region and the Ausable Bayfield SPA. The overview material presented is organized by the major watershed/drainage system present in the study area, specifically:

- Ausable River
- Bayfield River
- Shore Streams and Gullies

The Ausable River system drains approximately 57% of the Ausable-Bayfield Source Protection Area, while the Bayfield River drains approximately 23% of the study area. The series of varied shore streams and gullies drain a significant 20% of the SPA.

The Conceptual Water Budget (2007) document provides a more detailed description of the character of each of these main surface systems by presenting the historical observations and summarizing the findings and outcomes from earlier hydrologic modeling exercises that focused on these surface water systems.

3.1.2 Key Components and Processes

For the Ausable Bayfield Source Protection Area, the key components and processes to be considered for water budgeting are shown in **Figure 3.1**. This schematic strives to explain the pathways and fluxes of water between the key reservoirs.

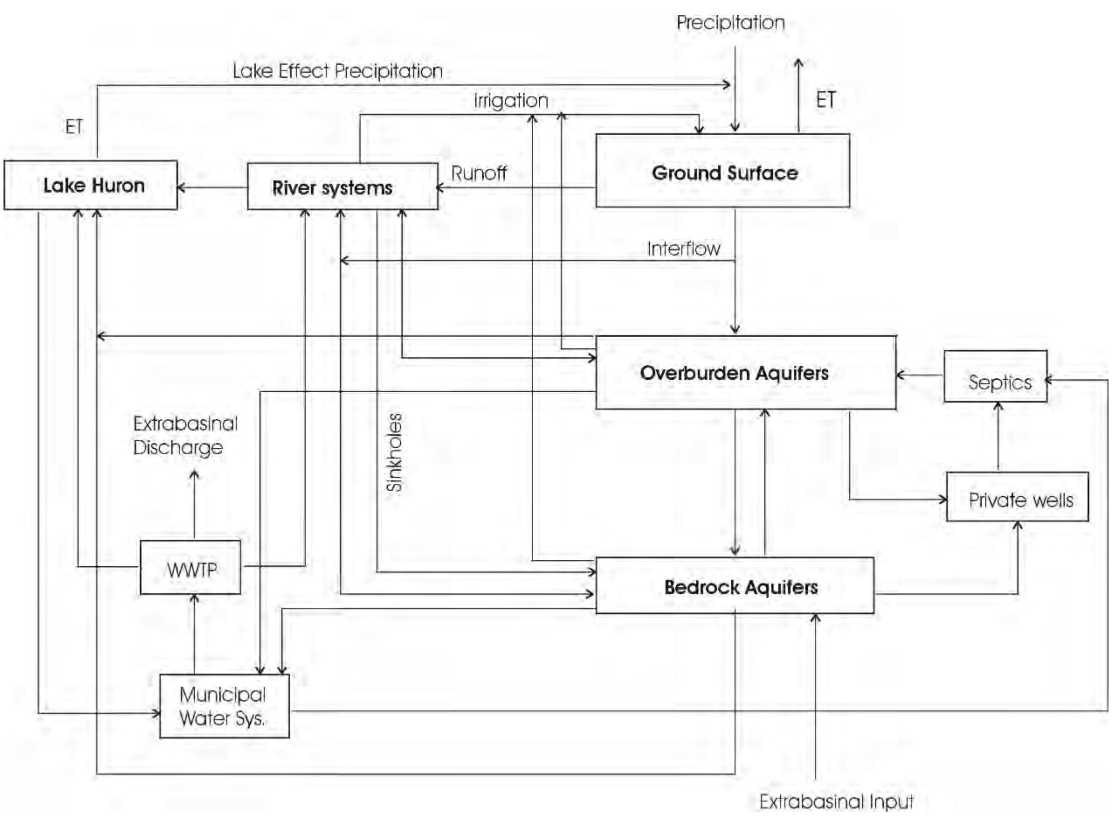
Ground Surface

The initial inputs into the system as a whole are in the form of precipitation. In addition, it is noted that a significant portion of groundwater entering the bedrock aquifer system is derived from extra-basinal sources. Precipitation falling to the ground is initially partitioned into surface runoff, which moves directly to surface systems, or into infiltration. Storage on or within the ground surface occurs as soil field capacity and depressional storage. From this point a portion of the water on or in the ground surface is released back into the atmosphere via evapotranspiration (ET on **Figure 3.1**). Evapotranspiration occurs throughout the system whenever water is exposed to the atmosphere or within the root zone of plant life. During dry periods, precipitation is augmented from the river systems, overburden and bedrock aquifers via irrigation. Ground surface topography is shown on **Map 3.1**.

River Systems

River systems receive direct runoff from the ground surface as well as groundwater discharge from both the overburden and bedrock aquifers. Interflow from infiltrating water is also diverted to river systems. All river systems in the region have outlet into Lake Huron. Major river systems of the Ausable and Bayfield Rivers drain approximately 80% of the region, the remaining 20% of the region drained directly into Lake Huron via smaller streams along the lake shore. River systems are not heavily exploited as sources of water in the planning region but a significant amount of irrigation is documented, removing water from the river systems and placing it on the ground surface.

Figure 3.1 Schematic of the Components and Fluxes of the ABMV Region Water Budget



Source: Luinstra 2006

Interflow

A portion of infiltrating water is redirected to surface water systems before entering the saturated zone via interflow. Tile drainage acts as a conduit which may accelerate interflow, particularly in areas with high permeability soils in the planning region, though its influence is not well documented.

Overburden Aquifers

The remainder of infiltrating water reaches the saturated zone within either the overburden or bedrock aquifers as recharge. The overburden aquifers also receive inputs of water from river systems via losing streams, septic systems and potentially discharge from the underlying bedrock aquifers. Groundwater flow within the overburden aquifers tends to follow the topography of the area, especially where they are unconfined. Confined overburden aquifers are not common in the watershed, and flow patterns within these tend to be complex, and can only be described at a local level. Overburden aquifers discharge water to the bedrock aquifers, private wells and most importantly to the river systems where they represent high quality sources of groundwater discharge for cold water streams. Water extracted for domestic consumption from private wells is subsequently discharged back into the overburden aquifers via septic systems.

Bedrock Aquifers

Inputs into the bedrock aquifers include recharge originating from the ground surface where the bedrock is exposed, recharge from overlying overburden aquifers, recharge from river systems via losing streams and most notably in the Ausable Bayfield Source Protection Area, via sinkholes which act as direct conduits for runoff into the bedrock aquifers. An important input into the bedrock aquifers is derived from extra-basinal sources located to the east and north of the study area. Water from the bedrock aquifer naturally flows in an east to west direction, where it eventually discharges into Lake Huron and, in certain areas, into river systems. In addition, large volumes of water are extracted from the bedrock aquifers for industrial and municipal water uses. The majority of this water is treated in municipal waste water treatment plants (WWTP in **Figure 3.1**) and released into the river systems. However, an unknown portion of this water is diverted to the overburden aquifers via private wells or municipal wells and septic systems.

Lake Huron

Lake Huron is the ultimate destination for water within the system. Lake Huron receives water from all the components shown in **Figure 3.1**. River systems, overburden and bedrock aquifers all naturally discharge into the Lake. Water from WWTPs also outlets directly into Lake Huron. The key process for Lake Huron is the extraction of water from the lake for drinking water purposes. The Lake Huron shoreline within the Ausable Bayfield Source Protection Area is host to a large water system which is exploiting Lake Huron. The Lake Huron Water Supply System is a large system which utilizes Lake Huron in order to provide drinking water for the City of London as well as numerous smaller communities both inside and outside of the Ausable Bayfield Source Protection Area. Most notably, the vast majority of water that is extracted from this system is treated and released outside of the Lake Huron Basin.

3.2 Climate of the Study Area

The climate of a region is a significant factor affecting its overall water budget. Precipitation, either in the form of rain or snow, provides the major input to a region's water cycle. Air temperatures influence the form of precipitation, runoff patterns, evapotranspiration rates and soil and ground cover conditions, all affecting water balance. Wind patterns at a macro level affect air moisture and precipitation patterns, particularly as they are influenced by Lake Huron to the west of the study area. At the local level, winds affect evapotranspiration in the growing season, and the drifting and accumulation of snow across the landscape.

Map 3.2 shows the location of the main active or recently active climatological stations located within or in close proximity to the Ausable Bayfield Source Protection Area, including those that have been developed through the years by the local conservation authorities, primarily for flood forecasting purposes.

3.2.1 Precipitation

Table 3.1 summarizes the Atmospheric Environment Services (AES) climate normals (1971 – 2000) for all AES stations within the study area for which these long-term climate normals have been prepared. Long-term data from these stations indicate that annual precipitation in the study area ranges from 975 mm to 1185 mm. In general, the precipitation levels are fairly uniform across the months, although the tendency is for the fall period (September through November) to receive slightly more precipitation than the other months of the year. Snowfall makes up a good portion of the annual precipitation for the SPA.

The Ausable Bayfield and Maitland Valley source protection authorities initiated a study to address the data concerns associated with the current available precipitation datasets. The study involves comparing historical AES climate (precipitation and air temperature) data with historical Conservation Authority (CA) data. The analysis is being undertaken by Schroeter and Associates using data filling techniques they have developed and described in Schroeter et al. (2000). The outcome of this project is a minimum 55 year (1950 to 2006) complete set of daily precipitation and air temperature data, as well as hourly precipitation data for the CA and AES stations in the Ausable Bayfield Source Protection Area. These datasets will be valuable for use in more fully characterizing precipitation amounts, form and distribution throughout the study area and will be valuable input files for numerical modeling tools.

Table 3.1 Long Term Climate Normals for Stations Within and Near the Ausable Bayfield Source Protection Area

CLIMATE STATION	DRAINAGE AREA (km^2)	CLIMATE STATISTIC	MONTH												
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Brucefield	54.9	**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	54.9	**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	54.9	**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	54.9	**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	54.9	**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**

Source: Atmospheric Environment Services

3.2.2 Air Temperature

Daily maximum, minimum and average air temperature is a common climatological input for most numerical water budget models. Therefore historical data characterizing this weather measurement from the study area will be valuable. **Table 3.1** summarizes the long-term normals for air temperature as measured at the main AES stations within the SPA. The average annual temperature ranges from 6.7°C to 8.0°C. Lake Huron tends to moderate air temperatures, having a decreasing impact as one moves inland. Average daily air temperatures are typically below freezing for the months including December through March in the study area. Comparing the average annual long-term normal temperatures over the past 20 years would suggest a very slight rise in the average annual temperature. Four of the six stations with data available for comparison show increases ranging from +0.1°C to +0.7°C. The other two stations saw a 0.3°C drop in the same time period. Overall, the difference in average temperature at the long-term stations is a minimal +0.17°C.

Air temperature data has not been collected as long at many of the CA climate stations. Many temperature sensors were installed in 2000 or later. Data filling techniques described for precipitation data (See Section 3.2.1) have also been applied to daily maximum, minimum and average air temperature data for the SPA to acquire a complete set of air temperature data for characterization and numerical modeling purposes (Schroeter et. al., 2000).

3.2.3 Wind, Barometric Pressure and Solar Radiation

Relatively few climatological stations in the SPA have measured wind speed and direction, barometric pressure, or solar radiation in the past. These data are useful as inputs for estimating potential evapotranspiration and may assist in other modeling tasks in the future. A few CA stations have been equipped to record these data, primarily since 2003, although some of the stations have been recording some, or all of this information since 1990.

Some initial use has been made of this climatological data to assist in estimating actual evapotranspiration rates occurring in the study area. The analysis, described in the section to follow, was completed for the 2004 calendar year only as this was the first and only full year of detailed data available. Nevertheless, it does demonstrate how such data may be used in future modeling exercises and will assist in evaluating the importance of collecting and maintaining such data.

3.2.4 Evapotranspiration

A report on the water quantity resources of Ontario (Acres Consulting Services, 1984) estimates that the mean annual evapotranspiration averaged over the province is 415 mm. The provincial average varies from less than 300 mm in the north to over 600 mm in the south. The report estimates that, in the southern areas of the province, approximately 60% of the precipitation that falls is lost to the atmosphere through evapotranspiration. This would suggest the Ausable Bayfield Source Protection Area should be experiencing evapotranspiration rates in the range of 500 to 575 mm/year. In a separate study, Dickinson and Diiwu (2000) suggested actual evapotranspiration should lie between 500 mm and 550 mm in Ontario’s southwest and 450 mm to 500 mm in Central Ontario.

The weather stations that collect data on air temperature, wind speed, barometric pressure and solar radiation are capable of estimating potential evapotranspiration (PET). Such stations have only been operational in the study area since mid 2003. A methodology for estimating actual evapotranspiration (AET) was developed using the PET calculated by the weather station at the nearby Wroxeter station and the existing Basin Runoff Forecast Unit (BRFU) hydrology (flood forecasting) model for the study area. **Table 3.2** summarizes the results for each of the study area’s gauged watershed units. This methodology used the BRFU model to estimate the water content of the top soil layer. Soil water content decreased the longer the elapsed time since the last precipitation event, reducing the amount of actual evapotranspiration that could occur. Immediately following a significant rainfall event that restored the water in the top soil layer, AET was allowed to rise to the PET for the day and slowly decline based on the modeled soil moisture content until the next rain event. The data in **Table 3.2** estimates actual ET in the study area to fall between 375 mm and 450 mm. This is slightly less than expected and may be a function of the lower precipitation inputs to the estimation approach and possibly the lower temperatures experienced in the 2004 growing season.

Table 3.2 Estimation of Actual ET within the Study Area's Gauged Watershed Units

Gauged Watershed Unit	**Estimated Actual Evapotranspiration (2004)** (mm/year)
Ausable	
Parkhill Inflow (02FF008)	418
South Parkhill Creek (02FF004)	402
Exeter (02FF009)	429
Springbank (02FF002)	376
Bayfield	
Silver Creek (02FF011)	375
Varna (02FF007)	451

3.2.5 Land Cover

Map 3.3 presents land cover in the Ausable Bayfield Source Protection Area. It is based on data published through the Ontario Ministry of Agriculture and Food's (OMAF) agricultural land inventory project undertaken in the late 1970s and early 1980s (OMAF, 1983). As such, the information on this map is dated. Nevertheless, it does give a regional overview of the trends in land cover across the study area. Approximately 82% of the SPA is agricultural land under various crops and cropping practices. Approximately 15% of the area is under undisturbed vegetative cover (i.e. woodlots, natural areas). Only 3% of the land area has been developed for urban and industrial use.

Based on the 1983 data, agricultural cropping activities which result in less vegetative cover through the year are distributed throughout the source protection region but are somewhat more concentrated in the south and in the lakeshore gully areas of the SPA. Areas with higher livestock based agriculture (i.e. dairy or beef) are more likely to see increased areas of pasture and hay production and more land in rotation under grass cover throughout the year. Since this land use survey was completed, some land managers, particularly those operating farms that are non-livestock based, have moved to using conservation tillage practices to reduce production costs and provide improved soil cover, particularly during the non-growing season. The extent of conservation tillage practices in the area, however, is not well documented.

The Ausable Bayfield Source Protection Authority teamed with the Ontario Ministry of Agriculture, Food and Rural Affairs to assess the applicability of the 1983 land cover data relative to current conditions. Land cover information is being collected in the field for the sub-watersheds listed in **Table 3.3**. Data gathered will be compiled and the results compared with the 1983 mapping. As well, where possible, information is being collected on the tillage practices being used in the area. This will further enhance our understanding of the land cover conditions in the study area. As well, the data has the potential to be used to verify remotely sensed land cover data when it becomes available and could assist with calibrating remotely sensed images.

Table 3.3 Areas of Study for Updated Land Cover Project

Study Area Drainage System	Sub-basin(s) where 2005 Land Cover is being Collected
Ausable	South Parkhill Creek, Exeter
Bayfield	Seaforth
Shore Streams and Gullies	Desjardin Drain, St. Joseph Creek, Kerry's Creek, Eighteen Mile

Source: McKague, K., OMAFRA

3.2.6 Infiltration

The capacity of the landscape to partition falling precipitation as either: interception water, runoff, or infiltration, plays a major role in the pathways for contaminant movement. Therefore some understanding is needed, both spatially and temporally, as to the potential for infiltration versus runoff to occur across the study region. Soils mapping as well as land use mapping were combined to provide a spatial overview of the relative potential for infiltration versus runoff across the study region, while default model input parameters used by the BRFU flood forecasting model were summarized to give some indication of temporal effects on infiltration capacity.

Soils information classified by hydrologic soil group is shown in **Map 3.4**. It is seen from this map that soils with a lower final infiltration rate (soil groups D and C) are more dominant in the southern half of the SPA and in bands inland along the lakeshore, suggesting higher levels of runoff from these lands. It is important to remember, however, that this soil classification approach does not account for "short-circuit" flow pathways that can develop in these finer-textured soils in dry weather in the form of cracks or macropores. Large cracks have the potential to develop, particularly in the summer months, due to the shrinking of clays forming the soil matrix. The result is an increase in the infiltration capacity of these soils even though they have relatively impermeable soils.

Temporally, infiltration capacity varies significantly depending on the soil and cover conditions of the study region at the time of the precipitation event. Attempts have been made in the past to capture this reality in the parameters used to define infiltration in the BRFU flood forecasting models for the major river systems of the study area. The baseline (maximum) infiltration rate is representative of June conditions (ABCA river systems) and July (MVCA river systems). In other months of the year the infiltration rate is adjusted downward by an adjustment factor to account for seasonal variations. Low infiltration values in the winter months are a function of frozen soil conditions that typically are present at that time. Observed historical runoff/streamflow patterns also show a similar trend to lower infiltration, higher runoff in the early spring and late fall periods.

3.3 Runoff and Streamflow

Streamflow has been monitored for a number of years in the Ausable Bayfield Source Protection Area and provides the basis for assessing the hydrologic response of the study area's gauged watershed units. **Map 3.2** identifies the current stream gauging stations and their associated gauged watersheds. No long-term data presently exists to assist with characterizing the runoff response of lakeshore streams and gullies. Historical daily and maximum/minimum streamflow data recorded and archived by Water Survey of Canada for stations within the SPA are summarized on a monthly basis in **Table 3.4**. The length of record for each station is identified in the table's first column. In general, the southern area of the SPA tends to experience lower total annual runoff volumes. The Silver Creek watershed has only one year of data associated with it, limiting the validity of the mapped result.

Seasonal variability in runoff across all monitoring stations and associated watershed is worth mentioning. An analysis of the data presented in **Table 3.4** reveals that, on average across the study region, approximately 76% of the total runoff occurs in the months beginning December through to May (i.e. much of the non-growing season). If baseflows were removed from this total streamflow volume, then it is expected that this percentage would increase. Such conditions suggest that an ideal water budget needs to be effective at modeling winter hydrology, snowmelt and early spring hydrologic conditions.

3.3.1 Baseflow

The baseflow (groundwater discharge) fraction of total streamflow was estimated for the years 2003 through 2004 using a graphical baseflow separation technique applied in a module of the BRFU hydrologic model developed for the SPA river systems. In general, baseflow values lie between 105 mm/year and 420 mm/year. Many of the higher baseflow values observed may be influenced by direct anthropogenic activities. For example, Exeter's baseflow, which in the analysis was shown to have the highest baseflow index (BFI), is likely being augmented to some extent by Morrison Dam and reservoir upstream. Discharge from the town of Exeter's wastewater treatment plant is also expected to be significantly influencing this BFI value. Data on wastewater plant outflows will be required to further assess their full impact.

Table 3.4 Historic daily Maximum/Minimum Flow Data for the Ausable SPA

PLANNING REGION SUBWATERSHED	DRAINAGE AREA (km^2)	STREAMFLOW STATISTIC	MONTH												
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
BAYFIELD															
Silver Creek (02FF011)	--	Day Count (days)	0	0	0	0	0	0	0	0	20	31	30	31	112
(2002 - 2002)		Average Daily Flow (m^3/s)										0.01	0.02	0.16	
		Maximum Daily Flow (m^3/s)									0.02	0.03	0.07	1.72	1.72
		Minimum Daily Flow (m^3/s)										0	0.01	0.02	
Varna (02FF007)	466	Day Count (days)	1116	1017	1116	1080	1116	1080	1116	1116	1080	1147	1110	1147	13241
(1966 - 2002)		Average Daily Flow (m^3/s)	7.18	9.08	17	10.9	4.24	2	1.18	0.86	2.56	3.52	6.89	8.27	6.13
		Maximum Daily Flow (m^3/s)	153	264	280	181	127	74.8	87	32.7	205	85.3	129	148	280
		Minimum Daily Flow (m^3/s)	0.37	0.47	0.7	1.45	0.34	0.09	0.03	0.04	0.04	0.07	0.14	0.36	0.03
AUSABLE															
Parkhill Inflow (02FF008)	110	Day Count (days)	899	839	930	900	930	900	930	930	900	930	900	930	10918
(1973 - 2002)		Average Daily Flow (m^3/s)	1.62	2.28	3.54	2.05	0.85	0.49	0.32	0.19	0.83	0.83	1.62	1.89	1.37
		Maximum Daily Flow (m^3/s)	30.4	39	32	36.8	26.1	15.6	17.8	14.4	28.5	21.1	28.3	24.4	39
		Minimum Daily Flow (m^3/s)	0.03	0.07	0.06	0.19	0.04	0	0	0	0	0	0	0.03	0
South Parkhill Creek (02FF004)	41.4	Day Count (days)	1147	1045	1410	1420	1147	1110	1147	1147	1110	1178	1140	1178	14179
(1955 - 2002)		Average Daily Flow (m^3/s)	0.66	1.03	1.52	0.66	0.32	0.25	0.11	0.08	0.33	0.37	0.66	0.83	0.59
		Maximum Daily Flow (m^3/s)	33.7	47.8	38.1	16	12.2	21.5	9.25	11.5	29.7	15.2	18.7	16.4	47.8
		Minimum Daily Flow (m^3/s)	0.01	0	0	0	0	0	0	0	0	0	0	0.01	0
Exeter (02FF009)	113	Day Count (days)	558	508	558	540	558	540	558	562	570	589	570	589	6700
(1984 - 2002)		Average Daily Flow (m^3/s)	2.27	2.56	3.96	2.23	1	0.81	0.59	0.3	1.12	0.95	1.95	1.97	1.63
		Maximum Daily Flow (m^3/s)	40.4	47.8	28.5	29.7	20.5	43	43.3	14.8	43.7	16.4	31.7	22.1	47.8
		Minimum Daily Flow (m^3/s)	0.1	0.16	0.22	0.32	0.07	0.01	0	0	0	0.01	0.02	0.1	0
Springbank (02FF002)	865	Day Count (days)	1705	1554	1749	1710	1767	1710	1767	1767	1710	1798	1740	1798	20775
(1945 - 2002)		Average Daily Flow (m^3/s)	12	16.1	29.4	18.1	7.45	3.94	2.23	1.68	3.55	5.08	9.68	14	10.2
		Maximum Daily Flow (m^3/s)	207	351	317	351	165	120	227	53	205	244	156	250	351
		Minimum Daily Flow (m^3/s)	0.23	0.23	0.91	0.82	0.3	0.14	0.1	0.06	0.11	0.03	0.17	0.28	0.03

Source: Water Survey of Canada

Table 3.5 Estimation of Actual ET within the Study Area's Hydrologic Response Units.

Gauged Watershed Unit	Average Annual Estimated Baseflow (mm)	Baseflow Index
Ausable		
Parkhill Inflow (02FF008)	106	0.36
South Parkhill Creek (02FF004)	136	0.33
Exeter (02FF009)	341	0.76
Springbank (02FF002)	130	0.35
Bayfield		
Silver Creek (02FF011)	142 (see note 1)	0.46 (see note 1)
Varna (02FF007)	158	0.33

Note 1: Data for 2004 only.
Source: Data calculated from CA gauges.

3.4 Groundwater System

3.4.1 Geology

3.4.1.1 Precambrian Basement Rocks

Underlying the entire source protection region and a large majority of the North American continent, are the metamorphic rock associated with the large physiographic feature called the Canadian Shield. These rocks are not exposed in the study area and what is known of them is known from oil and gas exploration wells which were terminated in the Precambrian rocks. From these drilling data, the rocks which underlie our area have been correlated with rocks of the Grenville Province, understood to have been formed between 1.7 and 2.5 billion years ago. East and north of the study area these rocks are exposed to the surface. In these areas, these rocks are dominated by metamorphosed plutonic rocks with thin bands of meta-volcanic and meta-sedimentary sequences. These rocks form the foundation upon which the later carbonate rocks were deposited.

Although the Precambrian geology of the area is not considered to have a significant influence on the hydrogeology of the area, it has played a significant role as a regional control on the deposition of later rocks. Two major features which have acted as regional-scale controls on the deposition, and are attributed to these rocks, are the development of the Michigan Basin and the Algonquin Arch.

The Michigan basin is composed of younger carbonate rocks but is centered along a failed rift zone (the North American rift) which unsuccessfully began to open approximately 1.1 billion years ago. The basin which formed as a result provided the initial depression into which the younger carbonate rocks were deposited, and began approximately 545 million years ago. The basin is centered in the middle of the main peninsula (a.k.a. the 'thumb') of Michigan, and it is the regional structure that the carbonate rocks of the study area are associated.

The second major Precambrian feature which has controlled the deposition of the younger carbonate rocks in our area is the Algonquin Arch. The Algonquin Arch is a linear uplift of the Precambrian rocks that extends roughly from the Algonquin Park in central Ontario southwest through to the Windsor area. The Algonquin Arch is poorly understood, but may have formed during an early phase of orogeny in the Appalachians. The arch likely acted as a barrier between waters circulating between the Michigan Basin and those associated with the fore-arch basinal waters of the Appalachians. As such it has had a profound effect on the depositional facies of similar aged rocks on either of its flanks. It is of particular note to our study area, that the Algonquin Arch, during deposition of the Lucas formation, likely restricted flow in the western portion of the Michigan Basin leading to development of Sabkha sequences in these rocks with which modern day sinkholes have developed. In fact, over time, the Algonquin Arch has had such a significant influence on the topography of the area that even today the boundaries between the Lake Huron and Lake Erie and Ontario basins can still be roughly traced along the spine of the Arch.

Some smaller Precambrian features may have also had an effect on present day topography, as it has been noted that major bedrock valleys in the younger carbonate rocks (i.e. the Dundas Bedrock Valley) and even modern river valleys have similar orientations as some of the larger Precambrian faults.

3.4.1.2 Paleozoic Bedrock of Southern Ontario

After a non-conformity spanning approximately 500 million years, deposition of the sedimentary rocks of the Michigan Basin commenced. The Michigan Basin is the dominant regional structure controlling deposition of rocks in central North America during this time. The Michigan Basin is a roughly circular depression centered within the present day State of Michigan and on the failed North American paleo-rift. The entire sequence of rocks within the Michigan Basin was deposited in warm seas analogous to modern day deposition in tropical regions. Periodic climatic and sea level changes led to the slight differences in the lithologies which were deposited. As an example of this, during periods of relatively high sea level, deeper water sediments such as shales and mudstones were deposited, while during lower stands, shallow water limestone, sabkha and reefal facies dominated. Indeed, there are likely several points during the deposition of these rocks that they were aerially exposed and eroded. In addition, differences in water chemistry led to slightly different chemical compositions of the rocks themselves.

The rocks of this area dip slightly towards the interior of the Michigan basin (southwest for the study area) and as such, the oldest rocks are exposed in the far northeastern portion of the study area. **Map 3.5** shows the major bedrock units in the SPA. For the purposes of this document, only bedrock units which subcrop in the SPA will be discussed, from oldest to youngest beginning with the Lucas formation. These formations are used as domestic and municipal sources of drinking water throughout the study area, which will be dealt with in Section 3.4.2 of this report.

Lucas Formation

The Lucas formation is composed of non-fossiliferous, microcrystalline limestones and dolostones. The Lucas formation subcrops in a small area within the far northeastern portion of the study area, including an inlier within the overlying Dundee formation that may be evidence of another bedrock valley in the area which extends from Hensall to Lake Huron at St. Joseph. The Lucas outcrops within the SPA near the Seaforth area.

The Lucas was deposited in extremely warm waters during a prolonged period of restricted flow within the Michigan Basin. These conditions led to the development of typical Sabkha sequences in the Lucas, which may also be responsible for the characteristic chemistry and groundwater within the Lucas.

Near the contact between the Lucas and the overlying Dundee, the Lucas has been associated with karst development. Within the study area, several sinkholes (see **Map 3.6**) are developed along the contact between the Lucas and the Dundee. Several studies have been conducted, and are continuing, which are investigating the relationship between the Lucas and karst development in the SPA (Waterloo Hydrogeologic Inc., 2002, 2004).

The Lucas formation is considered a high quality, high yielding aquifer in the study area and as such is used extensively as a source of drinking water. Numerous municipal wells have been completed into the Lucas formation for this purpose. The water is known for high levels of fluoride. In fact, the pioneering study on tooth decay that led to the use of fluoride in toothpaste was initiated in a community (outside of the study area) which was exploiting the Lucas for its groundwater, and where a dentist noticed a dramatic decrease in the instances of tooth decay.

Dundee Formation

Overlying the Lucas is the grey brown, highly fossiliferous Dundee formation. The Dundee formation is characterized by fossiliferous limestones and can be identified by the presence of the fossil zooplankton species *tasmanides*. The Dundee subcrops through a large portion of the SPA and outcrops along the shore of Lake Huron between Goderich and Bayfield as well as within the beds of the Ausable and Bayfield Rivers.

The relatively impermeable Dundee formation is a well-known aquifer of variable quality and quantity and is exploited widely for domestic drinking water supplies. In an area located east of the village of Hensall, the Dundee is thought to be host to a relatively shallow, perched aquifer.

Hamilton Group

The Hamilton Group is composed of interbedded shales and limestone horizons of the Bell, Rockport, Arkona, Widder, Hungry Hollow and Ipperwash formations with a total thickness of between 70 and 90 metres. The Hamilton Group subcrops in the southwestern portion of the SPA near Grand Bend and outcrops along the shore of Lake Huron, along the Ausable River in Rock Glen, as well as several inland locations. The uppermost Ipperwash formation forms an erosion resistant cap rock to the Hamilton Group. This has led to the development of a small escarpment which runs from the shore of Lake Huron near Port Franks eastward out of the study area.

Rocks of the Hamilton Group have been exploited historically for the production of bricks and tile. The Hamilton Group, however, is not exploited widely for groundwater as it has been noted to have generally poor water quality due to the presence of petroleum.

Kettle Point Formation

Approximately 30 m thick and extending over only a small portion of the study area is the Kettle Point formation. The Kettle Point formation is composed of highly organic, siliciclastic black shales that were deposited during late Devonian-early Mississippian time. These rocks also contain unique, large calcareous concretions commonly referred to as “Kettles” which have led to its name. These “kettles” can be seen in outcrop along the shore of Lake Huron at Kettle Point.

The Kettle Point is not considered a reliable aquifer in the area due to its low permeability and poor quality.

3.4.1.3 Pleistocene Glacial Geology

Paleozoic-Pleistocene Non-Conformity

Following deposition of the Paleozoic carbonate rocks, a long non-conformity of approximately 300 million years ensued. During this period the bedrock was exposed aerially and was eroded extensively. Erosion during this period was a major factor in the development of bedrock valleys in the study area, while weathering and fracturing of the upper surface of the rocks produced zones of high permeability which are important hydrogeological features for the study area.

Large bedrock valleys were carved into the bedrock surface by surface waters during this time and these continue to be important features, partially controlling the flow and distribution of groundwater in the region. **Map 3.7** shows the elevation of the top layer of the bedrock units. The bedrock surface slopes generally to the west, crossed by a number of smaller bedrock valleys.

Wisconsinan Glaciation

Numerous cycles of glacial advance (stades) and retreat (interstades) covered the study area, further eroding the bedrock and depositing unconsolidated materials. The latest glacial sheets of ice reached their furthest extents during the late Wisconsinan approximately 10,000 to 12,000 years ago. They are responsible for all of the unconsolidated overburden in the study area. During this period, major lobes of the Wisconsinan ice sheet covered the area, eroding pre-existing glacial deposits as well as the bedrock surface. In particular, the deposits of the planning region can be associated with two separate advances of the Wisconsinan Stage, the Port Bruce Stade and the Port Huron Stade, as well as the correspondent Mackinaw and Twocreeken Insterstades.

The dominant features associated with Port Bruce Stade are the deposition of the Elma, Tavistock, Stratford and Rannoch tills. The subsequent retreat of the ice sheets during the Mackinaw Interstade, glacial Lake Arkona was formed leaving behind paleoshoreline deposits and scarps. The re-advance of the ice sheets during the Port Huron Stade led to the deposition of the St. Joseph till in the study area. It also led to the formation of many of the physiographic features which dominate the landscape today, such as the Wyoming, Wawanosh and Seaforth moraines, as well as many of the glacial outwash features. During the latest retreat of the glaciers during the Twocreeken Insterstade, Lake Warren was formed leading to the deposition of shoreline deposits at the base of the Wyoming moraine. Subsequent melting and recession led to the establishment of Lakes Algonquin and Nippissing.

Map 3.6 shows the physiography of the study area and shows, at a crude scale, the distribution of glacial deposits. **Map 3.8** shows surficial geology. The most prominent feature in the area is the prevalence of till deposits which exist throughout the study area and underlie a significant portion of the watershed. Perched atop these till deposits, and less frequently incised into the till deposits, are numerous moraines, spillways, eskers and syn-glacial and post-glacial lake deposits. These deposits are extremely important features as they tend to include coarser grained gravels and sands, which serve as valuable sources of aggregate, and also tend to host many surficial aquifers. These deposits will be dealt with in more detail in the Section 3.4.2 of this report.

Post Glacial Lakes

During and immediately following the recession of the glaciers large lakes were formed. The shoreline deposits from these lakes, and the deltaic deposits from the rivers which had outlet into them, form important deposits of sand and gravel material for the watersheds. Shorelines tended to leave cuestas behind which have become important topographical features. In the study area, four major post glacial lakes are documented, in order of development, Lakes Warren (the oldest), Nippissing, Algonquin and present day Lake Huron. The lakes formed extensive, largely flat clay plains offshore of the shoreline deposits. These clay plains are a key element in the hydrology of the shoreline streams and gullies of the study area.

3.4.1.4 Holocene Erosion and Deposition

Erosion and deposition of sediment continues today. The major rivers of the watershed region continue to erode and transport sediment, which is eventually deposited into Lake Huron, and shape their respective valleys. Lake Huron is a major erosional force and continues to erode the glacial sediments along its shoreline, in the process mining and transporting sediment in cells along the shore. In the very southwestern portion of the area encompassing Pinery Provincial Park, large deposits of this sediment have been and continue to be altered by wind, forming large sand dunes which migrate inland from the shore of Lake Huron.

3.4.2 Hydrogeology

Major aquifers in the Ausable Bayfield Source Protection Area can be divided grossly into two major types – bedrock and overburden. Bedrock aquifers are by far the most important source of drinking water for the watershed region. All municipal supplies outside of the Lake Huron Primary Water Supply System (LHPWSS) rely on groundwater from the bedrock aquifer for their drinking water. A large majority of documented private wells also rely on the bedrock aquifers for their water supplies.

3.4.2.1 Bedrock Aquifers

The bedrock aquifers are composed of an aggregate of the bedrock formations discussed in Section 3.4.1.2. Within each specific bedrock formation, water quality and quantity can differ dramatically, largely a consequence of the chemical and physical characteristics of the rocks themselves.

Throughout the majority of the study area, the bedrock aquifer is confined by an overlying layer of clay and silt till. The aquifer itself is exposed at the surface in only a few locations and is known to have a potentiometric surface well above its contact with the overlying glacial deposits. **Map 3.9** shows the potentiometric surface for the bedrock aquifer for the Ausable

Bayfield Source Protection Area with groundwater flow directions outlined. A major feature of the potentiometric surface is the dramatic drop off which occurs on a north-south trend just east of Exeter. This evidence is corroborated by anecdotal accounts of known aquifer elevations from drillers in the area. This drop off corresponds with an increase in permeability within the Lucas formation which is likely associated with karst development in the area. The dramatic gradient shown on the map may also be partly an artifact of the existence of two bedrock aquifers in the area: the deeper aquifer situated within the Lucas formation and a shallow, perched aquifer within the overlying, more competent Dundee formation.

Regional Groundwater Flow

Groundwater flow within the bedrock aquifers radiates away from the Dundalk area and follows a generally west to southwest flow path towards Lake Huron. An important note of discussion for the purposes of this water budgeting exercise is that a significant portion of groundwater inside the SPA originates from the north and east outside of the SPA.

Groundwater-Surface Water Interactions

Significant Groundwater Recharge Areas (SGRAs) for the Ausable Bayfield SPA have been delineated using a physical based approach calibrated to Tier 1 surface water models. A thorough discussion on this methodology can be found in Section 3.8 of this chapter.

Little is known about the discharge of water from the bedrock aquifer. Based on potentiometric surfaces for the bedrock aquifer, it is thought that the bedrock aquifer likely discharges into the overlying overburden aquifers in the area but the extent of such an interaction is unknown. In the lower reaches of the major rivers (particularly the Bayfield River) bedrock is exposed in the river beds and it is assumed that the bedrock aquifers in these areas are discharging directly into the rivers. Ultimately the bedrock aquifers are also thought to discharge directly into Lake Huron in the offshore.

Within the watershed region several sinkholes have been documented. These sinkholes have extensive surface drainage areas which are drained directly into the sinkholes, providing a direct conduit of surface water to the bedrock aquifers themselves. Several studies have been completed investigating the development of the sinkholes and the extent of the resultant interaction between surface water and groundwater. These studies indicate that a high volume of water is recharged into the bedrock aquifer via sinkholes.

3.4.2.2 Overburden Aquifers

Located within the unconsolidated glacial deposits overlying the bedrock aquifers are numerous overburden aquifers. These aquifers are locally important sources of drinking water and are essential for their contribution to surface waters and ultimately recharge for the bedrock aquifers. These aquifers are for the most part unconfined and are generally much more susceptible to contamination from surface waters than the bedrock aquifers.

Unfortunately, very little information exists on the overburden aquifers for the watershed region.

A recent study has been completed by the Ausable Bayfield Conservation Authority for Pinery Provincial Park/North Lambton area (Luinstra, 2004). Due to the preference of local drillers for the bedrock aquifers, few well records exist for the overburden aquifers. As such, very little information exists for these aquifers and flow directions, water quality and quantity are poorly understood. In addition, it is recognized that there exists a number of overburden aquifers that are not exposed on the ground surface and for which no mapping exists. Where known, these aquifers have been outlined and will be discussed.

3.4.2.2.1 Surficial Overburden Aquifers

Lake Warren Shoreline Aquifer

Forming a narrow band and extending across, and north and south of the entire Source Protection Area is the former Lake Warren shoreline. These former beaches and dunes have formed well sorted, well rounded sand deposits which are ideal potential aquifers. This aquifer is an important source of cold water for the numerous lakeshore streams and gullies. In addition, several documented private wells are located within this aquifer. This is an unconfined aquifer, and is likely recharged *in situ*, otherwise, very little is known about it.

Lake Huron Beach Aquifer

Located within the beach deposits along the present day shoreline of Lake Huron, the Lake Huron Beach Aquifer is used sporadically as a source of drinking water by various cottagers. This aquifer is an aggregate aquifer composed of a number of unconfined aquifers that are likely recharged *in situ* with some contribution from surface runoff from nearby bluffs, where they exist. Flow within this aquifer is likely towards Lake Huron.

North Lambton Aquifer

The North Lambton Aquifer is one of the best understood overburden aquifers in the study area. In 2004 the ABCA undertook a study of the aquifer in partnership with the Ontario Geological Survey in order to investigate the interaction of the aquifer with the bedrock aquifer and Lake Huron. In addition, a water quality study was completed for this area in 2001, as well as a Masters thesis completed at the University of Western Ontario (Steinbach, 1999).

The North Lambton Aquifer is a composite aquifer located within former lakes Nippissing-Algonquin Beach deposits and more recent aeolian dune deposits. The aquifer is unconfined and is recharged *in situ*. Groundwater flow within the aquifer follows topography with water diverging from two divides, one between Lake Huron and the Old Ausable River Channel and another between the Old Ausable River Channel and the former Lakes Smith and Burwell, located to the east of the aquifer.

The aquifer is separated from the bedrock aquifer by more than 30 metres of clay till and is not connected to the bedrock. The aquifer was extensively used prior to extension of the Lake Huron Primary Water Supply System into the area.

Holmesville Outwash Aquifer

Located between the Wyoming and Wawanosh moraines, the Holmesville outwash deposit comprises an unknown thickness of gravel and sand. This aquifer is host to numerous aggregate extraction operations and is anecdotally well known as a high quantity, high quality aquifer. Several private wells are documented within this aquifer and some smaller developments rely on springs from this aquifer as sources of drinking water.

This aquifer is likely recharged *in situ*, with some contribution from the surrounding, topographically higher moraines. The Holmesville aquifer is an important source of water for a number of surface water bodies, including the coldwater stream, Trick's Creek, as well as the Hay Swamp. Otherwise, very little is known about this aquifer. The Holmesville aquifer also likely discharges directly into, and is an important source of baseflow for, the Bayfield and Ausable Rivers and the lakeshore streams and gullies that extend inland far enough to exploit it.

Seaforth Moraine Aquifer

Located within and on the flanks of the Seaforth Moraine and the associated subparallel outwash deposit, is the Seaforth Moraine aquifer. This aquifer forms a thin, linear band on the eastern flank of the Seaforth Moraine. There exists very little information on this aquifer, but it is thought to be an important source of drinking water for private well supplies in the southern portion of the watershed region, mostly as a result of the general decrease in groundwater quality in the bedrock aquifers in this area.

The Seaforth Moraine aquifer is an important source of water for the Ausable River and possibly the bedrock aquifer. This aquifer is likely recharged *in situ* with some contribution from the topographically higher Seaforth Moraine.

3.4.2.2.2 Confined Overburden Aquifers

Hensall Aquifer

The Hensall aquifer is centred on the village of Hensall and is situated within the overburden. This aquifer is partially confined and may extend to the Seaforth Moraine aquifer. Recharge for the aquifer is located to the east where the sand deposits are exposed on land surface. Very little geological information exists for this aquifer.

The aquifer was formerly the primary source of drinking water for a number of documented private wells. This aquifer is considered to be vulnerable to surface water contamination, which is corroborated by the known water quality problems associated with this aquifer. As a result of this, the Municipality of Bluewater has recently decommissioned the municipal wells which exploited this aquifer, and opted to extend a pipeline from the Lake Huron system into the village of Hensall.

Discharge from this aquifer is poorly understood. The deposit is thought to lie directly on bedrock and, accordingly, is likely a source of inline recharge for the bedrock aquifer.

3.4.2.2.3 Other Overburden Aquifers

Numerous other sand and gravel deposits, which cannot be accurately described at the scale of this report, exist throughout the watershed region. See **Map 3.10** for overburden thickness. These deposits may have local importance as sources of groundwater but are not well documented and poorly understood.

3.4.2.3 Groundwater/Surface Water Interactions

Shallow overburden aquifers are important sources of baseflow for many surface water streams. These aquifers help to moderate flow and provide cold water, valuable for specific fisheries. Shallow overburden aquifers, particularly unconfined aquifers, are areas of increased infiltration due to their coarse grained composition and topography.

Cold Water Fisheries

Map 3.11 shows the cold water fisheries throughout the source protection area. Cold water fisheries are indicative of areas where significant discharge from shallow overburden aquifers is occurring. In fact, a large portion of flows in the surface water systems can be attributed to groundwater discharge. This component of surface water flow is critical for maintaining baseflow and ecological health of the surface water system. Cold water fisheries, as a general rule, also tend to have a higher quality of water as well as quantity, due to the dilution of overland runoff from groundwater discharge. This is an example of how the issues of water quantity and quality cannot be considered discretely, but should be viewed as a single component within the framework of a water budget.

Map 3.11 also shows the locations of dams in the AB SPA. All dams in the AB SPA are not actively regulated and logs are typically installed during the late spring, and removed prior to the winter. Dams have a negligible impact on surface water flows in the area.

Hummocky Terrain

Hummocky terrain is described as areas with broad, gently sloping swales, within which there is increased depressional storage and increased flow lengths for overland flow. These factors lead to slower runoff to surface waters and a coincident increase in infiltration. Indeed, hummocky terrain tends to predominate within very coarse grained materials where overland flow is not likely to occur. Hummocky terrain is thus important as it may produce a disproportionately high volume of recharge to underlying aquifers.

Hummocky terrain has been identified in the Ausable Bayfield Source Protection Area, yet the full extent of its development has not been mapped. This is considered a data gap for the SPA and several methodologies for mapping hummocky terrain are being tested.

3.4.2.4 Groundwater Monitoring

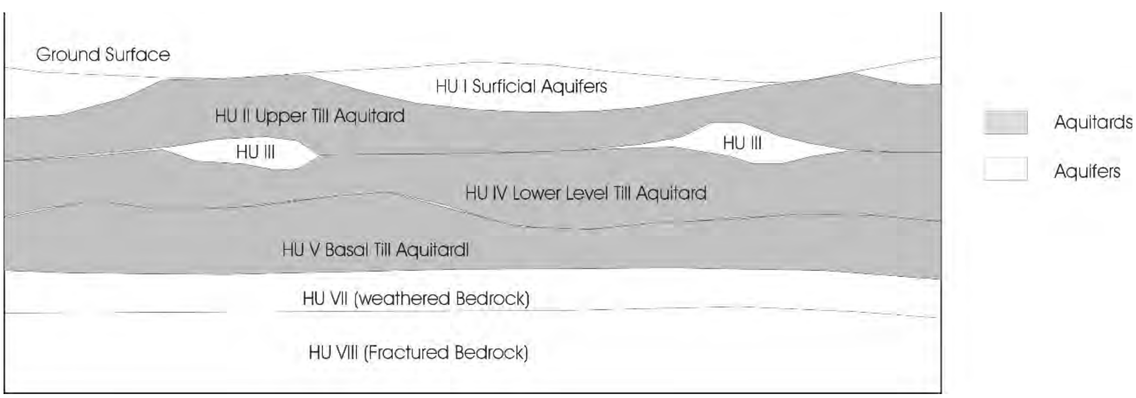
Groundwater monitoring locations were established in the Ausable Bayfield Source Protection Area in 2003 as part of the Provincial Groundwater Monitoring Network (PGMN). These sites have been equipped with water level and temperature loggers and are recording hourly values for these parameters. Due to the relatively short period of record it is not possible to examine long term trends of groundwater levels throughout the source protection region. PGMN monitoring locations are shown on **Map 3.2**.

3.4.2.5 Hydrostratigraphy

In order to develop a numerical groundwater model, the aquifers and aquitards must be developed into a hydrostratigraphy. As part of a regional scale three dimensional groundwater model developed for southern Ontario, a hydrostratigraphy has been developed for the watershed region. For this purpose, the geology of Southern Ontario has been broken into eight Hydrostratigraphic Units (HU), of which seven are thought to occur in the Ausable Bayfield Source Protection Area. **Figure 3.2** shows a schematic representation of the hydrostratigraphy, developed as part of this project.

For the purposes of developing a numerical model, each hydrostratigraphic layer was given an elevation, thickness and representative hydraulic conductivities. These layers were then incorporated into a groundwater flow model and calibrated to stream flow data for streams with significant groundwater discharge, as well as to known groundwater levels from existing monitoring sites and the Water Well Information System.

Figure 3.2 Hydrostratigraphy of Study Area**.**



Source: Modified from Waterloo Hydrologic Inc. 2006

Precipitation was applied across the entire study area and the model was used to help determine the pathways of the water.

Hydrostratigraphic Unit (HU) I Upper Unconfined Aquifers

These aquifers are located at the ground surface and include the Howick, the Holmesville, Seaforth Moraine, Wawanosh Moraine, Lake Warren Shoreline, and Lake Huron Shoreline Aquifers.

HU II Upper Till Aquitard

This layer is composed of the various surficial tills in the study area, including the St. Joseph, Rannoch and Elma Tills. This aquifer is an effective aquitard in the study area.

HU III Intermediate Sands and Gravels Aquifer

This unit includes the Hensall aquifer.

HU IV Lower Level Tills Aquitard

These include the lower stratigraphic tills including the Tavistock till.

HU V Basal Sand and Gravel Deposit Aquifer

This unit is not present in the study area.

HU VI Basal Tills Aquitard

This unit is not present in the study area.

HU VII Weathered and Fractured Bedrock Aquifer

This unit includes the upper 3-5 metres of the bedrock aquifers, which has enhanced permeability as a result of weathering and fracturing.

HU VIII Bedrock Aquifer

This unit includes the remaining bedrock aquifers.

3.5 Water Use

3.5.1 Data Sources

A number of sources of data for water usage are available for the Ausable Bayfield Source Protection Area. These data include the Provincial Permit To Take Water (PTTW) database (see **Maps 3.12 and 3.13**), the Water Well Information System, agricultural water usage studies, Statistics Canada census data, and Municipal Well annual reports. These data are useful for approximating the amount of water being extracted in the region. **Table 3.6** shows groundwater takings in the AB SPA while, **Table 3.7** shows surface water takings for the SPA.

Table 3.6 Groundwater Use in the Ausable Bayfield SPA by category (in m³/year)

Subwatershed	Permitted Use	Domestic Use	Agricultural Use	Total	Area (m²)	Mm
ABCA Gullies	0	16,524	373,384	389,907	196,540,843	**1.98**
Ausable	2,012,645	102,065	4,589,686	6,704,396	1,251,937,273	**5.36**
Bayfield	917,848	32,817	975,083	1,925,748	501,829,521	**3.84**
Goderich and Bayfield Gullies	3,218,756	10,873	299,104	3,528,733	109,349,871	**32.27**
Parkhill	290,304	13,304	1,127,427	1,431,035	465,783,570	**3.07**

Table 3.7 Permitted surface water use in the Ausable Bayfield SPA

Subwatershed	Permitted Use (L/yr)	Permitted Use (m³/year)	Area (m²)	Mm
ABCA Gullies	0	0	196,540,843	**0.000**
Ausable and Mud Creek	2,352,374,282	2,352,374	1,251,937,273	**1.879**
Bayfield	0	0	501,829,521	**0.000**
Goderich and Bayfield Gullies	0	0	109,349,871	**0.000**
Parkhill	517,296,528	517,297	465,783,570	**1.111**

3.5.2 Municipal Water Takings

Water takings for municipal drinking water supplies comprise a high volume of water takings within the Ausable Bayfield Source Protection Area. Most of these takings are exploiting bedrock aquifers with only one supply reliant on Lake Huron.

The Lake Huron Primary Water Supply System, which serves the City of London and numerous other communities, is a major taker within the Ausable Bayfield Source Protection Area. Of particular interest for the purposes of this water budgeting exercise, a majority of water from this system outlets in the Thames River system, outside the Ausable Bayfield Source Protection Area. As such, the Lake Huron Primary Water Supply System represents the largest consumptive water taking in the region.

Several smaller water supply systems exploit Lake Huron as a water source, including Goderich and several smaller private systems in the Municipality of Lambton Shores. Each of these systems outlets directly into Lake Huron via small lakeshore gullies.

Quantifying municipal water takings was completed as part of the Tier 1 Water Budget. Results from this exercise are shown below.

3.5.3 Agricultural Water Takings

Agriculture, including livestock feeding operations and irrigation, represents the largest land use within the Ausable Bayfield Source Protection Area. As a result, it is also expected that the highest water takings will also be associated with these operations.

Agricultural operations rely heavily on the bedrock aquifers as a water supply, with relatively few takings from surface water. Surface water takings associated with agriculture increase to the southern portion of the region, particularly in areas where bedrock water is known to be poor in quality.

Quantifying takings from agriculture is a difficult task. Most livestock facilities are not required to obtain a Permit to Take Water (PTTW), and as such, estimations of usage will be made for the different sectors. The University of Guelph completed an agricultural water usage survey which examined takings for different sectors, and this information has been correlated with agricultural census data in order to provide an estimate of overall water takings as part of the Tier 1 Water Budget.

Irrigation facilities often have PTTWs, and as such some information on their water takings may be obtained. However, the PTTW database often lists maximum allowable takings and may not represent actual takings. The newly amended PTTW regulation will require flow monitoring for all permits but this data is not yet available. With the aim of gaining a greater understanding of these takings, contact with operators was made in order to access records (required under existing permits) of takings (Luinstra Earth Sciences, 2006). The results of this work were incorporated into the Tier 1 Water Budget.

3.5.4 Private Domestic Consumption

Private consumption within the Ausable Bayfield Source Protection Area almost exclusively exploits the overburden and bedrock aquifers. The typical scenario involves a drilled, or less commonly, bored wells which recycle water into shallow overburden aquifers via a septic system.

The overall amount of water which is transferred from deeper aquifers to shallower aquifers needs to be addressed in order to accurately represent the flow of groundwater in the area numerically. To estimate this quantity, an average consumption per household was attributed to individual wells in the Water Well Information System as part of the Tier 1 Water Budget.

3.5.5 Industrial and Recreational Uses

Several industries within the Ausable Bayfield Source Protection Area rely on large quantities of water for production. These include aggregate extraction operations, greenhouses, and golf courses, among others. Other recreational uses include constructed wetlands, reservoirs for recreation and flow augmentation.

Most of these operations rely on the bedrock aquifer. However, several takings of surface water are documented in the PTTW database. To gain a greater understanding of these takings, contact with operators was made in order to access records (required under existing permits) of takings (Luinstra Earth Sciences, 2006). The results of this work were incorporated into the Tier 1 Water Budget.

3.6 Summary of Conceptual Water Budget Results

There are two dominant sources of municipal drinking water in the study area: Lake Huron and the bedrock aquifers. These sources can be considered to be large, high quantity sources. In addition, based on this preliminary water budgeting exercise and the overview of water usage in the area, takings from these sources tend to be small relative to the overall availability of water in the area.

3.7 Summary of Tier 1 Water Budget

A Tier 1 water budgeting exercise is intended to estimate the hydrologic stress of subwatersheds for the purpose of screening out areas from further, more detailed assessment. This is to be done using the best available data for the major hydrologic components and processes of these subwatersheds ("watershed elements"). This data is then compared to the amount of consumptive water demand within a given subwatershed to determine the degree of stress in the hydrologic system due to human water usage.

This section is a summary of the Ausable Bayfield Maitland Source Protection Region Tier 1 Water Budget Report (Luinstra Earth Sciences, 2008) which has been completed in compliance with the Technical Rules (MOE 2008).

3.7.1 Subwatersheds for Tier 1 Water Quantity Stress Assessments

For the Tier 1 Water Budget, new subwatersheds were proposed for the purposes of performing subwatershed stress assessments. These subwatersheds were delineated according to a hierarchy of factors, developed with the assistance of the Peer Review Committee, including:

- Total water contributing area for municipal water supplies
- Limits of existing subwatersheds used for modeling purposes
- Areas of concentrated water usage
- Physiographic and hydrologic characteristics

Based on the developed criteria, five different watersheds were delineated for the purposes of the Tier 1 surface water quantity stress assessment, namely:

- Ausable River (Including Mud Creek)
- Parkhill Creek
- Bayfield River
- ABCA Gullies (the Lakeshore Gullies within the ABCA Jurisdiction, south of the Bayfield River)

- Goderich and Bayfield Gullies (the Lakeshore Gullies between the mouths of the Maitland and Bayfield Rivers)

These units are shown on **Map 3.14**. A detailed rationale for the delineation of Tier 1 subwatersheds can be found as Appendix A to the Tier 1 Water Budget report (Luinstra Earth Sciences 2008).

3.7.2 Modeling

Quantitative estimates of the flow of water between the watershed elements for these subwatersheds were derived from existing surface and groundwater models.

3.7.2.1 Surface Water Modeling

Surface water modeling was carried out for the entire Ausable Bayfield Source Protection Area using the Soil and Water Assessment Tool (SWAT). This tool was used to simulate long-term evapotranspiration, streamflow, and deep drainage for all the major river systems located within the Ausable Bayfield Source Protection Area including the Bayfield River, the Parkhill River, the Ausable River as well as the extensive set of lakeshore gullies and streams situated along the Planning Region's Lake Huron shoreline. A report outlining the steps required to complete the modeling was developed by McKague and Mao (2007).

The simulated quantification of these watershed elements is essential in determining the Tier 1 subwatershed stress assessments for the region.

3.7.2.2 Groundwater Modeling

A fully calibrated 3D groundwater flow model was developed for the region using FeFlow groundwater modeling software. An existing model was completed at a coarse, regional scale for the combined jurisdictions of the Maitland, Ausable Bayfield, St. Clair, Upper Thames, Lower Thames, and Essex Region conservation authorities, and as such, is collectively known as the Six CA Groundwater Model. Details on this project, including information on development and calibration of the conceptual and groundwater flow models are available in the *Six CA Groundwater Modeling Report* (WHI, 2006).

The groundwater flow within the model was calibrated against static water levels from MOE water well records, Provincial Groundwater Monitoring Network wells throughout the region, and to fourth order or greater streams. Water well records were screened based on confidence in locations, and elevations from these water well records were adjusted using the Digital Elevation Model (DEM) for the area.

For the purposes of that project, each of the five Tier 1 subwatersheds were separated and refined from the Six CA scale model. In order to extract models, the regional scale model was overlain with a layer outlining the Tier 1 subwatersheds. As the individual elements within the model were of a coarse scale, some elements traversed subwatershed boundaries. In order to address this problem, the finite element mesh near subwatershed boundaries was refined, to 100 m, 50 m and finally 25 m sizes at subwatershed boundaries prior to extraction using FeFlow. Boundary conditions for each Tier 1 subwatershed groundwater model were extracted using FeFlow from the fully calibrated regional-scale model.

Tier 1 subwatershed models were simulated for the period 1985-2005. Groundwater fluxes were developed using the continuous boundary flux methodology within the FeFlow water budgeting module.

Based on available data and parameters modeled as part of the Tier 1 Water Budget the following cursory numeric water budget was developed for the Region and is shown as part of **Table 3.8**, below.

Details of the development of the individual watershed elements and fluxes can be found in the Ausable Bayfield Maitland Source Protection Region *Tier 1 Water Budget Report* (2008) and that by McKague and Mao (2007).

Table 3.8 Tier 1 Water Budget for the Study Area **(All values expressed as mm/year of equivalent precipitation)**

Tier 1 SubWat	GW-IN	PPT	**IN**	ET	Sur. Q	Rech.	Anthro	GW-Out	Bflow	**Out**
ABCA-Gully	568	971	**1539**	330	311	295	2	607	241	**1304**
Ausable	132	962	**1094**	430	292	218	7	206	115	**1038**
Bayfield	13	991	**1004**	421	326	221	4	63	104	**931**
Parkhill	13	935	**948**	426	286	206	4	135	91	**966**
G-B-Gullies	217	1058	**1275**	387	324	307	32	1	235	**816**

GW-IN = Groundwater flow in; PPT = Precipitation; ET = Evapotranspiration; Sur. Q = Streamflow; Rech. = Recharge; Anthro= Total Consumptive Water Use; GW-Out = Total groundwater flow out (includes Baseflow); Bflow = Baseflow

3.7.3 Surface Water Supply Estimate

At any given time, the available drinking water supply in a river or stream is limited to the instantaneous flow rate. Surface water supply is a method for determining the amount of flow available based on streamflow data for the Ausable Bayfield Source Protection Area. The prescribed approach for determining the surface water quantity stress takes into consideration seasonal variability, and is therefore evaluated using an estimate of expected monthly flow values.

For each subwatershed within the study area, median flows were calculated to provide an estimate of surface water supply. Fiftieth percentile flows were derived from the daily SWAT analyses for each month and then converted to monthly flows (mm/month).

3.7.4 Surface Water Reserve Estimate

The water reserve estimate for a surface water system in Tier 1 is based on the maximum of a statistical measure of low flow or a known anthropogenic need (i.e. wastewater assimilation). The water reserve estimate is the means by which a portion of water may be protected from being considered within the stress calculations. The concept behind its use is to support other uses of water within the watershed including both ecosystem requirements (instream flow needs) as well as other human uses (primarily permitted uses). The reserve quantity is subtracted from the total water source supply prior to evaluating percent water demand.

For the scale of this Tier 1 assessment surface water reserve is not complicated by the need for assimilative capacity and is therefore most simply expressed as the tenth percentile flows for each subwatershed. Tenth percentile flows were derived from the daily SWAT analyses for each month and then converted to monthly flows (mm/month). In order to be consistent with MOE Technical Rules (2008), for the Tier I surface water stress assessment, reserve values are used for the months with the lowest monthly water supply estimates, rather than the lowest monthly water reserve estimates.

3.7.5 Groundwater Supply Estimate

An estimation of the amount of groundwater available to supply a subwatersheds groundwater users is determined as a summation of groundwater recharge and lateral groundwater flow into the subwatershed. The percent water demand can then be calculated as both average annual and average monthly conditions for current and future (25 year) scenarios. For this Tier 1 analysis, aquifer storage is not considered and as such the water supply terms for the subwatersheds are assumed to be consistent on an average annual basis.

Groundwater flux through the system was developed from the Six CA FeFlow Model. Tier 1 subwatersheds were refined and extracted and flux values determined using continuous boundary flux within the FeFlow water budgeting module.

For the study area, two sources of recharge data are available, estimates derived from the Six CA Groundwater Model (annual only) and from the SWAT analysis (monthly and annual). **Table 3.8** summarizes groundwater flux through the Tier 1 subwatersheds derived from FeFlow. These recharge values derived from FeFlow for the Six CA Model will be used for the Tier 1 assessment. These data are considered the more conservative value, consistent with expectations for a Tier 1 Water Budget.

3.7.6 Groundwater Reserve Estimate

The groundwater reserve for Tier 1 analysis is determined by estimating the reserve quantity as 10% of the existing baseflow (groundwater discharge). Baseflow has been calculated from the Six CA Groundwater Model (annual only) and from the SWAT analysis (monthly and annual). **Table 3.8** shows estimated baseflow derived from SWAT analysis. For the purposes of the Tier

1 analysis, the SWAT based baseflow will be used as it is derived from more accurate streamflow data and has been rectified to actual baseflow determined from gauged streams, where possible.

3.7.7 Consumptive Groundwater Usage Estimate

3.7.7.1 Permitted Usage

Permitted groundwater usage is primarily documented through the PTTW database, as well as through municipal drinking water supply records. Similar to the permitted surface water takings, the best available water taking data (actual, estimated average, maximum permitted) was used to estimate permitted amounts, which were subsequently adjusted using the consumptive factor outlined in the MOE Technical Rules (2008).

3.7.7.2 Non-Permitted Agricultural Usage

Agricultural usage, particularly those not related to crop irrigation are exempt from requiring a Permit to Take Water. As a result, no documentation of this usage is available for analysis. Estimates of agricultural usage were developed based on agricultural data and projected watering requirements from the 2001 census data as part of de Loë (2001). This information is broken into watersheds for all of southern Ontario and was incorporated into the consumptive usage estimates. Estimated takings were then adjusted according to consumptive use factors provided by the MOE Technical Rules (2008).

3.7.7.3 Private-Domestic Usage

Private domestic usage is not considered within the MOE Technical Rules (2008). It was felt, due to the high reliance on groundwater for private potable water sources, that this taking should be incorporated into this Tier 1 water budgeting exercise.

Private well records for each subwatershed, available in the Ministry of the Environment's Well Record Information System (WWIS) were assigned a minimum taking value of 450 L/day, based on usage requirements set out in Ministry best practice documents for the sizing and evaluation of septic systems. These values were then adjusted according to consumptive use factors for domestic water takings provided by the MOE Technical Rules (2008).

3.7.8 Consumptive Surface Water Usage Estimate

3.7.8.1 Permitted Surface Water Usage

Permitted users are the only reliable source for surface water takings for the area. Surface water takings are generally confined to irrigation activities, with the exception of the Lake Huron based municipal (and private) water supply systems, which are necessarily excluded from the Tier 1 water budgeting exercise.

A study was completed in 2006 in order to attempt to determine actual takings for PTTW holders in the area (Luinstra Earth Sciences, 2006). The results of this work have been included in the calculations of consumptive surface water use for the study area. The best available water taking data (actual, estimated average, maximum permitted) was used to estimate permitted amounts, which were subsequently adjusted using the consumptive factor outlined in the MOE Technical Rules (2008).

3.7.9 Future Usage Projections

Future increases in the usage of both (non-Lake Huron) surface water and groundwater are not considered significant for the study area. The study area is considered to be "fully developed" in that it has very little natural area that will likely be converted to either agricultural or residential land uses.

Population growth is projected to be minimal in the immediate future, with growth centered along the shore of Lake Huron and in existing towns and villages. Given the low consumptive water uses in the area it seems unlikely that future usage, based on today's projections, will lead to any additional stress on the natural system. Caution should be added that not all future uses can be accounted for or anticipated, and that no additional stresses are anticipated for the subwatersheds at the scale being investigated. However, large takings within specific areas may still lead to significant problems.

3.7.10 Tier 1 Surface Water Stress Assessment

The Tier 1 surface water stress assessment is designed to screen and flag those subwatersheds where the degree of stress is considered moderate or significant for further study. The stress assessment evaluates the ratio of the consumptive demand for permitted and non-permitted users to water supplies, minus water reserves within a given subwatershed.

Within the study area, for each subwatershed, the monthly water reserve (10^{th} percentile flows) was subtracted from the monthly water supply (median flows) for the month with the lowest monthly water supply in order to determine water availability. The percentage water demand was then calculated as a percentage of the consumptive demand versus this water availability, where:

% Water Demand = Consumptive Demand / (water supply – water reserve) x 100

Subwatershed stress levels are defined as: less than 20% – Low; Between 20 and 50% – Moderate; more than 50% – Significant. **Table 3.9**, below, outlines the water supplies, reserves, availability, consumptive demand, percentage water demand, and surface water quantity stress levels for each subwatershed in the study area. The stress levels are presented graphically in **Map 3.15**. All subwatersheds are considered to have low surface water quantity stress at the scale analyzed for the Tier 1 Water Budget.

Table 3.9 Percentage Water Demand for Surface Water Subwatersheds in the Study Area**. (Expressed as equivalent mm of precipitation)**.

Tier 1 Subwat	Supply	Reserve	Consumptive Use	% Water Demand
ABCA-Gully	5.3	0.1	0	0.0
Ausable	88.6	15.6	1.164	1.6
Bayfield	22.8	5	0	0.0
Parkhill	19.8	2.2	1.696	9.6
Goderich and Bayfield Gullies	7.3	0.1	0	0.0

Based on the criteria for determining surface water quantity stress, the Parkhill subwatershed is not considered to be under stress, although it is approaching the threshold for moderate stress with approximately 9.6% of available water under demand. This is a result of very low median flows through the watershed, which creates a water demand approaching the threshold for moderate stress despite the relatively low takings. There are no municipal surface water takings in the Parkhill subwatershed.

3.7.11 Tier 1 Groundwater Stress Assessment

Similar to the Tier 1 surface water stress assessment, the Tier 1 stress assessment for groundwater is designed to determine the degree of stress within each subwatershed. The stress assessment evaluates the ratio of the consumptive demand for permitted and non-permitted users to water supplies, minus water reserves within a subwatershed.

Within the Ausable Bayfield Source Protection Area, the groundwater reserve (10% of supply) was subtracted from the groundwater supply (recharge plus groundwater influx) in order to determine groundwater availability. The percentage water demand was then calculated as a percentage of the consumptive demand versus this water availability, where:

% Water Demand = Consumptive Demand / (water supply – water reserve) x 100

Subwatershed stress levels are defined for average annual fluxes, as: less than 10% - Low; Between 10 and 25% – Moderate; more than 25% – Significant, and for monthly maximum fluxes as: less than 25% – Low; Between 25 and 50% – Moderate; more than 50% – Significant. **Table 3.10**, below, outlines the water supplies, reserves, availability, consumptive demand, percentage water demand and groundwater quantity stress levels on an annual basis for each subwatershed in the study area.

Table 3.10 Annual Percentage Groundwater Demand for Groundwater Subwatersheds in the Study Area**. (Units are mm/year unless otherwise specified)**

Tier 1 Subwat	GW IN	Recharge	Supply	Baseflow	Reserve	Cons. Use	% Water Demand
ABCA-Gully	568	121	689.0	241	68.9	1.98	**0.32**
Ausable	132	132	264.0	115	26.4	5.36	**2.26**
Bayfield	13	133	146.0	104	14.6	3.84	**2.92**
Parkhill	13	144	157.0	91	15.7	3.07	**2.17**
Goderich and Bayfield Gullies	217	141	358.0	235	35.8	32.27	**10.02**

The annual groundwater stress levels are presented graphically in **Map 3.16**. All subwatersheds are considered to have low annual groundwater quantity stress, with the exception of the Goderich and Bayfield Gullies, which are over the threshold developed for moderate stress. It is important to note that these stress assessments are relevant only at the scale analyzed for the Tier 1 Water Budget.

Based on the criteria for determining groundwater quantity stress, the Goderich and Bayfield Gullies subwatershed is considered to be under stress, passing the threshold for moderate stress with approximately 10.02% of available water under demand. This is a result of very high consumptive takings that create a water demand above the threshold for moderate stress despite the high water supply. There are several municipal groundwater supplies within the Goderich-Bayfield Gullies subwatershed.

Monthly groundwater stress is shown below in **Table 3.11**. Monthly stress values remain well below stress thresholds for all subwatersheds. This is a result of the relatively low consumptive takings relative to the overall supplies and flux of water through the subwatersheds.

Table 3.11 Monthly Percentage Groundwater Demand for Groundwater subwatersheds in the Study Area**. (Units are mm/month unless otherwise specified)**

Tier 1 Subwatershed	Supply	Reserve	Cons. Use	% Water Demand
ABCA-Gully	52.82	5.28	0.17	**0.36**
Ausable	20.24	2.02	0.81	**4.45**
Bayfield	11.19	1.12	1.25	**12.41**
Parkhill	12.04	1.20	0.31	**2.86**
Goderich & Bayfield Gullies	27.44	2.74	2.86	**11.58**

The Goderich and Bayfield Gullies subwatershed require further investigation as part of a Tier 2 Water Budget to determine and verify any potential stresses, as it is host to several municipal groundwater supplies.

3.7.12 Uncertainty and Data gaps

3.7.12.1 Uncertainty

The uncertainty associated with the Tier 1 watershed stress assessments are specific to the subwatersheds that they have evaluated. Uncertainty, in this context, is a function of the confidence in the final stress assessment, including the cumulative uncertainty inherent in the data used to develop that stress assessment.

In cases where a subwatershed is considered low in stress but approaches the moderate threshold, this uncertainty must be examined more carefully, given the inherent inaccuracy of the model outputs for natural water flux and estimated consumptive water use. The fundamental principle is that Tier 1 stress assessments should be conservative and overestimate stress.

3.7.12.2 Uncertainty Associated with Consumptive Water Usage

In general, there is a high degree of uncertainty associated with consumptive water usage estimates due to the inherent inaccuracy of the available water takings data. In most cases, data on water takings are not reflective of actual takings, but rely on estimates based on permitted values.

In the case of the Ausable Bayfield SPA, permitted values were only used where attempts to gather actual pumping values were not successful (Luinstra, 2006). These values were incorporated into the Tier 1 consumptive use estimates. However, actual takings were not available for all PTTWs, and as a result, the estimates contained herein can be considered conservative, in that they are likely overestimating takings.

3.7.12.3 Uncertainty Associated with Model Outputs

Model outputs are inherently uncertain. SWAT modeling for the study area was calibrated to measure streamflow where possible, and generally it is felt to be reasonably representative of actual conditions. However, it must be noted that it cannot be established that SWAT derived values are more conservative than measured or actual values. FeFlow modeling available for the study area was initially developed for a large, regional scale model. As a result of this, significant simplification of the hydrogeologic system for the study area was required. The resultant uncertainty must be considered high for groundwater flux data derived from this model.

3.7.12.4 Aggregate Subwatershed Uncertainty

Subwatershed uncertainty for groundwater and surface water stress is included in **Table 3.12**, below.

The aggregate uncertainty for all subwatersheds is low, with the exception of the Goderich and Bayfield Gullies and the Parkhill subwatersheds. Uncertainty within the Goderich and Bayfield Gullies must be considered high due to the relatively high percentage water demand (10.02%) and the potential that the groundwater influx values derived from the FeFlow model have significant uncertainty. In addition, the high takings in this subwatershed are a function of one large taking to which actual taking data is not available.

Table 3.12 Surface Water and Groundwater Stress Assessment Uncertainty for Tier 1 Subwatersheds

Tier 1 Subwatersheds	GW Stress	SW Stress	Cons. Use	Aggregate uncertainty
ABCA Gullies	low	low	Low	low
Ausable	low	low	Low	low
Bayfield	low	low	Low	low
Parkhill	low	**high**	Low	**high**
Goderich & Bayfield Gullies	**high**	low	**High**	**high**

Similarly, within the Parkhill subwatershed, percentage water demand is approaching the threshold for moderate stress. Accordingly, it is prudent to assign an uncertainty value of high for the surface water stress assessment in this watershed, based on the inherent inaccuracies of the SWAT-derived flow data and the lack of actual takings for all surface water takings in the subwatershed.

3.7.12.5 Data and Knowledge Gaps

A number of data and knowledge gaps have been identified in the text for the Tier 1 Water Budget, and include:

1. Evaporation data
2. Streamflow and baseflow data for ungauged watersheds;
3. Accurate WWTP discharge data and a system for keeping this data up to date;
4. Certificate of Approval data in order to determine appropriate surface water reserves as defined by assimilative capacity;
5. Delineation of significant recharge areas
6. Actual water takings for all PTTW holders, and a system for keeping this data up to date

3.7.12.6 Limitations

The key limitation to this work is scale. The stress assessments performed for the Tier 1 water budget were completed at the crude, subwatershed scale. For the surface water system, this scale may be considered appropriate for the purposes of drinking water source protection given the lack of municipal or any other drinking water supply from the surface water system. For the groundwater system, the scale should be considered appropriate for the bedrock aquifer, which, although it is host to numerous municipal and private drinking water systems, is a regional scale system and the analysis performed herein considered sufficient. However, overburden aquifers are less well understood and are not well represented in the regional scale groundwater model developed for the study area.

3.8 Summary of Tier 2 Water Budget

A Tier 2 Water Budget was required for the Goderich and Bayfield Gullies subwatershed after it was shown to be moderately stressed for groundwater in the Tier 1 water budget process. Accordingly, the Tier 2 Water Budget focuses solely on this subwatershed, and considers only the groundwater system.

The Tier 2 Water Budget is a more detailed analysis of the moderate or significantly stressed Tier 1 subwatersheds and typically includes advanced modeling and more detailed estimates of consumptive water use. Groundwater and surface water models created as part of the Tier 1 Water Budget are considered to be of sufficient quality and scale for the development of the Tier 2 Water Budget and are employed to develop water quantity stress assessments for the Goderich and Bayfield Gullies subwatershed. Annual and monthly groundwater stress thresholds within the Tier 2 Water Budget are the same as those used for the Tier 1 water quantity stress assessment. Those subwatersheds that are assigned a significant or moderate water quantity stress as a result of the Tier 2 evaluation will require a Tier 3 or local-area water budget and water quantity risk assessment.

3.8.1 Tier 2 Subwatershed Delineation

The Tier 2 subwatershed initially designated for further analysis (the Goderich and Bayfield Gullies subwatershed) was refined based on the presence of large water takings and municipal well supplies in the area. Upon review, it was found that a single large water taking reported in the Goderich and Bayfield Gullies subwatershed was responsible for the bulk of the water takings in the area. Further, this taking was located at the very northern edge of the subwatershed. While it was located a far distance from any of the municipal wells in the Goderich and Bayfield Gullies subwatershed, it was located quite close to the Century Heights municipal supply, located in the MVCA Gullies Tier 1 subwatershed (outside of the AB SPA). Therefore, it was felt appropriate to re-delineate the Tier 2 subwatersheds in order to better reflect the potential impacts of any takings on municipal groundwater supplies.

Map 3.17 shows the newly formed Tier 2 subwatersheds. The Goderich and Bayfield Gullies subwatershed was reduced in size, and a portion of the subwatershed included in a new Tier 2 subwatershed named the Goderich Tier 2 subwatershed. Portions of the MVCA gullies and Lower Maitland Tier 1 subwatersheds were included in the newly formed Goderich Tier 2 subwatershed, based on surface and groundwater flow regimes. **Table 3.13** identifies the municipal systems located in each of the Tier 2 subwatersheds.

Table 3.13 Municipal Systems within Tier 2 Subwatersheds.

SPA	Tier II Subwatershed	Municipality	System
Maitland	Goderich	Ashfield-Colborne-Wawanosh	Century Heights
	Goderich and Bayfield Gullies	Central Huron	McClinchey
			Kelly
Ausable Bayfield	Goderich and Bayfield Gullies	Central Huron	Vandewetering
			S.A.M.

The Goderich and Bayfield Gullies subwatershed is located within both the Maitland Valley and Ausable Bayfield Source Protection Areas. The Goderich subwatershed is located wholly within the Maitland Valley Source Protection Area. However, it is discussed herein since portions of the newly formed Goderich subwatershed comprise part of the original Goderich and Bayfield Tier 1 subwatershed (which was recommended for Tier 1 analysis as part of the Tier 1 Water Budget for the Ausable Bayfield Source Protection Area).

3.8.2 Model Updates

3.8.2.1 Surface Water Models

Existing SWAT models were further refined using the Guelph All Weather Sequential Event Runoff model (GAWSER) in order to include climatic data for 2007, and measured baseflow values for the Goderich-Bayfield Gullies and Goderich subwatersheds. Models were then used to develop groundwater supply and reserve estimates as outlined below for each of the previously delineated SWAT subwatersheds located in **Map 3.17**. **Table 3.14** and **Table 3.15** show the results of the fully calibrated GAWSER modeling for the Goderich and Bayfield Gullies and Goderich subwatersheds for the period 1950-2007, respectively.

Table 3.14 GAWSER Modeling Results for the Goderich-Bayfield Gullies for 1950-2007. **(All values expressed as equivalent mm of rainfall)**

subWAT	PPT	ET	RUNOFF	Recharge
720	1018	673	280	65
721	1018	667	321	30
722	1018	664	305	49
723	1018	629	388	1
724	1018	499	519	0
725	1018	381	637	0
726	1018	641	362	15
727	1018	669	261	88
728	1018	635	378	5
729	1018	673	262	84
730	1018	674	280	65
731	1018	629	388	1
732	1018	674	280	64
733	1018	663	274	81
734	1018	663	280	75
735	1018	631	382	4
736	1018	676	269	74
737	1018	638	373	7
738	1126	419	516	191
739	1126	416	548	162
740	1126	408	631	86
741	1126	411	573	142
742	1126	413	559	154
743	1126	410	608	108
744	1126	408	630	87
745	1126	407	607	113
746	1126	415	543	168
747	1126	425	431	270
748	977	435	377	164
749	977	433	394	150
750	977	456	239	282
751	977	401	425	151
752	977	449	282	246
753	977	448	293	236
754	977	452	267	258
755	977	429	417	131
756	977	465	170	342
757	977	457	225	294
758	977	431	376	169
759	977	464	165	347
760	977	459	153	365
761	977	425	466	85
762	977	435	392	149
763	977	452	263	262
764	977	435	394	148

Table 3.15 GAWSER Modeling Results for the Goderich Subwatershed for 1950-2007. **(All values expressed as equivalent mm of rainfall)**

subWAT	PPT	ET	RUNOFF	Recharge
701	1018	115	902	1
702	1018	115	902	1
703	1018	115	902	1
704	1018	115	902	1
705	1018	115	902	1
706	1018	115	902	1
707	1018	115	902	1
708	1018	197	813	8
709	1018	303	713	2
710	1018	530	476	12
711	1018	634	381	3
712	1018	633	366	20
713	1018	664	309	45
714	1018	663	344	12
715	1018	663	297	58
716	1018	692	277	49
717	1018	692	277	49
718	1018	681	296	41
719	1018	667	313	38
674	1018	690	278	50
675	1018	689	280	49
676	1018	603	389	27
677	1018	675	292	51
678	1018	377	608	34
679	1018	274	666	78
463	1018	559	242	217

3.8.2.2 Groundwater Models

Groundwater flux through the system was further developed from the Six CA FeFlow Model. Tier 2 subwatersheds were refined and extracted and flux values determined using continuous boundary flux within the FeFlow water budgeting module. It is most notable that the groundwater flux data did not change through refinement of the models as it is a boundary condition developed from an overall regional model. Refinements of the model have not included an analysis of the validity of these conditions as such a task was deemed beyond the scope of a Tier 2 Water Budget.

3.8.3 Consumptive Groundwater Use Estimate

Consumptive use estimates developed for the Tier 1 water quantity stress assessment were re-evaluated as part of the Tier 2 Water Budget process. This activity focused on the PTTW data, which is considered the least accurate of the water use information, due to the lack of reported takings for a majority of permit holders.

A study was completed in 2006 in order to attempt to determine actual takings for PTTW holders in the area (Luinstra, 2006). The results of this work have been included in the calculations of consumptive surface water use for the study area. For the Tier 1 water quantity stress assessment, the best available water taking data (actual, estimated average, maximum permitted) was used to estimate permitted amounts, which were subsequently adjusted using the consumptive factor outlined in the MOE Technical Rules (2008). For the Tier 2 water quantity stress assessment, it was felt that further confirmation of takings was appropriate for those permits located within the Goderich and Bayfield Gullies and Goderich subwatersheds. Accordingly, a request was made to the Ministry of the Environment, the regulator of permitted takings, to provide this information for all permits which had no information on actual takings.

Data from the Water Taking Reporting System (WTRS) was used to estimate actual takings where such information was available. Municipal water takings were based on annual average values derived from legislated water reports. Agricultural water usage was developed based on 2006 census data for the subwatersheds following methodology developed by de Loë (2001). Domestic usage was estimated based on the number of wells with records in each subwatershed, and assigning an estimated usage of 450 L/day for each well.

In the Tier 1 Water Budget, consumptive use was reduced through the usage of a consumptive use factor. In both the Goderich and Bayfield Gullies and Goderich subwatersheds, no consumptive factor was applied for the Tier 2 water quantity stress assessment. The takings in this area are from a deep bedrock aquifer, which is confined by a minimum of 25 metres of fine-grained, low permeability sediments. It is therefore prudent to consider all water takings in these areas to be consumptive relative to the source, in this case the deep bedrock aquifer. **Table 3.16** shows annual consumptive water usage for the Goderich and Bayfield Gullies and Goderich subwatersheds.

Table 3.16 Annual Rates of Consumptive Water Use (in m^3/day)

Subwatershed	Permitted use	Agricultural	Domestic	Municipal	Total Use
Goderich	16353	304	107	160	16924
Goderich and Bayfield Gullies	477	688	110	48	1323

Monthly consumptive water use is necessary to complete maximum monthly water demand for the Tier 2 water budget exercise. Permitted water takings were analyzed based on anticipated peak monthly flows, based on permit requirements. Municipal, domestic and agricultural takings were assumed to be constant over the year, and averaged for each month. **Table 3.17** shows maximum monthly rates of consumptive water usage for the Goderich and Bayfield Gullies and Goderich subwatersheds.

Table 3.17 Maximum Monthly Rates of Consumptive Water Use (in m^3/day)

Subwatershed	Commercial	Agricultural	Domestic	Municipal	Total Use
Goderich	16353	304	107	153	16917
Goderich and Bayfield Gullies	500	688	110	64	1362

3.8.4 Tier 2 Water Budget

A summary of the Tier 2 Water Budget values for the Goderich and Bayfield Gullies and Goderich subwatersheds, including precipitation (PPT), evapotranspiration (ET), runoff, recharge, groundwater flux in, and consumptive use are shown below in **Table 3.18**. Precipitation, evapotranspiration, runoff and recharge are derived from GAWSER modeling. Groundwater flow in, is from the Six CA Regional FeFlow Model, and consumptive use is based on estimates developed for the Tier 2 Water Budget.

Table 3.18 Tier 2 Water Budget for the Goderich and Bayfield Gullies and Goderich Subwatersheds (All values expressed as equivalent mm/year of rainfall)

Tier 1 Subwatershed	PPT	ET	RUNOFF	Recharge	Gw Flow IN	Use
Goderich	1018	552	338	129	123	116
Goderich and Bayfield Gullies	1023	543	338	142	153	5

3.8.5 Tier 2 Water Quantity Stress Assessments

3.8.5.1 Groundwater Supply Estimates

An estimation of the amount of groundwater available to supply a subwatersheds' groundwater users is determined as a summation of groundwater recharge and lateral groundwater flow into the subwatershed. The percent water demand can then be calculated as both average annual and average monthly conditions for current and future (25-year) scenarios. For this Tier 2 analysis, aquifer storage is not considered, and as such the water supply terms for the subwatersheds are assumed to be consistent on an average annual basis.

Groundwater flux through the system was further developed from the Six CA FeFlow Model. Tier 2 subwatersheds were refined and extracted and flux values determined using continuous boundary flux within the FeFlow water budgeting module.

For the study area GAWSER modeling results were considered to be the most accurate reflections of actual recharge conditions, given the sensitivity of their calibration when compared with the FeFlow results. GAWSER was also considered to be the more robust of the two surface water models (i.e. in comparison with SWAT) in calculating recharge. As a result, GAWSER-derived recharge values were used for the developing groundwater supply estimates for the Tier 2 subwatersheds.

3.8.5.2 Groundwater Reserve Estimate

The groundwater reserve for Tier 2 analysis is determined by estimating the reserve quantity as 10% of the calculated water supply for the subwatershed.

3.8.5.3 Tier 2 Water Quantity Stress Assessment Results

Tier 2 groundwater quantity stress assessment was developed for the Goderich and Bayfield Gullies and Goderich subwatersheds by incorporating the results of the Tier 2 Water Budget. This is shown in **Table 3.19**, below and graphically in **Map 3.20**.

Table 3.19 Tier 2 Annual Groundwater Quantity Stress Assessment for the Goderich and Bayfield Gullies and Goderich Subwatersheds. **(All values expressed in m^3/day)**

Tier 1 Subwatershed	GW IN	Recharge	Supply	Reserve	Consumptive Use	% Water Demand	Stress
Goderich	17921	19847	37768	3777	16917	50	Significant
Goderich and Bayfield Gullies	38960	34241	73201	7320	1323	2	Low

Based on the Tier 2 groundwater quantity stress assessment, a Tier 3, local area water budget is recommended for the Goderich Tier 2 subwatershed. The relatively low water demand for the Goderich and Bayfield Gullies indicate that it is not under water quantity stress.

3.8.6 Planned Systems

There are no planned systems for either the Goderich and Bayfield Gullies or Goderich Tier 2 subwatersheds.

3.8.7 Future Use Scenario

The Technical Rules require that a future use scenario be undertaken for all Tier 2 subwatersheds. In order to complete this, population growth projections based on official plans are used to estimate future water consumption, and are evaluated based on present day water supply and reserve estimates.

For the Goderich and Bayfield gullies, future population projections range from 20-35% for the 20 year time period (Lakeshore Class EA, 2010). Given the relatively low initial population, the impacts of future growth may have dramatic implications on the water quantity assessment. In order to evaluate this and be conservative, present water use was increased by 35% and water demand estimates were produced. This is shown in **Table 3.20**.

Table 3.20 Water Quantity Stress for the Goderich and Bayfield Gullies Based on 35% Increase in Water Use

Tier 2 Subwatershed	GW IN	Recharge	Supply	Reserve	Consumptive Use	% Water Demand	Stress
God and Bayfield Gullies	38960	34241	73201	7320	2423	4	Low

These future water use conditions are highly conservative, as it is not expected that future population growth would require a 35% increase in water takings. Therefore, under extreme future use scenarios, no water quantity stress is anticipated for the Goderich and Bayfield Gullies subwatershed.

3.8.8 Drought Scenario

The Technical Rules require that a drought scenario be undertaken for all Tier 2 subwatersheds. The intention of the analysis is to determine if a prolonged period of drought could result in a drop in water levels that could interfere with the operation of municipal wells. This is done by comparing the drop in water levels in the aquifer, with the available drawdown for each municipal well.

In order to complete this analysis, the Feflow model for the Goderich and Bayfield gullies was run in transient mode for a period of two years with no recharge. This analysis is thought to represent an extreme drought event.

Under these conditions, water levels across the subwatershed were reduced approximately 0.5-1.0 metres. hese conditions were compared with available drawdowns in all municipal wells in the Goderich and Bayfield Gullies subwatershed. **Table 3.21** shows the results of this analysis.

Table 3.21 Available Drawdown in Municipal Wells and Observed Reductions in Water Levels in the Bedrock Aquifer Under 2-year, Extreme Drought Conditions

Well	Pump level (masl)	Steady-state water level* (masl)	Available Drawdown	Drought Scenario water level (masl)	Modeled head reduction
S.A.M	148.6	184.6	36 m	183.8	0.8 m
Vandewetering	156.7	181.2	24.5 m	180.6	0.6 m

*under constant pumping conditions

Given the extremely high available drawdowns in the Goderich and Bayfield gullies subwatershed, interference with operational capacity of municipal wells under drought conditions is unlikely.

3.8.9 Uncertainty

Uncertainty in the water budget process is closely tied to the data sources and models that have been utilized to develop the important data. In the case of the Goderich and Bayfield

Gullies subwatershed, significant uncertainty exists due to the widely differing values for recharge which have been developed through separate groundwater and surface water modeling processes. In order to develop an estimate of the potential change in water quantity stress due to changes in water flux, two scenarios were developed.

Firstly, in **Table 3.22** a reduction of the water supply term by 20% was undertaken, in order to account for potential uncertainties in groundwater flux and recharge values.

Table 3.22 Water Quantity Stress Assessment with a 20% Reduction in Water Supply**.**

Tier 2 Subwatershed	GW IN	Recharge	Supply	Reserve	Cons. Use	% Water Demand
Goderich	17921	19847	30214.4	3021	16924	62
Goderich and Bayfield Gullies	38960	34241	58560.8	5856	1346	3

Secondly, a 20% increase in demand was evaluated to account for potential uncertainties in consumptive water use and is shown in **Table 3.23**.

Table 3.23 Water Quantity Stress Assessment with a 20% Increase in Consumptive Water Use.

Tier 2 Subwatershed	GW IN	Recharge	Supply	Reserve	Cons. Use	% Water Demand
Goderich	17921	19847	37768	3777	20309	60
Goderich & Bayfield Gullies	38960	34241	73201	7320	1615	2

Under both scenarios, no changes in water quantity stress were noted. Therefore, uncertainties for the Tier 2 water quantity stress assessments were considered to be low.

3.8.10 Recommendation for Tier 3 Water Budgets

No Tier 3 Water Budget was recommended for the Ausable Bayfield Source Protection Area.

3.9 Significant Groundwater Recharge Areas (SGRAs)

Under the Clean Water Act (2006), Technical Rules for the development of an Assessment Report have been established. These rules outline the delineation of four types of vulnerable areas within which policies will be developed and implemented to protect water, namely: wellhead protection areas, intake protection zones, highly vulnerable aquifers and significant groundwater recharge areas.

Significant groundwater recharge areas are to be developed using existing models and data from Tier 1 Water Budgets, and the Technical Rules allow for the use of professional judgment in the form of a technical Peer Review Committee. Specifically, the rules state:

44. Subject to rule 45, an area is a significant groundwater recharge area if,

(1) the area annually recharges water to the underlying aquifer at a rate

that is greater than the rate of recharge across the whole of the related groundwater recharge area by a factor of 1.15 or more; or

(2) the area annually recharges a volume of water to the underlying aquifer that is 55% or more of the volume determined by subtracting the annual evapotranspiration for the whole of the related groundwater recharge area from the annual precipitation for the whole of the related groundwater recharge area.

45. Despite rule 44, an area shall not be delineated as a significant groundwater recharge area unless the area has a hydrological connection to a surface water body or aquifer that is a source of drinking water for a drinking water system.

46. The areas described in rule 44 shall be delineated using the models developed for the purposes of Part III of these rules and with consideration of the topography, surficial geology, and how land cover affects groundwater and surface water.

(Technical Rules: Assessment Report, December, 2008)
Clean Water Act, 2006

Further guidance was provided by the Ministry of the Environment on the development of significant groundwater recharge areas (SGRA) in the form of a Technical Bulletin (dated April, 2009). This bulletin highlighted what aspects of the methodology require professional judgment. Specifically, key decisions which require professional judgment are:

1. Which methodology is to be used in order to determine SGRA (i.e. rule 44 (1) or (2))

2. The scale at which these methodologies will be applied

3. Incorporation of local geological and hydrological knowledge into the SGRA delineation process (see **Map 3.18**)

3.9.1 Karst and Sinkhole Drainage Areas

The Ausable Bayfield Maitland Source Protection Region is host to a unique category of geological features related to karst topography and, more specifically sinkhole development. Large sinkholes, located in several areas in the Region have had natural and agricultural drainage directed into them under the *Drainage Act* (although this practice is now discouraged). These features allow for direct recharge of the bedrock aquifers (WHI, 2002, 2004).

Under the guidance of the *Clean Water Act, 2006*, the areas which drain into these sinkholes are considered herein to be significant groundwater recharge areas under rule 44(2). In these areas, approximately 100% of water remaining after subtracting the annual evapotranspiration from the annual precipitation recharges the underlying aquifer. In accordance with Rule 45, these areas are known to have influence on local private water wells, though the extent of that influence has not been adequately determined (WHI, 2004). Drainage areas which are connected to sinkholes that have direct connections to the underlying bedrock aquifers are shown on **Map** 3.6.

3.9.2 Hydrologic Response Units

In order to determine SGRAs at a finer scale than the Tier 1 subwatersheds, it was decided by the Peer Review Committee for this process that another approach be implemented. This approach was designed to account for the geology, soils, land cover and topography of the Region. In order to do this, a series of unique Hydrologic Response Units (HRUs) were created using available geology, land cover and topographical mapping. HRUs were developed following a similar methodology to that of the abutting Saugeen Grey Sauble Northern Bruce Peninsula and Lake Erie Source Protection Regions (see for example, AquaResource, 2008). Once HRUs have been developed for the entire region specific recharge values can be approximated.

Hydrologic Response Units were created by reclassifying and intersecting a number of data sets. The details of this are described below.

3.9.2.1 Surficial Geology

Surficial geological units were reclassified according to the texture of the materials of which they are composed. It should be noted that the surficial geological classifications also account for the soil texture distribution and topography of the region, and are therefore considered redundant with respect to determining SGRAs. The reclassification of the surficial geological units is listed below in **Table 3.24**.

Table 3.24 Surficial Geology Reclassification for HRU Derivation

Geologic Grouping	Quaternary Geology Description
Impervious	Open Water, Alluvium
Clay Tills	St. Joseph Till, Glaciolacustrine Deep Water Deposits, Lacustrine Clay and Silt, Man-Made Deposits, Tavistock Till Fluvial Deposits, Modern Fluvial Deposits, Flood Plain Deposits
Silt Tills	Bruce Till, Dunkeld Till, Elma Till, Rannoch Till, Newmarket Till, Tavistock Till
Sand Tills	Catfish Creek, Wentworth Till
Sand and Gravels	Eolian Deposits, Fan or Cone Deposits, Aeolian Deposits, Glacial-outwash Sand, Glaciofluvial Ice-Contact Deposits, Glaciofluvial Outwash Deposits, Glaciolacustrine Deposits Beach Bar, Glaciolacustrine Deposits Shallow Water, Glaciolacustrine Shoreline Deposits, Modern Beach Deposits, Ice-contact deposits
Bedrock	Exposed Bedrock or Bedrock with Thin Drift.

3.9.2.2 Land Cover

Land cover datasets were created by overlaying the following existing datasets: forested areas (Ministry of Natural Resources (MNR) Forest Resource Inventory); wetland areas (MNR wetlands); and urban areas identified on the municipal parcel fabric. Land areas that did not fall into one of the three categories (forest, wetland or urban) are assigned as agricultural. Initial attempts at creating this synthetic land cover layer were reviewed and stream beds were poorly represented (i.e. they were reclassified as agricultural) as they have no unique land cover category. However, these stream beds are typically represented by the geological unit “alluvium” and, as such, it was deemed appropriate to reclassify these types of deposits as impervious within the new geological classifications for the purpose of SGRA delineation (see **Table 3.25**) rather than attempt to extract them manually from the Land Cover data set.

Table 3.25 Land Cover Reclassification for HRU development

Land Cover Reclassification
Wetland
Forested
Urban
Agricultural
Hummocky

3.9.2.3 Hummocky Topography

Hummocky topography is those areas typified by highly variable, gentle slopes which have high depressional storage and closed depressions with no outlets. They are commonly associated with moraines in the Region. These areas typically have enhanced recharge rates due to the lack of outlet and increased depressional storage. Areas of hummocky topography were identified in the Grey Bruce Groundwater Study (WHI, 2003). These areas were then overlain on the land cover data set to create unique HRUs. All areas of identified hummocky topography were given the hummocky land cover designation. Final land cover categories are listed below in **Table 3.26**.

Table 3.26 HRU Classifications

HRU	Description
1	Impervious
2	Wetland
3	Clay / Clay Till Agricultural
4	Silt Till Agricultural
5	Sand Till Agricultural
6	Sand & Gravel Agricultural
7	Low Permeability Forest
8	High Permeability Forest
9	Low Permeability Hummocky
10	High Permeability Hummocky Vegetation
11	Clay / Clay Till Urban
12	Silt Till Urban
13	Sand Till Urban
14	Sand & Gravel Urban
15	Bedrock
16	Karst

3.9.2.4 Hydrologic Response Unit Creation

Hydrologic Response Units (HRUs) were then created by combining all 4 reclassified datasets: quaternary geology, land cover, karst and hummocky topography into 16 HRUs, as shown in **Table 3.27**, below.

It should be noted that clay till and silt till were grouped together into the 'Low Permeability' category, while sand till and sand and gravel grouped into the 'High Permeability' category for forested and hummocky land cover groups. This was done to be consistent with HRU development methodologies in abutting regions.

3.9.2.5 Assigning Recharge Values to HRUs

Recharge values for individual HRUs are typically derived from a surface water model calibration exercise using the GAWSER modeling package (see for example, AquaResource, 2008). As no GAWSER model was available for the Ausable Bayfield Source Protection Area, an alternative approach was developed.

Initial recharge values were assigned to each individual category of HRU based on calibrated modeling of the Otter Creek watershed within the Saugeen Grey Sauble Northern Bruce Peninsula Source Protection Region. Assigned values are listed below in **Table 3.27**.

Table 3.27 Assigned Initial Recharge Values for the Region

(HRU)	Name	Recharge – SVCA
1	Open Water	
2	Wetland	59.56
3	Clay-till Ag	65.50
4	Silt-till Ag	138.91
6	Sand and Gravel Ag	398.90
7	Low Permeability Forest	268.18
8	High Permeability Forest	493.10
9	Low Permeability Hummocky	369.18
10	High Permeability Hummocky	526.78
11	Clay-till Urban	42.57
12	Silt-till Urban	90.29
14	Sand and Gravel Urban	259.28
15	Bedrock	239.41
16	Karst Areas	

Recharge in mm/yr
SVCA data developed form GAWSER model for the Otter Creek Sub watershed (Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region Tier 1 and Tier 2 water budget, 2009)

3.9.2.6 Adjustment of Recharge Values

In order to develop unique recharge values for each HRU in the region, an adjustment exercise was undertaken. Existing SWAT models, created as part of the Tier 1 Water Budget for the Ausable Bayfield Source Protection Area, provided calibrated recharge estimates at a subwatershed scale (approximately 460 subwatersheds). For each of these subwatersheds, an estimate of recharge was developed by summing the initial assigned recharge values for all of the HRUs in that specific subwatershed. This value was then compared to the SWAT-developed recharge estimate and a scalar determined to adjust this value. This scalar was then applied to all the HRU recharge values in that subwatershed, such that each category of HRU had a unique recharge value within each subwatershed.

It should be noted that the relative value of recharge rates between different HRUs was maintained, but actual estimated recharge values were adjusted on a subwatershed scale.

3.9.3 Determination of Groundwater Recharge Areas

In order to determine which HRUs would be considered significant groundwater recharge areas, the Peer Review Committee recommended the approach outlined in Rule 44 (1); whereby any HRU with an annual recharge rate more than 1.15 times the average for the surrounding area would be considered an SGRA. In order to develop an average for the ‘surrounding area,’ it was decided that the Region would be split into the Maitland Valley Source Protection Area (jurisdiction of the Maitland Valley Conservation Authority) and the Ausable Bayfield Source Protection Area (jurisdiction of the Ausable Bayfield Conservation Authority).

Accordingly, mean annual adjusted recharge values for all HRUs in the Ausable Bayfield Source

Protection Area were developed, and all HRUs with values more than 1.15 times this mean were identified as potential SGRAs.

3.9.4 Determination of Significance

In order to determine significance, under rule 45 the identified SGRA must have a drinking water system located within it. In order to assess this, the HRUs identified as having annual adjusted recharge rates greater than 1.15 times the SPA mean, were assembled into new, larger polygons. Due to the prevalence of wells throughout the area, an assumption was made that all recharge areas reasonably have the potential to be hydraulically connected to a drinking water system, consistent with Technical Rule 45. Significant groundwater recharge areas are shown in **Map 3.19**.

3.9.5 Tier 2 Significant Groundwater Recharge Areas

Recharge values derived from GAWSER analysis for the Goderich and Bayfield and Goderich Tier 2 subwatersheds were incorporated into the delineation of significant groundwater recharge areas. GAWSER derived recharge values are dispersed to HRUs, and values for specific HRUs were included in the overall delineation of SGRAs in the area.

Recharge values for specific HRUs were averaged across each source protection area, and those HRUs with recharge values greater than 115% of the average were identified as being groundwater recharge areas. All HRUs considered significant recharge areas in the Tier 1 water budget remain above the threshold of 115% of the average for the SPA, and all HRUs not considered significant recharge areas in the Tier 1 water budget remain below the threshold of 115% of the average for the SPA. For the Maitland Valley SPA the threshold was established at 209 mm/year, and the Ausable Bayfield SPA, this threshold was established at 248 mm/year, based on mean recharge rates of 182 mm/year and 216 mm/year, respectively.

Due to the likely presence of undocumented wells in most areas, and the high uncertainty of local geological conditions, the Ausable Bayfield Maitland Valley Source Protection Committee has resolved that a conservative approach be taken in the delineation of SGRAs. Accordingly, hydraulic connection was inferred for all the identified HRUs with greater than 115% average recharge, and as such all were similarly considered to be SGRAs. Similarly, the ABMV SPC requested that all areas with greater than 115% average recharge be included, unless significant geological evidence suggested that they were not recharge areas.

Although different models were used in the determination of recharge for Tier 2 subwatersheds, SGRA delineation for the Tier 2 subwatersheds were unchanged from the Tier 1 delineations.

3.9.6 Data Limitations and Uncertainty

The data used for the development of the SGRAs is based on existing climate data, Tier 1 surface water modeling outputs, and existing geological and land cover data. These data sets were not developed for the explicit purposes of delineating SGRAs, and have certain limitations which can be attributed to them, specifically:

- Climate data has been filled and corrected to try and account for missing data for discrete time intervals and locations where no monitoring stations exist
- Surface water modeling has been completed for the entire Source Protection Area, yet has not been calibrated in certain regions due to a lack of monitoring data. In such cases models were calibrated to similar subwatersheds
- Land cover data is valid only at the time it was collected, and has not been altered or corrected for changes in land use since the time of collection
- The SGRAs have not been evaluated with respect to their hydrologic connection to specific aquifers themselves. Rather, they have been calculated to the nearest surficial aquifer. Recharge areas for confined regional aquifers may lie outside areas. Future use of this delineation, specifically at local scales, should consider the aquifer of interest before employing this methodology.

Uncertainty for SGRAs is a measure of the reliability of the delineations with respect to providing protection to the overall groundwater system, rather than specific aquifers. In this light, the methodology for calculating SGRAs is highly reliant on the surficial geology of the area and can be considered reliable for the overall groundwater system. The uncertainty for SGRAs is therefore considered low for the Source Protection Area.

3.10 Peer Review

The water budget process was completed with consultation and approval from a Peer Review Committee. This committee was formed at the commencement of the water budgeting exercise and met regularly throughout the process. The following individuals were part of the Peer Review Committee:

Dr. Trevor Dickinson, *Hydrologist and Professor Emeritus*, University of Guelph

Stan DenHoed, P.Eng, *Hydrogeologist* , Harden Environmental

Sam Bellamy, P.Eng, *Hydrologist*, AquaResource Inc.

Lynne Milford, *Water Budget Analyst*, Ministry of Natural Resources

References

Author & Publisher	Title	Date	Purpose
AquaResources	*Saugeen, Grey Sauble and Northern Bruce Peninsula Tier 1 Surface Water Budget and Stress Report*	2008	Tier 1 water budget for neighbouring region.
Ausable Bayfield Maitland Source Protection Committee	*Watershed Description for the Ausable, Bayfield Maitland Source Protection Region*	2006	General information on the Source Protection Areas
Ausable Bayfield Maitland Source Protection Committee	*Conceptual Water Budget – Ausable, Bayfield Maitland Source Protection Region*	2007	General information on the Source Protection Areas
Acres Consulting Services Limited, G. Lyon's Litho Limited, Fort Erie	*Water Quantity Resources of Ontario*	1984	Used to evaluate the validity of Evapotranspiration values
de Loë, R.	*Agricultural and Rural Water Use in Ontario*	2001	Provided methodology for estimating water usage based on the number of livestock for a given area
Dickinson T. and J. Diiwu	*Water balance calculations in Ontario* (unpublished). Guelph ON: School of Engineering, University of Guelph	2000	Used to evaluate the validity of Evapotranspiration values
Environment Canada – Atmospheric Environment Service, Downsview, ON	*Canadian Climate Normals – Volume 3 – Precipitation 1951–1980*	1982	Provided Climate normals for the SPA water budgeting exercise.
Luinstra Earth Sciences.	*Permit To Take Water Update*	2006	Provided updated PTTW usage information (survey) for water budgeting purposes
Luinstra Earth Sciences.	*North Lambton Geology Study*	2004	Hydrogeology of North Lambton Aquifer
Luinstra Earth Sciences.	*Tier 1 Water Budget for the Ausable Bayfield Maitland Source Protection region*	2008	Tier 1 water budget for region
McKague, K., and Mao, C.	*Development of a Long-Term Numerical Water Budget Model for the Ausable Bayfield Maitland Valley Planning Region*	2007	Contains results of hydrological modeling work completed for the SPA water budgeting exercise.
Ontario Ministry of Agriculture and Food, Toronto	*Agricultural Resource Inventory*	1983	Provided land cover estimates for the SPA water budgeting exercise.

Ontario Ministry of the Environment	*Technical Rules*	2008	Guidance document
Ontario Ministry of the Environment	*Technical Memo – April 2009 – Significant Recharge Areas*	2009	Guidance document
Schroeter, H. O., D. K. Boyd and H. R. Whiteley	*Filling gaps in meteorological data sets used for long-term watershed modelling*. In Proceedings of the Ontario Water Conference 2000, Richmond Hill, ON	2000	Provided methodology for filling data gaps in climatological data
Steinbach, 1999	*Unpublished M.Sc. Thesis – University of Western Ontario*	1999	Hydrogeology of the North Lambton Aquifer
Waterloo Hydrogeologic Incorporated (WHI)	*Six Conservation Authorities FEFLOW Groundwater Modeling Project Final Report*	2006	Contains results of hydrogeological modeling work completed for the SPA water budgeting exercise.
Waterloo Hydrogeologic Incorporated (WHI)	*Phase I Sinkhole Study – Ausable Bayfield Conservation Authority*	2002	Provided drainage areas and outlined connection between surface drainage and sinkholes in the ABCA area
Waterloo Hydrogeologic Incorporated (WHI)	*Grey Bruce County Groundwater Study*	2003	Contains groundwater information for the county.
Waterloo Hydrogeologic Incorporated (WHI)	*Phase II Sinkhole Study – Ausable Bayfield and Maitland Conservation Authorities*	2004	Provided drainage areas and outlined connection between surface drainage and sinkholes in the ABCA and MVCA areas

AUSABLE BAYFIELD: CHAPTER 4

VULNERABILITY, THREATS AND RISKS

Table of Contents

List of Tables and Figures

Part 1

4.1 Regulatory Context

The Assessment Report gives specific attention to those municipal residential drinking water sources identified in the Terms of Reference. The purpose of this section is to identify where the sources of drinking water are susceptible to contamination given the natural environment and human activity around the source of water. This is determined by using scientific models which evaluate the vulnerability of the area around a drinking water source (what exists in nature). Then within these areas, what activities or conditions exist that use chemicals or contain pathogens that could, in the right circumstance, contaminate drinking water (what humans do or have done). By identifying areas where the potential for such contamination is greatest, protection measures can be directed to the most vulnerable areas through the source protection plan.

Vulnerable Areas

The *Clean Water Act, 2006*, identifies four types of vulnerable areas which are defined by regulation in the following way:

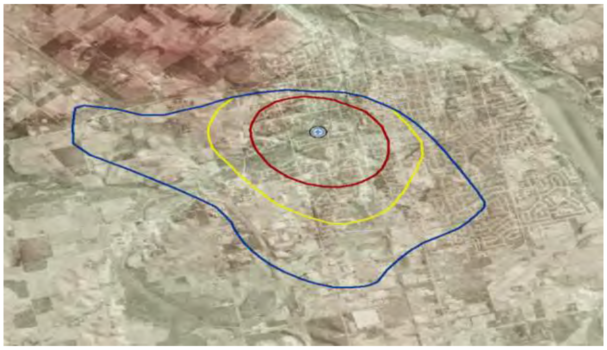
"*Highly vulnerable aquifer*" means an aquifer on which external sources have or are likely to have a significant adverse effect, and includes the land above the aquifer,

"*Significant groundwater recharge area*" means an area within which it is desirable to regulate or monitor drinking water threats that may affect the recharge of an aquifer,

"Surface water intake protection zone" means an area that is related to a surface water intake and within which it is desirable to regulate or monitor drinking water threats,

“Wellhead protection area" means an area that is related to a wellhead and within which it is desirable to regulate or monitor drinking water threats.

The *Technical Rules* (MOE, 2009) indicate how to delineate each type of vulnerable area and how to assess the degree of vulnerability within each. These methodologies will be expanded upon below. The degree of vulnerability is represented by a score where a score of 8 – 10 is considered high vulnerability, 6 – 8 is moderate vulnerability and 4 – 6 is low vulnerability.

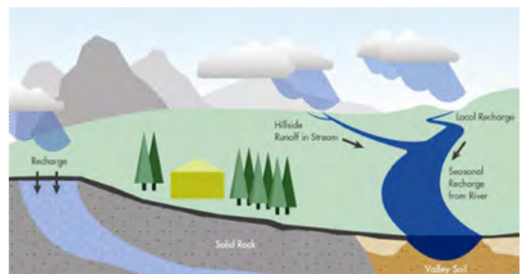


A **wellhead protection area** is the area of land around a well that has an outer boundary from which it takes up to 25 years for water to travel to the well head.

A **highly vulnerable aquifer** is an area of soil or rock where underground cracks or spaces allow water (and possibly contaminants) through more quickly from the surface to the aquifer.

An **intake protection zone** is the area of water and land around a surface water intake defined by the distance water can travel from upstream or shore to the intake.

A **significant groundwater recharge area** is land where rain or snow seeps under-ground into an aquifer at a higher rate than typical.



Groundwater Vulnerability Score is shown as a score where 2 is low vulnerability and 10 is high vulnerability. This score combines two ideas: The closer the wellhead, the higher the vulnerability score and the more vulnerable the aquifer, the higher the vulnerability score. Thus the score accounts for both horizontal and vertical movement of water into the aquifer that the well draws from.

4.2 Methods for Delineating Vulnerable Areas

Data was gathered for each of the four types of vulnerable areas in keeping with the *Technical Rules*. The methodology, limitations, and uncertainty associated with this methodology, are outlined below.

Highly Vulnerable Aquifers (HVAs):

Highly Vulnerable Aquifers (HVAs) are aquifers that are more susceptible to contamination. The Intrinsic Susceptibility Index (ISI), a measure of overburden porosity, was used to delineate HVAs in all areas. While the rules allow for several different approaches, the ISI method was chosen because data was readily available for the entire SPR. ISI for the region was available through county groundwater studies (Grey Bruce Groundwater Study, 2003; Perth County Groundwater Study, 2003; Lambton and Middlesex County Groundwater Study, 2003; Huron County Groundwater Study, 2003). The areas above aquifers that were designated as having ‘high’ intrinsic susceptibility (ISI) are considered Highly Vulnerable Aquifers for the purposes of source protection planning.

ISI is a regional aquifer assessment tool designed to identify areas where those aquifer systems are sensitive to contamination via surface activities. Data used in the calculation for the index is derived from water well records housed in the Ministry of the Environment’s Water Well Information System (WWIS). Wells used in the calculation were screened based on location reliability codes in the WWIS, and only those deemed sufficiently accurate were included in the final ISI calculation. Details on the screening of data can be found in the corresponding reports (Grey Bruce Groundwater Study, 2003; Perth County Groundwater Study, 2003; Lambton and Middlesex County Groundwater Study; 2003, Huron County Groundwater Study, 2003). The screening process leads to the exclusion of some data sources, which may have an impact on the certainty associated with the ISI.

ISI is calculated for individual wells and employs statistical methods for estimating values between wells. This process does not take into account discrete boundaries of local geological features which may be the source of the different index values. Exclusion of data points has a higher impact on the local scale calculations of ISI, as the exclusion of a single data point could have profound implications on the ISI locally, whereas at a regional scale the impact of a single data point has less significant ramifications.

Uncertainty associated with ISI is highly dependent on the scale at which they are viewed. From a regional scale perspective, ISI can be considered a good indicator of areas where aquifers are highly vulnerable, and as such, can be considered to have low uncertainty at that scale. However, when applied at a local scale, the uncertainty increases. The data relied on in this study is intended for broad scale use. It is recommended that additional study take place for any property where specific ISI information is required.

Some areas within the SPA which have surficial sands are not mapped as being highly vulnerable with the ISI process. The primary reason for this is the lack of wells or well records for these shallow aquifers from which the ISI was developed.

According to the *Technical Rules*, all HVAs have vulnerability scores of 6.

Significant Groundwater Recharge Areas (SGRAs):

A significant groundwater recharge area is land where rain or snow seeps underground into an aquifer at a higher rate than typical, and where water quantity may be vulnerable to certain activities.

Significant groundwater recharge areas (SGRAs) were calculated using a Hydrologic Response Unit (HRU) approach for the source protection area. HRUs were developed on a 15 m by 15 m grid for the entire SPA based on surficial geology and land cover, and were corrected at a subwatershed scale using Tier 1 water budget models. Individual recharge values for each type of HRU were developed on a subwatershed basis, and mean annual recharge values for the SPA were calculated.

Those HRUs with recharge values that exceed 115% of the mean recharge value for the SPA were identified as being High Volume Groundwater Recharge Areas in accordance with Rule 44 (2) of the Technical Rules. In order to be considered, the high volume recharge area must have a hydraulic connection with a drinking water system (e.g. a well). Due to uncertainties related to the location and distribution of well records, the SPC requested that all high volume recharge areas be included as significant recharge areas. This was considered appropriate given the lack of information on shallow wells and surficial aquifers in the region. Sinkholes, and areas that drain into sinkholes, were included as SGRAs based on Rule 44 (1), as all water which is not lost to evapotranspiration is recharged, either by infiltration or via runoff into surface water bodies which are outlet directly into sinkholes. SGRAs were further refined within those areas included in the Tier 2 water budget.

The data used for the development of the SGRAs is based on existing climate data, Tier I surface water modeling outputs and existing geological and land cover data. These data sets were not developed for the explicit purposes of delineating SGRAs, and have certain limitations which can be attributed to them, specifically:

1. Climate data has been filled and corrected to try and account for missing data for discrete time intervals and locations where no monitoring stations exist
2. Surface water modeling has been completed for the entire source protection area, yet has not been calibrated in certain regions due to a lack of monitoring data. In such cases models were calibrated to similar subwatersheds
3. Land cover data is valid only at the time it was collected, and has not been altered or corrected for changes in land use since the time of collection
4. The SGRAs have not been evaluated with respect to their hydrologic connection to specific aquifers themselves. Rather they have been calculated to the nearest surficial aquifer. Recharge areas for confined regional aquifers may lie outside areas. Future use of this delineation, specifically at local scales, should consider the aquifer of interest before employing this methodology.

Uncertainty for SGRAs is a measure of the reliability of the delineations with respect to providing protection to the overall groundwater system, rather than specific aquifers. In this light, the methodology for calculating SGRAs is highly reliant on the surficial geology of the area and can be considered reliable for the overall groundwater system. The uncertainty for the SGRAs is therefore considered low for the source protection area.

According to the amended *Technical Rules, 2017*, SGRAs are no longer assigned a vulnerability score and therefore no significant, moderate or low drinking water threats related to water quality are assigned to them. Previously, SGRAs with a score of 6 had identified low and moderate threats. Once HVAs were delineated, it was observed that HVAs consistently aligned with SGRAs with a score of 6, making the scoring of SGRAs redundant. Accordingly, references to SGRA scores were removed from this document and maps.

Intake Protection Zones (IPZs):

The Ausable Bayfield Source Protection Area has one intake, the Lake Huron Primary Water Supply System (LHPWSS). It is classified as a Type A intake, an intake located in a Great Lake. This intake is in Lake Huron approximately 2.5 kilometres off shore just north of Grand Bend at a depth of approximately nine metres.

Consultants with coastal modeling expertise were selected to undertake the delineation of IPZs (Stantec). Their work was peer reviewed by recognized and qualified experts who concurred with the outcomes and recommended potential improvements (Baird & Associates).

The in-water portion of an IPZ-1 is prescribed as a 1 km circle around the intake except where it intersects land. Where the IPZ reaches land, its inland extent is limited to the greater of 120 metres or the regulatory limit. The LHPWSS intake is located such that its 1 km circle does not reach land. The IPZ-2 is delineated as the two hour time-of-travel to the intake under a series of wind and wave conditions considered typical for a 10-year period. The IPZ-2 was delineated using both two dimensional and three dimensional hydro-dynamic models for (POM and ADCIRC 2-d Vertical). These models were well suited, given the intake's distance from shore, natural environment, and treatment plant capacity.

The vulnerability scores for the intake are based on the attributes of the intake (length and depth), type of water body, the physical characteristics of the environment it is situated in, and the influences affecting intake water. It is essentially qualitative, based upon scores assigned to the contributing factors through the professional judgment of coastal modeling consultants. The vulnerability score is derived by multiplying the Area Vulnerability Factor by the Source Vulnerability Factor (as defined in the *Technical Rules*). The Area Vulnerability Factor for IPZ-1 is 10 as prescribed by the *Technical Rules*.

The area vulnerability factor for IPZ-2 must be assigned a whole number ranging from 7 to 9 based upon consideration of the following sub factors:

a. Percentage of area that is land within the IPZ-2;

b. Land cover, soil type and permeability; and

c. Transport pathways within the IPZ-2 upland environment.

To assist with the development of the area vulnerability score for the intake, a decision matrix was developed using ranges of characteristics for each of the three sub factors. The evaluation of each of these factors was completed for the LHPWSS intake such that the percentage of land was scored at 8, the land cover soil type was scored at 7.8 and the transport pathways at 8.3.

Area Vulnerability Factor = (land area + land cover soil type + tpt pathways) / 3

Thus, the area vulnerability factor for IPZ-2 was determined to be 8 (see the *Phase 1: Surface Water Vulnerability Assessment Addendum for the Lake Huron Water Treatment Plant Phase 1 Addendum*, Stantec, 2009, pgs 3.2 – 3.8).

Storm sewer outfalls, networks or drainage areas were not provided and have been listed as a data gap. For the purposes of the upland delineation, the consultant assumed that the urban area of Grand Bend was storm drained, and therefore, was included within the IPZ-2 upland delineation. However, upon discussion with the municipality, the village does not have a fully developed systematic storm drainage network. Upland areas north of the village represent tile drainage of farm fields.

Where tile drained lands existed next to a watercourse/drain, and the watercourse/drain was included in the IPZ-2, the IPZ-2 was extended to include the adjacent tile drained land, as well as all other tile drain lands that were assumed to contribute water to that drain, based on topography. The tile drain area composes approximately 71% of the upland IPZ-2.

Areas without watercourses, nor transport pathways, were extended inland from the Lake Huron shore 120 m as, in this case, it extended further inland than the Regulatory Limit.

According to the *Technical Rules*, the Source Vulnerability Factor must be assigned a value of 0.5 to 0.7 based on the following factors;

a. The depth of the intake,
b. The distance of the intake from land,
c. The number of recorded drinking water issues related to the intake.

To quantify these factors, a decision matrix was developed using ranges of characteristics for each of the three sub factors. The sub factors are assumed to have equal importance, and thus, were weighted equally. Given the distance from shore of the intake, the depth of the intake and the minimal number of water quality concerns each of these factors was given a value of 0.5 and applied to the following formula.

Source Vulnerability Factor = (offshore length + depth + water quality) / 3

Thus, the Source Vulnerability Factor was determined to be 0.5, to reflect the intake's relative security from contamination (see the *Phase 1: Surface Water*

Vulnerability Assessment Addendum for the Lake Huron Water Treatment Plant Phase 1 Addendum, Stantec, 2009, pgs 3.8 – 3.11).

The Vulnerability Factor was multiplied by the area vulnerability score for a final vulnerability score for the IPZ-1 is 5 and the score for IPZ-2 is 4.

Like any methodology, this approach to vulnerability has limitations. Uncertainty is the confidence in the accuracy of IPZ delineations and vulnerability scores based on factors such as: data quality, quantity and distribution; ability of models and formulas to accurately delineate the zones; accuracy and relevance of the vulnerability scores for the zones to represent the situation. The uncertainty levels for the LHPWSS IPZ-1 and IPZ-2 have been based upon the above listed components such that for the vulnerability score the uncertainty is “low” and for the IPZ delineations the uncertainty is “low” because of the offshore location and excellent raw water quality.

Under the Technical Rules, an IPZ-3 can be created to include threats which have the potential to interrupt the safe operation of a water supply. An IPZ-3 can be developed for a Great Lakes intake where the Source Protection Committee has identified land use activities that are of sufficient concern to warrant further investigation. These land use activities are then evaluated to determine if, under extreme conditions, they can cause an interruption of water supply. In order to be included, it must be shown that there is a hydrodynamic connection between the land use activity and the intake, and that a sufficient quantity of an identified contaminant could be released resulting in an interruption in the water supply.

In the Ausable Bayfield SPA, a screening procedure was implemented to identify potential land use activities that require a detailed analysis. This screening procedure began first by identifying all properties located within 120 m of Lake Huron or any stream identified in the provincial stream network layer. These properties were further screened to eliminate land uses that are unlikely to have any sources of contaminants, such as natural environment and conservation lands. Finally, the properties were screened in order to identify only those properties which have a structure located within the 120 m buffer surrounding the water courses or Lake Huron. Under extreme events, any property located within the 120 m buffer of a watercourse has the potential to have a hydrodynamic connection with the intake located in Lake Huron (everything is upstream of Lake Huron).

Properties with a structure located within the 120 m buffer were evaluated using aerial photography to identify any major storage tanks which could be of concern. Those included based on the aerial photography were then evaluated based on the volume, concentration, fate and toxicity of any contaminants stored on site. Land use activities were also evaluated based on the likely pathway of any spill to the watercourse. Land use activities that include partially of fully below grade storage were eliminated from the process as they are unlikely to result in rapid spill into surface water systems.

Remaining threats were then assessed for inclusion into an IPZ-3 by developing a realistic spill scenario and using a simple dilution calculation. This scenario considers the potential size and duration of any spill, the concentration of any contaminants, the location and hydrologic situation of the storage facility and the fate of the contaminant. In cases where multiple contaminants have been identified, the contaminant with the most conservative fate was considered for the dilution scenario. Land use activities which were included for the IPZ-3 assessment were then evaluated to determine if a sufficient hydrodynamic connection exists. Once that hydrodynamic connection has been demonstrated through modeling or analysis, a spill scenario was undertaken to determine if a spill has the potential to sufficiently impact the source of municipal drinking water such that it would cause an interruption in water supply.

If the spill scenario calculations determine that a spill could cause deterioration to the quality of the drinking water, and result in an interruption in supply, an IPZ-3 could be extended to include the evaluated land-use activities. It should be noted that none of the assessed activities in the Ausable Bayfield Source Protection Area resulted in the delineation of an IPZ-3.

Wellhead Protection Areas (WHPAs):

The wellhead protection areas were modeled using three dimensional groundwater flow models by identifying certain areas which correspond to times-of-travel to the well. For each well head the following times of travel have been modeled:

- 100 metre WHPA – A
- Two year time-of-travel WHPA – B
- Five year time-of-travel WHPA - C
- Twenty-five year time-of-travel WHPA – D
- If there is a GUDI well, two hour time-of-travel WHPA – E

(There are no GUDI wells in the Ausable Bayfield Source Protection Area)

WHPA-A is not a time-of-travel model, rather is a prescribed 100 metre (m) buffer surrounding all municipal wells.

The groundwater modeling and time-of-travel calculations were all completed in keeping with the *Technical Rules*. The three-dimensional groundwater modeling code MODFLOW-SURFACT, developed by Waterloo Hydrogeologic Inc. (Now Schlumberger Water Services), was used for delineating the wellhead protection areas in the ABMV Source Protection Region. MODFLOW-SURFACT is a commercially available software package that simulates the groundwater flow using a finite difference formulation, incorporating the USGS-developed MODFLOW code. MODFLOW SURFACT is an advance groundwater modeling package that couples unsaturated and saturated subsurface conditions which allows it to take into account preferential pathways. For each municipal well, the known individual wells are included in the model. The updated models were constructed using the hydrogeologic units from ground surface down to the lower extents of the aquifers from which municipal wells are taking their groundwater. Surface water boundaries interacting with the groundwater system were included in the groundwater models. The groundwater models were calibrated to provide good representation of the aquifer systems supplying the groundwater to the municipal wells. Once calibrated, the models were used to run multiple reverse-particle tracking scenarios in order to develop the times of travel for the well head protection area.

Recognized and qualified consultants (WESA) undertook a peer review of this methodology and concurred with the outcomes and recommended potential improvements. These will be addressed in an updated Assessment Report. Similar methods by each consultant provided seamless delineation between source protection regions.

This method was chosen because it utilizes the analytical complexity required by the rules while building on existing data. Uncertainty analyses are a conservative approach which is used to account for the intrinsic variations that exist in natural hydrogeologic environments.

The limitations of the modeling tasks are driven by the uncertainty of the data itself, primarily the recharge, hydraulic conductivity and variations in the temporal water level data. In developing the groundwater models for the ABMV Source Protection Region uncertainty was incorporated into the wellhead protection areas. The WHPAs presented within the report include an uncertainty analysis and represent conservative but reasonable zones based on the information available. A sensitivity analysis was conducted, in which those model parameters for which the

WHPA delineations were sensitive to, were varied in a range, above and below the calibrated value, but remained within reasonable limits of that parameter. The most sensitive parameters were found to be recharge and hydraulic conductivity as is usually found with most groundwater modeling simulations. For hydraulic conductivity parameters the uncertainty range was typically assumed to be between a half or a full order of magnitude above and below the calibrated value. For recharge parameters the uncertainty range was assumed to range from twice to half of the calibrated value. The water level data used for calibrating the groundwater models was primarily the static water levels at the time of drilling from the provincial Water Well Information System. Since these water levels have been collected over many decades and at various times throughout the year the static water level at the time of drilling may be quite different from the water level under current conditions. Lastly, the WHPA Zone B and Zone C will generally have less uncertainty than the WHPA Zone D. The size of the WHPA Zone B is smaller and centered closer to the wellhead where the presence of more wells allows for the geology to be better understood than farther away from the wellhead. The projected pumping rates for 25 years were used for generating the WHPAs and unlikely to change drastically over the next two years, but may change drastically over the next 25 years for a variety of unforeseen reasons. For these reasons listed above, the WHPA Zone B and Zone C have low uncertainty and the WHPA Zone D has high uncertainty. (see Ausable Bayfield Maitland Valley Wellhead Protection Area Delineation Project, WNMI, 2009)

Vulnerability scores in WHPAs can be 2, 4, 6, 8, or 10 and are based on the time-of-travel and the ISI rating. The chart below shows how scores are determined in a WHPA.

Intrinsic Vulnerability	Travel Time Zones			
	100m	2 year	5 year	25 year
HIGH	10	10	8	6
MEDIUM	10	8	6	4
LOW	10	6	4	2

Details on data information sources for delineations and scoring are available in the consultant's reports. These reports are noted in the Reference section at the end of this chapter.

Transport Pathways

Within wellhead protection areas, vulnerability scores were developed by intersecting Aquifer Vulnerability scores, typically derived from the Intrinsic

Susceptibility Index (ISI) or Aquifer Vulnerability Index (AVI), with the time-of-travel capture zones associated with the WHPA. Where anthropogenic transport pathways exist that circumvent the natural vulnerability of the aquifer, the Aquifer Vulnerability score can be increased according to the following technical rules 39, 40 and 41, listed below:

> 39. Where the vulnerability of an area identified as low in accordance with rule 38 is increased because of the presence of a transport pathway that is anthropogenic in origin, the area shall be identified as an area of medium or high vulnerability, high corresponding to greater vulnerability.
>
> 40. Where the vulnerability of an area identified as medium in accordance with rule 38 is increased because of the presence of a transport pathway that is anthropogenic in origin, the area shall be identified as an area of high vulnerability.
>
> 41. When determining whether the vulnerability of an area is increased for the purpose of rules 39 and 40 and the degree of the increase, the following factors shall be considered:
>
> (1) Hydrogeological conditions.
>
> (2) The type and design of any transport pathways.
>
> (3) The cumulative impact of any transport pathways.
>
> (4) The extent of any assumptions used in the assessment of the vulnerability of the groundwater.
>
> *Clean Water Act*, Technical Rules (December, 2009)

Based on these rules, before an adjustment to aquifer vulnerability to account for transport pathways can be made, the hydrogeology of the site, the type and design of any transport pathways, the cumulative impact of the pathways, and any assumptions used in developing the original aquifer vulnerability rating must be considered.

Methodology

Preliminary identification of Transport Pathways was completed through aerial photo interpretation. Properties and areas of interest were identified from the 2007 photos in a GIS environment. Properties located in the WHPA were also visited as part of a larger effort to evaluate drinking water threats throughout the region. As part of these visits, routine questions were asked of the property owners about the location and condition of any wells on the property. The results of these site visits were entered and stored in a geo-referenced database, facilitating review as part of the Transport Pathways review.

Similarly, a number of stewardship programs have been carried out in the region both relating to drinking water source protection, as well as municipal programs. Well head upgrades are a common constituent of these programs, and properties where work has been completed have been recorded, entered into a geo-referenced data and were useful tools in evaluating potential Transport Pathways.

As part of a provincial initiative to verify the Water Well Information System (WWIS) and as part of the data collection phase of the proposed Drinking Water Source Protection project, the Ausable Bayfield and Maitland Valley Conservation Authorities undertook a review of the Water Well Information System: specifically, the Water Well Records with respect to spatial accuracy and well record completeness. Phase One (2005) refined the WWIS based on existing data and Phase Two (2006/2007) field verified these records with the ultimate goal of updating provincial records.

Field verification using Global Positioning System (GPS) technology was implemented to capture the position of the well. This location was compared against WWIS Records in order to verify their accuracy. To capture the well location, a team of two individuals visited properties within the 25-year time-of-travel wellhead protection area (WHPA) for municipal wells within the Ausable Bayfield Maitland Valley (ABMV) region. Upon completion of the GPS coordinate reading, a photograph was taken of the well in context to surrounding buildings, and the condition of the well was noted. This data was available for review of the Transport Pathways in the Region.

In the Ausable Bayfield Maitland Valley Source Protection Region (SPR) transport pathways can be grouped into several categories, namely: pits and quarries; private wells; and urban areas and private well clusters. Detailed methodology and consideration of these areas are outlined below. In assigning transport pathway adjustments, the hydrogeology of the site and the condition of the pathway were considered, as well as the cumulative impact of transport pathways.

Pits and Quarries

Pits and quarries were primarily identified through aerial photography. Where prudent, these operations were examined by a roadside or windshield survey in order to ascertain the type of operations. There are relatively few pits and quarries in the region. Where they exist, and dependent on their depth with respect to the water table, aquifer vulnerability was adjusted from low to moderate or high, or from moderate to high. Details of any such adjustments are provided in Part 2 for individual WHPAs.

Private Wells

Private wells were first identified using the WWIS. Information made available from the well record improvement project undertaken by the Maitland Valley and Ausable Bayfield Conservation Authorities was used to evaluate the condition of the wells, which was current for the WHPAs for the year 2006. Additional information was gathered from site visits carried out as part of the Source Protection Committee consultation, and stewardship programs to determine if any upgrades had occurred since 2006.

Wells that were not in compliance with existing regulations were identified as being potential conduits for water that increase the vulnerability of the aquifer locally. Vulnerability scores were adjusted for 30 m surrounding the well, and were adjusted a maximum of one level (i.e., low to moderate; or moderate to high).

Additionally, several properties for which no well record exists, nor any well obvious by site inspection, yet have structures which require water were identified. In these cases, vulnerability scores were adjusted for 60 m surrounding any of the principal structures on the property, and were adjusted a maximum of one level.

Details of all vulnerability adjustments for private wells are provided in Part 2 of this chapter for individual WHPAs.

Urban Areas and Private Well Clusters

Urban areas inside WHPAs were delineated based on aerial photography. These areas warrant special consideration as potential areas for Transport Pathway adjustments under Technical Rule 41 (3) as the cumulative effects of a high density of abandoned historic wells are common. Although these areas today are serviced by a municipal well, most were historically serviced by private wells. Additionally, the age of these wells precludes the existence of a record for the wells.

As part of this review, the historical servicing of these urban areas was reviewed, and the areas themselves visited to determine if former private wells could be in existence. Where this information indicates that wells are in existence and are substantially non-compliant, vulnerability scores were adjusted for the areas, and were adjusted a maximum of one level.

In areas where the aquifer being exploited by the municipal well is poorly protected, vulnerability scores can be adjusted to account for a reduction in the natural protection of the aquifer due to the installation of underground services, including sewer lines, septic systems, water supply and electricity supply lines.

Where the hydrogeology warranted it, aquifer vulnerability scores were adjusted a maximum of one level in these areas. Details of all vulnerability adjustments within urban areas are for individual WHPAs.

4.3 Overview and Description of Vulnerable Areas

The ISI method (as described previously) was used to determine groundwater vulnerability across the entire SPA and the results of this are shown on **Map 4.AB.Vul**.

Highly vulnerable aquifers (HVAs) in the SPA are shown on **Map 4.AB.HVA**. HVAs are scattered throughout the source protection area with lower densities south of Centralia, and along the Lake Huron shore zone north from Grand Bend. The most extensive HVA includes The Pinery-Port Franks-Thedford Flats area due to the presence of shallow sand aquifers which are exploited.

Significant groundwater recharge areas in the SPA are associated with permeable hydrologic response units and are presented on **Map 4.AB.SGRA**. SGRAs correspond to sand plains that parallel the shoreline for the full length of the Source Protection Region. Although the Ausable Bayfield watershed has less SGRA extent, strips occur on narrow sand plains and spillways.

There is one surface water intake from Lake Huron: the Lake Huron Primary Water Supply System (LHPWSS). The LHPWSS intake is approximately two kilometres offshore just north of Grand Bend and supplies the City of London as well as residents in the south end of the Ausable Bayfield Maitland Valley Source Protection Region.

The Ausable Bayfield Source Protection Area has three municipalities with municipal residential well systems: Bluewater, Central Huron and Huron East.

4.4 Threats, Conditions, Issues and Risk

The **threats** to drinking water are identified in *Ontario Regulation 287/07* as follows:

Table 4.1 List of Threats in Ontario Regulation 287/07, Section 1.1

1. The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the *Environmental Protection Act*.
2. The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.
3. The application of agricultural source material to land.
4. The storage of agricultural source material.
5. The management of agricultural source material.
6. The application of non-agricultural source material to land.
7. The handling and storage of non-agricultural source material.
8. The application of commercial fertilizer to land.
9. The handling and storage of commercial fertilizer.
10. The application of pesticide to land.
11. The handling and storage of pesticide.
12. The application of road salt.
13. The handling and storage of road salt.
14. The storage of snow.
15. The handling and storage of fuel.
16. The handling and storage of a dense non-aqueous phase liquid.
17. The handling and storage of an organic solvent.
18. The management of runoff that contains chemicals used in the de-icing of aircraft.
19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.
20. An activity that reduces the recharge of an aquifer.
21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.
22. The establishment and operation of a liquid hydrocarbon pipeline. *

*In 2018, the province amended regulation 287/07 to include the establishment and operation of a liquid hydrocarbon pipeline as a prescribed drinking water threat. There is a pipeline located at the southern tip of the AB SPA, but it does not intersect a vulnerable area so it not assessed as a drinking water threat.

The Source Protection Committee may recommend threats be added to the above list (**Table 4.1**). This can only be done upon Ontario Ministry of the Environment, Conservation, and Parks approval. No additional threats have been identified by the Ausable Bayfield Maitland Valley Source Protection Committee.

The Source Protection Committee may also identify **conditions** which constitute a risk. As per the *Technical Rules: Assessment Report* (Rule 126) *conditions* are any one of the following that exist in a *vulnerable area* and result from a past *activity*:

- The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area
- The presence of a single mass of more than 100 litres of one or more *dense non-aqueous phase liquids* in surface water in a surface water *intake protection zone*
- The presence of a contaminant in groundwater in a *highly vulnerable aquifer, significant groundwater recharge area* or a *wellhead protection area*, if the contaminant is listed in Table 2 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table;
- The presence of a contaminant in surface soil in a surface water *intake protection zone*, if the contaminant is listed in Table 4 of the Soil, Ground Water and Sediment Standards is present at a concentration that exceeds the surface soil standard for industrial/commercial/community property use set out for the contaminant in that Table; and
- The presence of a contaminant in sediment, if the contaminant is listed in Table 1 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceeds the sediment standard set out for the contaminant in that Table

The Ausable Bayfield Maitland Valley Source Protection Committee has not identified any conditions within vulnerable areas in the Ausable Bayfield Source Protection Region.

It is possible for an extreme event to threaten a drinking water source. An **event based approach** was therefore used for surface water intakes, such as the LHPWSS, to determine whether contaminants released during an extreme event may be transported to an intake. This approach models an Intake Protection Zone 3 (IPZ-3), that includes areas beyond IPZ-1 and IPZ-2, based on extreme event conditions, (such as a 100-year storm), and an understanding of contaminant transport to the intake. Activities occurring within an IPZ-3 can then be identified as significant drinking water threats ***if*** it can be shown through modeling that a release of a specific contaminant would result in an issue at the intake. The modelling conducted in the Ausable Bayfield SPA did not demonstrate any deterioration of the source of drinking water as a result of contaminants being transported to the LHPWSS during an extreme event. Therefore, no IPZ-3 was delineated.

Finally, there may be a documented water quality **issue** at a drinking water source. An example would be water contamination that threatens to exceed drinking water standards and treatment is beyond the capacity of the water treatment plant. The Source Protection Committee has identified that if a contaminant of concern reaches half the maximum acceptable concentration, then it is an issue. Currently, no issues are known for the Source Protection Region's municipal drinking water sources.

However, there is evidence of nitrates trending toward this threshold in individual and test wells in Huron East in proximity to the sink holes. Also in Huron East, there was a history of radionuclides in the municipal wells in Seaforth. These wells have been replaced. However, there is concern that road salt use may contribute to the release of radionuclides. Further research is required for both these issues.

A **risk** to drinking water sources exists where the land is sufficiently vulnerable and the threat is great enough. The amount of risk is identified for a location given the degree of vulnerability where there is or may be a prescribed threat under certain circumstances (as identified in the *Table of Drinking Water Threats*). The degrees of risk are significant, moderate or low.

Identifying Threats

The Assessment Report provides an inventory of possible threats. In simple terms, the present land use is identified for each parcel in wellhead protection areas or intake protection zones. Then a range of threats (as noted above) that are normally associated with that type of land use are assigned to the parcel. Finally, the risk associated with that threat activity is determined. This method takes into account intrinsic risk and does not consider risk management activities. In other words, it uses the precautionary principle. Source Protection Plan policies will be based on the potential or intrinsic risk. However, as part of the Assessment Report, an attempt is made to identify the number and type of significant risks that actually exist in each wellhead protection area. The only locations where significant threats based on activities could exist are in the wellhead protection areas throughout the ABMV Source Protection Region.

Ontario Regulation 287/07 prescribes drinking water threats. This list was established after extensive research on the part of the Ministry of the Environment. There are 22 threats listed and they pertain to both water quality and water quantity threats. Water quantity threats are considered in the Water Budget process (see Chapter 3). For water quality, the threats are activities which could result in the release of chemicals of concern and/or pathogens. Chemicals are man-made substances of distinct molecular composition. Pathogens are agents that cause infection or disease and can be microorganisms, such as bacteria or protozoa, or viruses.

To understand if an area has the potential for significant, moderate or low threats, the reader should first determine which type of vulnerable area the property is located in:

- WHPA A – 100 metres around the wellhead
- WHPA B – Two year time-of-travel around the wellhead
- WHPA C – Five year time-of-travel around the wellhead
- WHPA D – Twenty-five year time-of-travel around the wellhead
- WHPA E – Two hour time-of-travel at a GUDI well*
- IPZ 1 – 1 km radius from lake intake or 120 m inland – See p. 4-5
- IPZ 2 – Two hour time-of-travel from the intake
- SGRA – significant groundwater recharge area
- HVA – highly vulnerable aquifer

*GUDI means the well is groundwater under direct influence of surface water.

The vulnerability score should then be ascertained for the location. WHPAs range from 2 – 10 where 10 is the most vulnerable. The IPZ scores range from 4 – 6 and HVAs score 6 or less. SGRAs are not assigned a score. The score is indicated by the colour on the map and map legend (see example below).

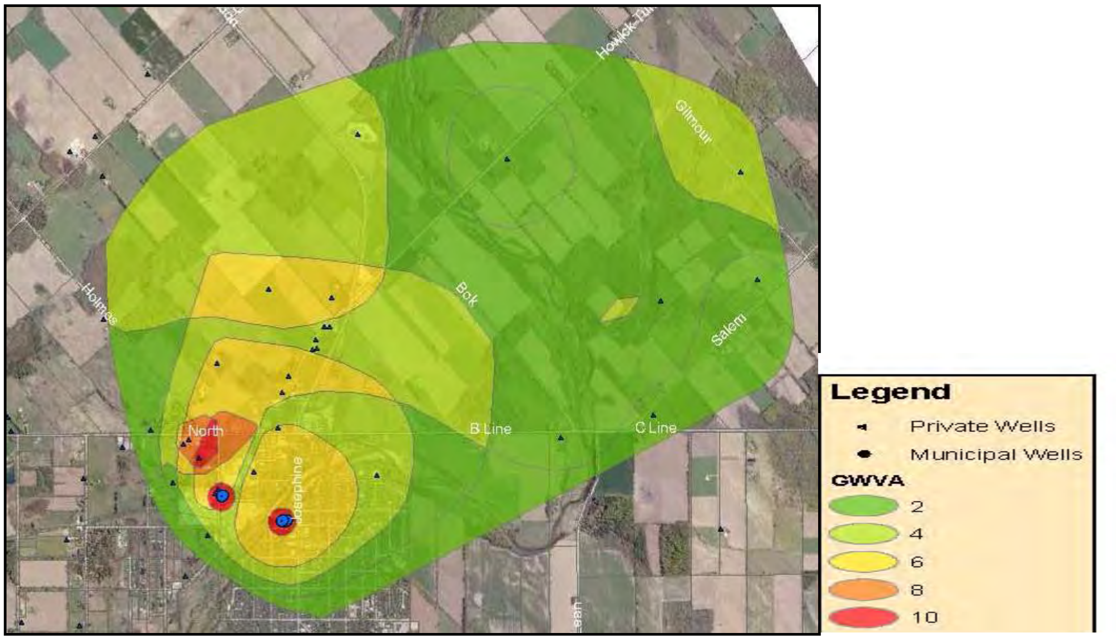


Figure 1: Example of WHPA Map with Vulnerability Scores

For example, where the area is located in a WHPA A, the vulnerability score is 10 (signified by the red circle). By using the *Table of Drinking Water Threats*, one can determine the number and type of possible chemical, DNAPL or pathogen threats that may occur on the property. It does not mean that these threats exist rather that they might exist given the land uses on the property.

Once these two factors are known, the reader can then look up the circumstances in which an activity might be of significant, moderate or low risk. This is done using the Table of Drinking Water Threats, found within the Technical Rules at https://www.ontario.ca/page/2021-technical-rules-under-clean-water-act.

A Threats Look Up Tool is available at: https://swpip.ca, which allows users to search through the Tables of Drinking Water Threats by the various activities and circumstances.

Below is a sample from the Table of Drinking Water Threats, which describes specific circumstances in which the threat activity would present a risk. Often the circumstance relates to the quantity of the chemical of concern (it is more risky to have 2,500 litres of fuel stored than 25 litres). Further, this Table provides the corresponding degrees of risk (significant, moderate, or low) depending on the groundwater vulnerability score (it is more risky to have 2,500 litres of fuel stored where the score is 10 than where the score is 6).

Table 4.2 Sample from Table of Drinking Water Threats, Road Salt Application

Circumstance type and number	Circumstances	Areas of SDWT	Areas of MDWT	Areas of LDWT
Chemical C12.1.1	1. The road salt is applied in an area where the default percentage of impervious surface area, as set out on a total impervious surface area map, is less than 1 percent.	n/a	IPZ/ WHPA-E 9 – 10	IPZ/ WHPA-E 6 – 8.1 WHPA 8 – 10
Chemical C12.1.2	1. The road salt is applied in an area where the default percentage of impervious surface area, as set out on a total impervious surface area map, is at least 1 percent, but less than 8 percent in WHPA-A, B, C, C1, D or HVA; or is at least 1 percent, but less than 6 percent in IPZ-1, 2, 3 and WHPA-E.	n/a	IPZ/ WHPA-E 8 – 10 WHPA 10	IPZ/ WHPA-E 5.4 – 7.2 WHPA 6 – 8 HVA 6
Chemical C12.1.3	1. The road salt is applied in an area where the default percentage of impervious surface area, as set out on a total impervious surface area map, is at least 8 percent, but less than 30 percent in WHPA-A, B, C, C1, D or HVA; or is at least 6 percent, but less than 8 percent in IPZ-1, 2, 3 and WHPA-E.	IPZ/ WHPA-E 10	IPZ/ WHPA-E 8 – 9 WHPA 8 – 10	IPZ/ WHPA-E 4.9 – 7.2 WHPA 6 HVA 6
Chemical C12.1.4	1. The road salt is applied in an area where the default percentage of impervious surface area, as set out on a total impervious surface area map, is 30 percent or more in WHPA-A, B, C, C1, D or HVA; or is 8 percent or more in IPZ-1, 2, 3 and WHPA-E.	IPZ/ WHPA-E 9 – 10 WHPA 10	IPZ/ WHPA-E 7 – 8.1 WHPA 8	IPZ/ WHPA-E 4.5 – 6.4 WHPA 6 HVA 6

Technical Rules, 2021. *CWA, 2006*

The tables below summarize where in the vulnerable areas chemical, dense non-aqueous phase liquids (DNAPL) and pathogen threats, are or would be significant, moderate and low drinking water threats. The level of threat that an activity poses to a drinking water supply depends on the vulnerability scores within a vulnerable area. This table can be used in combination with the maps that show vulnerability scores to determine where significant, moderate and low threats can be found. In addition, this table and the vulnerability maps can be used in combination with the provincial Table of Drinking Water Threats to determine the types of activities that would be deemed a significant, moderate and low drinking water threat in each area.

Table 4.3 Areas within Highly Vulnerable Aquifers Where Activities and Conditions are or would be Significant, Moderate and Low Drinking Water Threats

Threat	Vulnerability Score	Threat Level Possible		
		Significant	Moderate	Low
Chemical (including DNAPLs)	6		✓	✓
Pathogen	6			

Table 4.4 Deleted

Table 4.4: Areas within SGRA where Activities or Conditions are Drinking Water Threats, was deleted following change to Technical Rules which removed scores, and therefore any drinking water threats, for SGRAs.

<u>Sources of Water Considered</u>

The Ausable Bayfield Source Protection Area has a surface water intake and wells serving municipal drinking water systems specified by the *Clean Water Act, 2006* and identified in the *Terms of Reference*. These sources are the Great Lakes intake, which is the Lake Huron Primary Water Supply System (LHPWSS), and the wellheads identified as “Type 1 Wells” in the *Technical Rules*. Type 1 Wells are: existing and planned municipal drinking water systems that serve or are planned to serve major residential developments. This list was identified through the Terms of Reference.

Other sources of drinking water are not under consideration at this point. Although municipalities may choose to elevate other systems into the source protection planning process, none have selected this option to date.

Table 4.5 Areas within Intake Protection Zones Where Activities and Conditions are or would be Significant, Moderate and Low Drinking Water Threats

Threat	IPZ	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemical (including DNAPLs)	IPZ-1	8 – 10	✓	✓	✓
		6 – 7	-	✓	✓
		5	-	-	✓
	IPZ-2	8 – 9	✓	✓	✓
		6.3 – 7.9	-	✓	✓
		4.2 – 5.9	-	-	✓
		<4.2	-	-	-
	IPZ-3	8 – 9	✓	✓	✓

Threat	IPZ	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
		6 – 7.9	-	✓	✓
		4.5 – 5.9	-	-	✓
		< 4.5	-	-	-
Pathogen	IPZ-1	8 – 10	✓	✓	✓
		6 – 7	-	✓	✓
		5	-	-	✓
	IPZ-2	8 – 9	✓	✓	✓
		6.3 – 7.9	-	✓	✓
		4.2 – 5.9	-	-	✓
		<4.2	-	-	-
	IPZ-3	0.8 – 9	-	-	-

Table 4.6 Areas within Wellhead Protection Areas Where Activities and Conditions are or would be Significant, Moderate and Low Drinking Water Threats

Threat	WHPA	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemical	A	10	✓	✓	✓
	B	10	✓	✓	✓
		8	✓	✓	✓
		6		✓	✓
	C	8	✓	✓	✓
		6		✓	✓
		<6			
	D	6		✓	✓
		<6			
	E	8 – 9	✓	✓	✓
		6.3 – 7.9		✓	✓
		4.2 – 5.9			✓
		<4.2			
DNAPL	A	10	✓		
	B	6 – 10	✓		
	C	4 – 8	✓		
	D	6		✓	✓
		<6			
	E	8 – 9		✓	✓
		6.3 – 7.9		✓	✓
		4.2 – 5.9			✓
		< 4.2			
Pathogen	A	10	✓	✓	
	B	10	✓	✓	
		8		✓	✓
		6			✓
	C	4 – 8			
	D	2 – 6			
	E	8 – 9	✓	✓	✓
		6.3 – 7.9		✓	✓
		4.2 – 5.9			✓
		<4.2			

Methodology Notes

The storage, handling and application of pesticides, fertilizers and agricultural source material associated with agricultural activities can result in surface water runoff and potential pathogen and chemical contamination. This report utilizes information on managed lands and livestock density as an indicator of areas in a watershed where intensive agricultural and other land management activities are conducted.

Managed Lands Methodology

The purpose of the managed lands layer was to develop a portrayal of how much land was subject to human management. The management of land meant that the land was probably receiving nutrients or fertilizer. The managed land was created from all lands which were classed agricultural, large sports fields/golf courses, as well as a percentage of the residential area of all towns. A constraint was placed on the areas where land was managed to limit the area of interest to those areas where the vulnerability was ≥ 6 for areas reliant on groundwater and ≥ 4.4 for areas reliant on surface water.

The methodology for the analysis was completed in two separate steps. While the steps were distinct from each other, the methodology was the same.

First, using the wellhead protection and intake protection zones with vulnerability ≥ 6 for areas reliant on groundwater and ≥ 4.4 for areas reliant on surface water the datasets were united together and then exploded into distinct polygons. These polygons denoted areas that were physically separated from any other polygon.

The Terranet parcel fabric was united with the areas of interest resulting in roadways being created via the closing of empty space between parcels. By using the MPAC property codes and farm operation codes those areas which were “managed” could be identified.

The area was calculated for all areas with the designation of agricultural managed land vs. non-agricultural managed land being noted. In addition, the footprint of the towns and cities was merged into the dataset. Those areas of the town which were not agricultural were further adjusted to account for the potential for fertilizers to be applied to the grassed areas of the towns. For those non-agricultural areas the land base was considered to be .35 the area or 35% managed land.

Given that unique polygons were created from the vulnerability polygons ≥ 6, the total areas for the polygons was created. The managed land was calculated and then further adjusted for the urban footprints. It is possible to calculate the percentage managed through the following formula:

Managed Land Percentage = Agricultural managed land + ((town footprint parcels exclusive agricultural land and roads x 0.45) + non-agricultural managed land / total area → for those areas of vulnerability ≥ 6 for areas reliant on groundwater and ≥ 4.4 for areas reliant on surface water in the source water region summarized by distinct polygon.

Second, the managed land for the HVA/SGRA was completed in the same manner as above except the areas were handled distinctly from the WHPA/IPZ analysis. This may result in percentage managed land edge match differences at the transition zone between WHPA areas and HVA areas which are portrayed by different colours where they meet. As well, where the score is less than 6 for areas reliant on groundwater and less than 4.4 for areas reliant on surface water, it is not included, thus it appears as the air photo on the maps.

Nutrient Unit per Acre Methodology

The purpose of the livestock density map was to develop a layer which showed the nutrient amounts per acre (NU/acre) that were being generated. The livestock farms under consideration were limited to those in areas where the vulnerability was ≥ 6 for areas reliant on groundwater and ≥ 4.4 for areas reliant on surface water.

There were two distinct methodologies used in the creation of the nutrient unit/acre maps and datasets. The first method was internal to the wellhead protection areas and intake protection zones and involved field verified animal numbers and nutrient calculations for estimating the nutrient units for any given property in the significant areas. The second method was completed in SGRA/HVA areas and involved the use of the agricultural census (2006) data for census consolidated subdivisions (CCS).

The areas internal to the WHPA and IPZ had the nutrient units (NU) calculated by estimating the nutrient units via field visits and air photo interpretation. To assist in the field visits a set of maps was created for those properties designated with MPAC farm operation codes indicating livestock was present for those properties with vulnerability scores ≥ 6 for areas reliant on groundwater and ≥ 4.4 for areas reliant on surface water.

The property level maps were taken to the field by staff to record visit information such as the presence or absence of farm animals and the facilities to house the animals. These observations were completed via windshield survey.

Information was written on the orthophoto based property level maps designating which barns housed animals. The barn footprints were digitized and a square footage for any given barn could be established. By combining the observed animal species, provincial guide tables indicating NU/square foot for any given animal species, and the square footage of a barn, the overall nutrient units for any given farm could be estimated.

All barns housing animals were calculated on any given farm property and then summarized by property. This created the total nutrients on any given property. The woodlots were removed from the property thereby creating the managed land of the property. Since some of the land for a given farm may lie outside the wellhead protection zone the NU were pro-rated to account for only the land internal to the wellhead protection zone.

Two calculations are then completed. The first provides the NU/acre calculation for any given farm by summing the nutrient units/dividing by the hectares and then converting to NU/acre via a factor of 2.45. This provides the NU/acre for a given farm.

The second calculation takes all the nutrient units calculated in a given wellhead protection area and sums them. The total agricultural managed land on the contributory farms is summed and an overall NU/acre is derived from these two summations. The maps portray the nutrient units per acre where the vulnerability is equal to or greater than 6 for areas reliant on groundwater and ≥ 4.4 for areas reliant on surface water and the lands are managed (e.g. Excluding the urban footprint or forested areas).

Nutrient units in the HVA/SGRA areas were calculated from the agricultural census (2006) data using total agricultural managed land, animal numbers and finally NU/animal tables for generating NU/acre estimates for each census consolidated subdivision. The NU/acre was calculated for the entire CCS however when mapping only those HVA/SGRA areas with vulnerability ≥ 6 were symbolized (there are no HVA or SGRA in areas reliant on surface water in this region). This methodology required the Directors approval. It was determined that for areas outside wellheads, the vulnerability scores were low enough to preclude significant risks and the results of this methodology would be equivalent to those of the methodology used within the wellhead areas.

Impervious Surface Methodology

Impervious surfaces are mainly constructed surfaces such as sidewalks, roads and parking lots that are covered by impenetrable materials such as asphalt, concrete, brick, and stone. These materials seal surfaces, repel water and prevent precipitation and melt water from infiltrating soils. Impervious surfaces can generate large amounts of runoff during storm events. Road salt used during winter road maintenance is regarded as a threat, and the percentage of impervious surfaces is an indicator of the potential for impacts due to road salt. A map showing the percentage of impervious surface in defined vulnerable areas is provided at the municipal level in this report.

The following is an explanation of the creation of the impervious surface layer. The first section is a list and explanation of the input datasets while the second section is an explanation of the methodology used in modifying the input datasets to create the resultant impervious surface layer.

Input layers:

- Highly Vulnerable Aquifers
- Wellhead protection areas delineating the municipal well capture zone areas for groundwater.
- Intake protection zones delineating the capture areas for the surface water intakes.
- The Terranet assessment parcel dataset. The dataset contains the boundaries of the land use parcels. Areas between the parcels represent roads.
- Footprints layer. This layer represents a delineation of the built up or urban area for cities and towns. This layer is used to adjust the impervious surface in urban areas to account for buildings, parking lots and driveways.
- Source Protection Region boundary. This layer is used to limit the data set to those areas inside the ABMV Source Protection Region.

This dataset was used to create 1 km square areas to reduce the analysis area for the study to 1 km. This allows the local features for any 1 km area to be captured and not lost in a large area averaging technique.

Methodology:

The HVA, IPZ and WHPA all contained a vulnerability score created previously. Those areas which have a vulnerability score of ≥ 6 represent those areas where impervious surface threats can exist. These areas were merged together to create the area of interest to analyze.

The parcel fabric was united with the areas of interest. All areas which were not a parcel were assigned the classification of road as these contribute to the impervious surface. In addition, after merging the footprints of the town, any areas which were in a parcel in the town footprints were assigned an impervious percentage to account for the driveways and buildings. A factor of .45 was used representing 45% of a parcel being impervious in towns.

Additional datasets were united to limit the analysis to both the source water region as well as to provide the 1km grid area scope. The 1km grid, via a unique grid identifier for any given 1km square, was used to summarize the data.

The final dataset represents the percentage of roads and 45 % of the town footprints (exclusive of the roads) in any area of vulnerability ≥ 6 divided by those areas of vulnerability ≥ 6 in any 1km square:

Percent Impervious = Road area + (town footprint exclusive of roads * .45) / area of interest → for those areas of vulnerability ≥ 6 in the source water region based on a 1km grid summary.

The mapping of the impervious surface was completed using the standard symbology classes as required in the *Mapping Symbology for the Clean Water Act, 2006* (MNR, 2009). The coloured areas on these maps represent only those areas with vulnerability ≥ 6. Therefore, some of the grid may contain impervious surface and some part of the grid cell may not. The inclusion of the 1km grid linework facilitates the understanding of how the impervious surface change occurs at the limits of any grid cell.

Approach to Significant Threat Enumeration

Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

It should be noted that the identification of threats is based on a blend of field research and a “desktop” approach. The desktop approach relied on Municipal Parcel Assessment Corporation (MPAC) data. This data indicates the type of land use taking place and can be associated with certain types of activities and presence of related chemicals or pathogens. The North American Industry

Classification System code (NAICS) data was helpful in associating chemicals typically used at various types of land uses. During the course of the preparation of this document, there was consultation with property owners in vulnerable areas where significant risks would exist. Information was provided by many land owners which helped to refine the data base used to enumerate significant threats. However, not all property owners responded to requests for such information. In these cases, the desktop approach was the best source of information. This approach made the assumptions that:

- Home heating is oil, in a basement tank,
- Houses use septic tanks,
- Businesses (including home occupations), industries and agricultural uses within the five-year year time-of-travel could store DNAPLs.

Due to these assumptions, the threat enumeration provided in the 2012 Assessment Report was conservative (assessing threats where there was no information to confirm absence of that threat).

For the 2014 Updated Assessment Report, additional information was collected through site visits, landowner contact and drive-by assessments. For this approach, it was assumed properties that had a gas meter did not use heating oil and would not pose a significant threat for fuel. It was also assumed properties with access to municipal sewer did not have a septic system. Where there was insufficient information available to determine the presence or absence of a threat, a conservative approach was taken, and it was assumed the activity was a potential significant threat. As a result of this verification, the number of potential significant threats dropped significantly.

Threats are assigned to parcels, and represent the best information available at the time of writing. Numbers are expected to vary over time, according to changes in land use and activities, and as additional information becomes available.

The Application of Commercial Fertilizer, Non-agricultural Source Materials and Application of Road Salt cannot be a significant drinking water threat in some areas due to the percent managed land, livestock density and / or percent impervious surface.

In 2018, the Assessment Report was amended to include the Varna system and to remove the Carriage Lane and Harbour Light systems. Threat numbers were not updated for the other systems at that time.

In 2023, the Assessment Report was updated to incorporate the amended 2021 Technical Rules, as well as changes to water systems. The 2021 Technical Rules included numerous changes to the circumstances in the tables of drinking water threats. The thresholds for salt and snow threats, in particular, were significantly lowered. A desktop risk assessment was completed to estimate the number of significant threat activities, using the new Rules. These numbers are unverified at time of writing.

Part 2

4.5 Municipal Profiles

4.5.1 Adelaide Metcalfe

This township is located in the south western part of the source protection area. The portion of the municipality within the study area represents approximately one third of the land mass and one third of the population, approximately 860 people. There are no municipal residential drinking water sources in this area. There is limited access to the Lake Huron Primary Water Supply pipeline as this area has a dispersed population which is rural in character. Therefore, the majority of the population relies on individual wells.

Map 4.AM.IS shows the percentage of impervious surface area; **Map 4.AM.ML** shows the location and percentage of managed lands, and **Map 4.AM.LD** shows the livestock density within vulnerable areas for Adelaide Metcalfe.

4.5.1.1 Adelaide Metcalfe – HVAs and SGRAs

Maps 4.AM.HVA and 4.AM.SGRA show the locations of HVAs and SGRAs respectively in Adelaide Metcalfe. The vulnerability score for all HVAs is 6 while SGRAs are not assigned a score. There are no significant risks within these areas.

<u>Threats & Risk</u>

As there are no municipal residential drinking water sources and the vulnerability scores for the HVAs are 6 or less, there are no significant drinking water threats in this area (**Table 4.7**). **Table 4.3** can be used in combination with **Maps 4.AM.HVA** to determine where chemical, pathogen, and DNAPL threats can be moderate and low risks in HVAs. There are no known conditions or issues in the portion of the municipality within the AB SPA (**Table 4.8**).

Table 4.7 Adelaide Metcalfe Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.8 Adelaide Metcalfe Issues and Conditions

Drinking Water Issue	Parameter
None	None

Drinking Water Condition	Threat
None	None

4.5.2 Bluewater

The Municipality of Bluewater is on the Lake Huron shore, extending from just north of Grand Bend and Exeter in the south to the Bayfield River in the north. It is entirely in the jurisdiction of Ausable Bayfield SPA. In 2006, the population was 7,120, an increase of 2.9% from 2001. Seasonal residents add approximately 2,500. Bluewater has attracted extensive shoreline development and pressure mounts to convert seasonal occupation to year-round. The main towns are Bayfield (population 900) and Hensall (population 1,081); smaller villages include Zurich, Dashwood and Varna. Cropland covers 88.5% of Bluewater. The main crops are soybeans, corn, winter wheat and dry white beans. Livestock density (cattle: 18/sq.km.; pigs: 257.2/sq.km.) is high for pigs, exceeding the Huron County density of 209.6/sq.km (Statistics Canada 2007).

Map 4.BW.IS shows the percentage of impervious surface area; **Map 4.BW.ML** shows the location and percentage of managed lands, and **Map 4.BW.LD** shows the livestock density within vulnerable areas for Bluewater.

4.5.2.1 Bluewater HVAs and SGRAs

Maps 4.BW.HVA and 4.BW.SGRA show the locations of HVAs and SGRAs respectively in the Municipality of Bluewater. HVAs occur in irregular patterns at the eastern boundary of the municipality. The largest area lies roughly between Zurich and Hensall. SGRAs run in linear bands of sand plain and spillways parallel to the Lake Huron shoreline. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score. There are no significant risks within these areas.

<u>Threats and Risks</u>

Since the vulnerability scores for the HVAs are 6 or less, only moderate and low drinking water threats may exist in this area. **Table 4.3** can be used in combination with **Map 4.BW.HVA** to determine where chemicals or pathogen can be moderate and low threats in HVAs in Bluewater. There are no known conditions or issues in the municipality.

4.5.2.2 LHPWSS Intake Protection Zone

The Lake Huron Primary Water Supply System (LHPWSS) intake serves a population of about 350,000, approximately 4,000 of which are in Bluewater. The largest user is the City of London. Ontario Drinking Water Quality Standards were met in 100% of the tests in the latest available reporting period, April 1, 2007 to March 31, 2008. Bluewater uses 415,000 cubic metres per year. Current international agreements on water taking from the Great Lakes have no effect on this intake.

Vulnerability

Since the LHPWSS intake is more than one kilometre offshore, Intake Protection Zone-1 (IPZ-1) does not reach land (**Map 4.BW.IPZ**). Intake Protection Zone-2 (IPZ-2) extends 120 metres inland, up five gullies and drains; and approximately five kilometres from the municipal boundary, northward along the shoreline. IPZ-1 has a vulnerability score of 5, and IPZ-2 has a vulnerability score of 4 (**Map 4.LHPW** and **Table 4.9**). **Table 4.9** indicates the vulnerability scores determined by the consultants and verified through peer review. Please see section 4.2 for more information about the Area Vulnerability Factor and Source Vulnerability Factor.

Table 4.9 LHPWSS IPZ: Vulnerability Score Summary

Location	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
Lake Huron	IPZ-1 10	IPZ-2 : 8 Medium	0.5 Low	IPZ-1 5	IPZ-2 4

Threats and Risks

Table 4.10 indicates that no significant risks from chemicals, pathogens or DNAPLs would be present based on activities. **Table 4.5** can be used in combination with **Map 4.LHPW** to determine where chemical and pathogen threats can be low risks in the intake protection zones for the LHPWSS. In addition, the table of drinking water threats within the Technical Rules can be used to determine the types of activities that would be deemed a low threat in IPZ-1.

Table 4.10 LHPWSS IPZ: Enumeration of Potential Significant Threats

Threat Type	Significant Instances		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
Total:	0	0	0

Drinking Water Issues and Conditions

Table 4.11 indicates that no issues with the intake or conditions resulting from past activities were identified within the IPZ. Using the events based approach, modelling was conducted to determine whether contaminants from the Grand Bend Sewage Treatment System, or a harbour marina could be transported to the intake during an extreme event. The modelling concluded that no contaminants transported to the intake during an extreme event would result in a deterioration of the water as a drinking water source. Thus no IPZ-3 was delineated.

Table 4.11 LHPWSS IPZ: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.2.3 Wellhead Protection Areas

Most of the population relies on the Lake Huron Primary Water Supply System (LHPWSS). A municipal residential groundwater system serves the community of Varna.

Prior to 2015, the Carriage Lane and Harbour Lights wells served two subdivisions north of Bayfield. The Municipally of Bluewater discontinued the use of the Carriage Lane and Harbour Lights well systems and these wells have been decommissioned. The communities are now served by the LHPWSS. The well systems were removed from the Assessment Report and Source Protection Plan.

In 2017, the Municipally of Bluewater took over the ownership of the Varna well system. The Source Protection Plan was amended pursuant to section 34 of the Act to include the Varna well system.

In 2023, the Municipally of Bluewater discontinued the use of the Zurich groundwater well system and these wells have been decommissioned. The community is now served by the LHPWSS. The well system was removed from the Assessment Report and Source Protection Plan in 2023 via section 51 of the CWA.

A very small part of Brucefield's WHPA also extends into Bluewater. No new drinking water systems are planned. **Map 4.BW.WHPA** shows the WHPAs for each of these systems.

4.5.2.3.1 Brucefield

The Brucefield well is located in Huron East and extends into Bluewater. A description of the Brucefield water supply system and risk assessment can be found in section 4.5.4 under Huron East.

Table 4.12 Deleted

Table 4.13 Deleted

4.5.2.3.2 Varna

The Varna well system (Varna Well 1) was owned by the Varna Water Works Association until June 2017, at which time the Municipality of Bluewater assumed ownership. As required for all municipal drinking water systems, a WHPA delineation was completed and the system was added to the Source Protection Plan and this Assessment Report.

The WHPA delineations were completed in 2016 by Matrix Solutions Inc. (Matrix, 2016). The Matrix report details the methodology and results of the WHPA delineation, and the vulnerability scoring within the newly delineated WHPAs for Varna Well 1. Methodologies were consistent with those used for earlier delineations in this region, in keeping with the Technical Rules (MOE, 2009). Matrix chose a porosity value of 3%, rather than 5% used in earlier studies. This decision reflected recent research that suggested the effective porosity values of carbonate rocks in southern Ontario are lower than previously estimated. As a result of applying a lower effective porosity, the 2-year and 5-year WHPAs delineated for Varna extend further away from the well, as compared to zones delineated with higher rates.

Existing groundwater vulnerability mapping was utilized. Vulnerability rating of "low" was mapped for much of the area due to the presence of thick fine-grained sediments overlying the bedrock aquifer (Matrix, 2016).

The following is a description of the Varna well system:

- ***Location:*** 38807 Vienna Street, Varna**;** Municipality of Bluewater
- ***SPA:*** Both the well and WHPA are in the AB SPA
- Year constructed: 1995
- ***Depth:*** 73.2 m
- ***Users Served:*** 44 connected properties

- ***Design Capacity:*** 1.26 litres/sec
- ***Permitted Rate:*** *144* m^3/day as per PTTW 066-AE9NRG, Oct. 2016
- ***Average Usage:*** 0.24 L/s (21 m^3/day) (2016)*
- ***WHPA delineation rate***: 0.3 L/s (26 m^3/day) *
- ***Treatment:*** Chlorination
  * Matrix, 2016

Groundwater Vulnerability

Map 4.BW.WHPA show that the Varna WHPA extends east of the well and is located entirely within the Municipality of Bluewater. A vulnerability score of 10 applies to the 100 metre radius of WHPA-A which includes residential and commercial uses. The vulnerability scores of WHPA-B and WHPA-C are six and four, respectively, reflecting the low ISI in this area

Aquifer vulnerability was not adjusted for transport pathways in the Varna WHPA. ABMV staff did not find any wells or other potential transport pathways located in the WHPA that would elevate the vulnerability score.

Threats and Risks

Enumeration of drinking water threats was conducted by ABMV staff in 2017, following same process used previously in other wellheads. Information was collected through site visits, landowner contact and drive-by assessments.

Table 4.14 Column 1 lists the drinking water threats in Varna's WHPA. They are all prescribed drinking water threats listed in Subsection 1.1(1) of *Ontario Regulation 287/07*. No other type of local threat was identified. **Table 4.14** also indicates the number of significant threat instances for each threat type. The table of drinking water threats within the Technical Rules provides details on circumstances pertaining to these threats. No other local circumstances were identified.

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Map 4.Varn shows the WHPA and vulnerability scores. It can be used with Table 4.6 to identify the areas where chemicals, pathogens and DNAPLs can be significant, moderate, and low drinking water threats within the Varna WHPA.

Table 4.14 Varna WHPA: Enumeration of Potential Significant Threats

Threat Type	Significant Instances*		
(numbered according to Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
2. Sewage System		13	
12. Application of Road Salt	0		
13. Storage of Road Salt	0		
14. Storage of Snow	0		
15. Fuel Handling/Storage	0		
16. Dense Non-Aqueous Phase Liquid Handling/Storage			1
Total:	0	13	1

*Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

Drinking Water Issues and Conditions

Table 4.15 indicates that no issues with wells or conditions resulting from past activities were identified within the WHPA.

Table 4.15 Varna WHPA: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.2.3.3 Deleted (Carriage Lane)

4.5.2.3.4 Deleted (Zurich)

Table 4.18 Deleted

Table 4.19 Deleted

4.5.3 Central Huron

The Municipality of Central Huron is located on Lake Huron and falls entirely within the Source Protection Region, extending from the Maitland River in the north to the Bayfield River in the south. By Conservation Authority jurisdiction, Central Huron is 76% in Maitland Valley and 24% in Ausable Bayfield. The 2006 permanent population was 7,641, a decrease of 2.1% since 2001. There are also seasonal residents. The main town is Clinton (2006 population 3,082), upstream on the Bayfield River. Central Huron has attracted extensive shoreline development and pressure mounts to convert from seasonal occupation to year round. Two-thirds of the municipality is in crops – mainly soybeans, corn and winter wheat. Livestock density (cattle: 24.7/km^2.; pigs: 126.2/km^2.), while low compared to the rest of Huron County, substantially exceeds Western Ontario's average pig density of 78.7/km^2 (Statistics Canada 2007).

Map 4.CH.IP shows the percentage of impervious surface area; **Map 4.CH.ML** shows the location and percentage of managed lands; and **Map 4.CH.LD** shows the livestock density within vulnerable areas for Central Huron.

4.5.3.1 Central Huron – HVAs and SGRAs

Maps 4.CH.HVA and 4.CH.SGRA show the locations of highly vulnerable aquifers and significant groundwater recharge areas respectively in Central Huron. Most HVAs are scattered east from Holmesville. Two small HVAs fall in the west portion: one just beyond the south east corner of Goderich and the other immediately across the Maitland River from Benmiller. SGRAs correspond to coarse-textured physiographic units which generally run north/south across the municipality: a sand plain in a broad band near the Lake Huron shore, and spillways and kame moraines covering much of the east half of Central Huron. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score.

<u>Threats and Risks</u>

Since the vulnerability scores for the HVAs are 6 or less, only moderate and low drinking water threats may exist in this area. **Tables 4.3** can be used in combination with **Map 4.CH.HVA** to determine where chemical/pathogen/DNAPL threats can be moderate and low threats in HVAs in Central Huron. There are no known conditions or issues in the municipality.

4.5.3.2 Wellhead Protection Areas

Central Huron's major well field is at Clinton. Smaller well systems are associated with shoreline development and include: McClinchey, Kelly, Vandewetering and SAM. Auburn is also in Central Huron, though most of its WHPA extends into North Huron. The Benmiller well is located in Ashfield-Colborne-Wawanosh but its WHPA extends into Central Huron.

Map 4.49 shows the locations of each of the WHPAs in the municipality. Only wells or WHPAs that fall within the Ausable Bayfield SPA will be discussed in this section.

4.5.3.2.1 Deleted (Carriage Lane)

Table 4.20 Deleted

Table 4.21 Deleted

4.5.3.2.2 Clinton

The following is a description of the Clinton well system:

- ***Location:*** The three wells are all located in the vicinity of Park Lane and Princess Street in Clinton, one of which is located at 17 Park Lane
- ***SPA:*** All three wells are in AB SPA, WHPA extends into MV SPA
- ***Year constructed:*** Well #3 – Established early 1900's, no record for other 2 wells.
- ***Depth:*** Well #1 – 99 m, Well #2 – 108 m, Well #3 – 110 m
- Users Served: 4500
- ***Design Capacity:*** 4838 m^3/day (56 litres/second)
- Permitted Rate: No known rate
- ***Average Usage:*** combined 1968 m^3/day (2001 to 2005)*
- ***Modelled rate:*** 1968 m^3/day *
- ***Treatment:*** Gas Chlorination
  *WNMC et al, 2010

<u>Groundwater Vulnerability</u>

Map 4.Clin shows the wellhead protection area (WHPA) and vulnerability scores. The WHPA extends almost 15 km north-eastward into the agricultural land in the Maitland Valley SPA. WHPA-A, the immediate 100 m radius of the wells has a score of 10, while all other areas that fall within the AB SPA have a score of 6 or

less. Parts of WHPA-B and WHPA-C have a vulnerability score of 8, but these are located in the Maitland Valley SPA.

A review of transport pathways was conducted with the following results. Aquifer vulnerability within the Clinton WHPA was adjusted for several undocumented wells that were inspected and georeferenced as part of the Well Location Update completed by the Ausable Bayfield Maitland Valley Source Protection Region (2007). These wells were located as part of the project, and were found to have wells that are out of compliance with provincial requirements for well construction. Vulnerability was adjusted one level for a 30 m area surrounding the wells, based on the updated coordinates.

Additional adjustments were completed for undocumented wells which were not visited as part of the Well Location Update. In these cases, wells were assumed to be within 30 m of the principal structure on the property, and vulnerability was therefore adjusted for 60 m surrounding the principal structure to account for the uncertainty with both the location of the well and the condition of the well.

No adjustments to the urban area were incorporated into the WHPA as all residences are on municipal water, there were not sufficient records of wells which pre-date the system, and the depth to the services (placed at typical depths) are insignificant in comparison to the depth to the municipal supply aquifer.

Threats and Risks

Table 4.22 Column 1 lists the drinking water threats in Clinton's WHPA. They are all prescribed drinking water threats listed in Subsection 1.1(1) of Ontario Regulation 287/07. No other type of local threat was identified. **Table 4.22** also indicates the number of significant threat instances for each threat type. The table of drinking water threats within the Technical Rules provides details on circumstances pertaining to these threats. No other local circumstances were identified.

Map 4.Clin shows the WHPA and vulnerability scores. It can be used with Table 4.6 to identify the areas where chemical, pathogen and DNAPL threats can be significant moderate or low.

Table 4.22 Clinton WHPA: Enumeration of Potential Significant Threats

Threat Type	Significant Instances*		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
1. Waste Disposal Site	0		
2. Sewage System	1	1	
3. Agricultural Source Material Application			
4. Agricultural Source Material Storage			
6. Non- Agricultural Source Material Application			
10. Pesticide Application			
12. Application of Road Salt	8		
13. Storage of Road Salt	4		
14. Storage of Snow	8		
15. Fuel Handling/Storage	2		
16. Dense Non-Aqueous Phase Liquid Handling/Storage			8
21. Grazing/Pasturing Livestock			
Total:	23	1	8

*Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

Drinking Water Issues and Conditions

Table 4.23 indicates that no issues with wells or conditions resulting from past activities were identified within the WHPA.

Table 4.23 Clinton WHPA: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.3.2.3 Deleted (Harbour Lights)

Table 4.24 Deleted

Table 4.25 Deleted

4.5.3.2.4 SAM

The following is a description of the SAM well system:

- ***Location:*** 77301 Forest Ridge Rd., 1.8 km north of the Bayfield River
- ***SPA:*** Well and WHPA are in AB SPA
- Year constructed: 1979
- ***Depth:*** 59.4 m
- Users Served: 12
- ***Design Capacity:*** 164 m^3/day (1.9 litres/second)
- ***Permitted Rate:*** 164 m^3/day (1.9 litres/second)
- ***Average Usage:*** 9 m^3/day (2001 – 2005) *
- ***Modelled rate:*** 9 m3/day *
- ***Treatment:*** Chlorination and iron sequestering

  *WNMC et al, 2010

<u>Groundwater Vulnerability</u>

Maps 4.CH.WHPA and 4.SAM show that the wellhead protection area (WHPA) extends in a narrow strip 1.3 km eastward from the well, largely across forested land. WHPA-A, the 100 m radius around the well is the only area with a vulnerability score of 10. All other WHPAs (WHPA-B, WHPA-C, and WHPA-D) have a vulnerability score of 6 or less.

Aquifer vulnerability was not adjusted for transport pathways in the SAM WHPA.

<u>Threats and Risks</u>

Table 4.26 Column 1 lists the drinking water threats in SAM's WHPA. They are all prescribed drinking water threats listed in Subsection 1.1(1) of *Ontario Regulation 287/07*. No other type of local threat was identified. **Table 4.26** also indicates the number of significant threat instances for each threat type. No other local circumstances were identified.

Map 4.SAM shows the WHPA and vulnerability scores. It can be used with Table 4.6 to identify the areas where chemical, pathogen and DNAPL threats can be significant moderate or low.

Table 4.26 SAM WHPA: Enumeration of Potential Significant Threats

Threat Type	Significant Instances*		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
2. Sewage System		7	
12. Application of Road Salt	NA		
13. Storage of Road Salt	0		
14. Storage of Snow	0		
15. Fuel Handling/Storage	0		
Total:	0	7	0

*Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

Drinking Water Issues and Conditions

Table 4.27 indicates that no issues with wells or conditions resulting from past activities were identified within the WHPA.

Table 4.27 SAM WHPA: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.3.2.5 Vandewetering

The following is a description of the Vandewetering well system:

- ***Location:*** Concession1, Lot 36 of the former Township of Goderich, 3.6 km north of the Bayfield River
- ***SPA:*** Well and WHPA are in AB SPA
- Year constructed: 1989
- ***Depth:*** 42.1 m
- Users Served: 22
- ***Design Capacity:*** 199 m^3/day (2.3 litres/second)
- ***Permitted Rate:*** 97.9 m^3/day (1.1 litres/second)

- **Average Usage**: 9 m^3/day (2001 – 2005) *
- **Modelled Rate**: 9 m^3/day *
- ***Treatment:*** Chlorination and iron sequestering
  *WNMC et al, 2010

<u>Groundwater Vulnerability</u>

Maps 4.CH.WHPA and 4.Vand show that the wellhead protection area (WHPA) extends in a narrow strip 1.3 km eastward from the well across cropland and Highway 21. The only area with a vulnerability score of 10 is the 100 m radius of WHPA-A, all in residential lots. WHPA-B, WHPA-C, and WHPA-D all have a vulnerability score of 6 or less.

A review of transport pathways was conducted with the following results. Aquifer vulnerability within the Vandewetering WHPA was adjusted for an undocumented well that was not visited as part of the Well Location Update. In this case, the well were assumed to be within 30 m of the principal structure on the property, and vulnerability was therefore adjusted for 60 m surrounding the principal structure to account for the uncertainty with both the location of the well and the condition of the well.

No adjustments to the urban area as it is located entirely outside of all but the WHPA-A, which already has a maximum vulnerability score of 10.

<u>Threats and Risks</u>

Table 4.28 Column 1 lists the drinking water threats in Vandewetering's WHPA. They are all prescribed drinking water threats listed in Subsection 1.1(1) of *Ontario Regulation 287/07*. No other type of local threat was identified. **Table 4.28** also indicates the number of significant threat instances for each threat type. The table of drinking water threats within the Technical Rules provides details on circumstances pertaining to these threats. No other local circumstances were identified.

Map 4.Vand shows the WHPA and vulnerability scores. It can be used with Table 4.6 to identify the areas where chemical, pathogen and DNAPL threats can be significant, moderate or low.

Table 4.28 Vandewetering WHPA: Enumeration of Potential Significant Threats

Threat Type	Significant Instances		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
2. Sewage System	3	17	
12. Application of Road Salt	0		
13. Storage of Road Salt	0		
14. Storage of Snow	0		
15. Fuel Handling/Storage	0		
Total:	3	17	0

*Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

Drinking Water Issues and Conditions

Table 4.29 indicates that no issues with wells or conditions resulting from past activities were identified within the WHPA.

Table 4.29 Vandewetering WHPA: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.4 Huron East

The Municipality of Huron East is inland from Lake Huron and adjacent to Perth County. By Conservation Authority jurisdiction, Huron East is 72% in Maitland Valley and 28% is in Ausable Bayfield. In 2006, the municipality had a population of 9,310, a decline of 3.8% since 2001. The main town within the AB SPA portion of the municipality is Seaforth (2001 population 2,300). Cropland is 78% of the land area, dominated by corn, soybeans and winter wheat. Livestock density (cattle: 47.9/ km^2.; pigs: 298.6/ km^2.) is high (Statistics Canada 2007).

Map **4.HE.IS** shows the percentage of impervious surface area; **Map 4.HE.ML** shows the location and percentage of managed lands; and **Map 4.HE.LD** shows the livestock density within vulnerable areas for Huron East.

4.5.4.1 Huron East – HVAs and SGRAs

Maps 4.HE.HVA and **4.HE.SGRA** show the locations of highly vulnerable aquifers and significant groundwater recharge areas respectively in Huron East. The highly vulnerable aquifers are scattered throughout the municipality, while there are relatively few SGRAs. Most areas are narrow eskers or spillways; a larger area in the north-east corner corresponds with a kame. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score.

<u>Threats and Risks</u>

Since the vulnerability scores for the HVAs are 6 or less, only moderate and low drinking water threats may exist in this area. **Table 4.3** can be used in combination with **Map 4.HE.HVA** to determine where chemical/pathogen/DNAPL threats can be moderate and low threats in HVAs s in Huron East. There are no known conditions or issues in the municipality.

4.5.4.2 Wellhead Protection Areas (WHPAs)

Huron East's main well system within the AB SPA portion of the municipality is in Seaforth. Brucefield has a smaller system, which extends into Bluewater. **Map 4.HE.WHPA** shows the locations of all WHPAs in Huron East.

4.5.4.2.1 Brucefield

The following is a description of the Brucefield well system:

- ***Location:*** The corner of Highway 4 and County Road 3
- ***SPA:*** Both the well and WHPA are in the AB SPA
- Year constructed: 1972
- ***Depth:*** 88.4 m
- Users Served: 175
- ***Design Capacity:*** 458 m^3/day (5.3 litres/second)
- ***Permitted Rate:*** 270 m^3/day (3.1 litres/second)
- ***Average Usage:*** 60 m^3/day (2001 – 2005) *
- ***Modelled rate:*** 60 m^3/day *
- ***Treatment:*** Chlorination and ultraviolet radiation
  *WNMC et al, 2010

<u>Groundwater Vulnerability</u>

Map 4.Bruc show that the wellhead protection area (WHPA) extends about 5.7 km to the north east from the wellhead. WHPA-A, the 100 m radius around the well has a vulnerability score of 10. Half of WHPA-B has a vulnerability score of 8 while the other half has a score of 6. WHPA-C and WHPA-D have vulnerability scores of 6 or less.

A review of transport pathways was conducted with the following results. Aquifer vulnerability within the Brucefield WHPA was adjusted for several undocumented wells that were inspected and georeferenced as part of the Well Location Update completed by the Ausable Bayfield Maitland Valley Source Protection Region (2007). These wells were located as part of the project, and were found to have wells that are out of compliance with provincial requirements for well construction. Vulnerability was adjusted one level for a 30 m area surrounding the wells, based on the updated coordinates.

Additional adjustments were completed for undocumented wells that were not visited as part of the Well Location Update. In these cases, wells were assumed to be within 30 m of the principal structure on the property, and vulnerability was therefore adjusted for 60 m surrounding the principal structure to account for the uncertainty with both the location of the well and the condition of the well.

No adjustments to the urban area were incorporated into the WHPA as all residences are on municipal water, there were not sufficient records of wells which pre-date the system, and the depth to the services (placed at typical depths) are insignificant in comparison to the depth to the municipal supply aquifer.

<u>Threats and Risks</u>

Table 4.30 Column 1 lists the drinking water threats in Brucefield's WHPA. They are all prescribed drinking water threats listed in Subsection 1.1(1) of Ontario Regulation 287/07. No other type of local threat was identified. **Table 4.30** also indicates the number of significant threat instances for each threat type. The table of drinking water threats within the Technical Rules provides details on circumstances pertaining to these threats. No other local circumstances were identified.

Map 4.Bruc shows the WHPA and vulnerability scores. It can be used with Table 4.6 to identify the areas where chemical, pathogen and DNAPL threats can be significant moderate or low.

Table 4.30 Brucefield WHPA: Enumeration of Potential Significant Threats

Threat Type	Significant Instances		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
1. Waste Disposal Site	1	0	
2. Sewage System	0	17	
3. Agricultural Source Material Application		0	
4. Agricultural Source Material Storage			
6. Non-Agricultural Source Material Application			
7. Non-Agricultural Source Material Handling/ Storage			
8. Commercial Fertilizer Application			
9. Commercial Fertilizer Handling/Storage			
10. Pesticide Application			
11. Pesticide Handling/Storage			
12. Application of Road Salt	NA		
13. Storage of Road Salt	5		
14. Storage of Snow	5		
15. Fuel Handling/Storage	0		
16. Dense Non-Aqueous Phase Liquid Handling/Storage			2
21. Grazing/Pasturing Livestock	0	0	
Total:	11	17	2

*Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

Drinking Water Issues and Conditions

Table 4.31 indicates that no issues with wells or conditions resulting from past activities were identified within the WHPA.

Table 4.31 Brucefield WHPA: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.4.2.2 Seaforth

The following is a description of the Seaforth well system:

- **Location:** 40 Welsh St.
- **SPA:** Wells located in MV SPA but WHPAs extend into AB SPA
- **Year constructed:** Well TW1: 2005, Well PW1: 2006, Well PW2: 2007
- **Depth:** Well TW1: 42.9 m, Well PW1: 105 m, Well PW2: 105 m
- Users Served: 2900
- **Design Capacity:** All 3 wells: 3456 m^3/day (40 litres/second)
- **Permitted Rate:** TW1: 518.4 m^3/day, PW1: 3024 m^3/day, PW2: 3456 m^3/day
- **Modelled Rate**: 1628 m^3/day (WESA, 2009)
- **Treatment:** Sodium Hypochlorinate and Sodium Silicate

Groundwater Vulnerability

Maps 4.HE.WHPA and 4.Seaf show that the wellhead protection area (WHPA) is approximately 3 km long and 2.3 km wide. A vulnerability score of 10 applies to the WHPA-A 100 m radius and a portion of WHPA-B. The remainder of WHPA-B and part of WHPA-C has a vulnerability score of 8. All other areas of the WHPA have a vulnerability score of 6 or less.

A review of transport pathways was conducted with the following results. Aquifer vulnerability within the Seaforth WHPA was adjusted for several undocumented wells that were inspected and georeferenced as part of the Well Location Update completed by the Ausable Bayfield Maitland Valley Source Protection Region (2007). These wells were located as part of the project, and were found to have wells that are out of compliance with provincial requirements for well construction. Vulnerability was adjusted one level for a 30 m area surrounding the wells, based on the updated coordinates.

Additional adjustments were completed for undocumented wells that were not visited as part of the Well Location Update. In these cases, wells were assumed to be within 30 m of the principal structure on the property, and vulnerability was therefore adjusted for 60 m surrounding the principal structure to account for the uncertainty with both the location of the well and the condition of the well.

No adjustments to the urban area were incorporated into the WHPA as all residences are on municipal water, there were not sufficient records of wells that pre-date the system, and the depth to the services (placed at typical depths) are insignificant in comparison to the depth to the municipal supply aquifer.

Threats and Risks

Table 4.32 Column 1 lists the drinking water threats in the Seaforth WHPA. They are all prescribed drinking water threats listed in Subsection 1.1(1) of Ontario Regulation 287/07. No other type of local threat was identified. **Table 4.32** also indicates the number of significant threat instances for each threat type. The table of drinking water threats within the Technical Rules provides details on circumstances pertaining to these threats. No other local circumstances were identified.

Map 4.Seaf shows the WHPA and vulnerability scores. It can be used with Table 4.6 to identify the areas where chemical, pathogen and DNAPL threats can be significant moderate or low.

Table 4.32 Seaforth WHPA: Enumeration of Potential Significant Threats

Threat Type	Significant Instances*		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
1. Waste Disposal Site	1		
2. Sewage System		7	

Threat Type	Significant Instances*		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
3. Agricultural Source Material Application	2	2	
4. Agricultural Source Material Storage			
6. Non- Agricultural Source Material Application			
7. Non- Agricultural Source Material Handling/Storage			
8. Commercial Fertilizer Application			
10. Pesticide Application	5		
12. Application of Road Salt	0		
13. Storage of Road Salt	3		
14. Storage of Snow	1		
15. Fuel Handling/Storage	2		
16. Dense Non-Aqueous Phase Liquid Handling/Storage			3
21. Grazing/Pasturing Livestock			
Total:	14	9	3

*Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

Drinking Water Issues and Conditions

Table 4.33 indicates that no issues with wells or conditions resulting from past activities were identified within the WHPA.

Table 4.33 Seaforth WHPA: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.5 Lambton Shores

The Municipality is located in the south western part of the Source Protection Area. The portion of the municipality within the study area is a mix of seasonal residential on the shoreline, and agriculture in-land. The area represents approximately 55% of the land mass with a population of approximately 5,900 people (approximately 750 live in the community of Thedford and 460 live in Arkona). There is access to the Lake Huron Primary Water Supply pipeline throughout the municipality and no municipal wells. The municipality uses approximately 3,490 cubic metres per day, or 20% of the design capacity. However, some of the population continues to use individual wells.

Map 4.LS.IS shows the percentage of impervious surface area; **Map 4.LS.ML** shows the location and percentage of managed lands; and **Map 4.LS.LD** shows the livestock density within vulnerable areas for Lambton Shores.

4.5.5.1 Lambton Shores – HVAs and SGRAs

Maps 4.LS.HVA and 4.LS.SGRA delineate the locations of highly vulnerable aquifers and significant groundwater recharge areas respectively in Lambton Shores. A relatively large HVA dominates the shoreline, while SGRAs are scattered in bands throughout the municipality. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score.

<u>Threats and Risks</u>

Since the vulnerability scores for the HVAs are 6 or less, only moderate and low drinking water threats may exist in this area. **Table 4.3** can be used in combination with **Map 4.LS.HVA** to determine where chemical, pathogen, and DNAPL threats can be moderate and low risks in HVAs in Lambton Shores. There are no known conditions or issues in the municipality.

4.5.5.2 Intake Protection Zone

The Lake Huron Primary Water Supply System is north of Lambton Shores and over one kilometre off shore, thus the IPZ-1 does not intersect with the land. A small portion of the LHPWSS IPZ-2 lies within Lambton Shores. This area encompasses an area just south of the core area of Grand Bend up the Ausable River. **Map 4.LHPW and Table 4.34** indicate the vulnerability scores for the intake, determined by the consultants and verified through peer review. Please see section 4.2 for more information about the Area Vulnerability Factor and Source

Vulnerability Factor. The vulnerability score is 4 in this area; therefore no significant risks are identified.

Table 4.34 LHPWSS IPZ: Vulnerability Score Summary

Location	Vulnerability Factor		Source Modifying Factor	Vulnerability Score	
	IPZ 1	IPZ 2		IPZ 1	IPZ 2
Lake Huron	10	8 Moderate	0.5 Low	**5**	4

<u>Threats & Risk</u>

Since the vulnerability scores for the IPZ are low, there is only the potential for low drinking water threats in this area. **Table 4.5** can be used in combination with **Map 4.LHPW** to determine where chemical, pathogen, and DNAPL threats can be low risks in the intake protection zones for the LHPWSS. The Tables of Drinking Water Threats within the Technical Rules can be used to determine the types of activities that would be deemed a low threat in IPZ-1. **Table 4.35** shows that there are no significant drinking water threats within vulnerable areas in Lambton Shores. **Table 4.36** shows that there are also no known conditions or issues in the portion of the municipality within the AB SPA. Using the events based approach, modelling was conducted to determine whether contaminants from the Grand Bend Sewage Treatment System, or a harbour marina could be transported to the intake during an extreme event. The modelling concluded that no contaminants transported to the intake during an extreme event would result in a deterioration of the water as a drinking water source. Thus no IPZ-3 was identified.

Table 4.35 Lambton Shores Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.36 Lambton Shores Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.6 Lucan Biddulph

This Township is located in the central eastern part of the Source Protection Area and is mostly agricultural. The portion of the municipality within the study area represents approximately 68% of the land mass and 68% of the population, approximately 4,200 people (approximately 2,000 live in the community of Lucan). There are no municipal residential drinking water sources in this area. There is access to the Lake Huron Primary Water Supply pipeline in Lucan and limited access in other hamlets within the municipality. Approximately 65% of the Lucan Biddulph population within the AB SPA is on the pipeline. The township uses approximately 643 cubic metres of water per day and the system was designed to provide 3,085 cu m/d.

4.5.6.1 Lucan Biddulph – HVAs and SGRAs

Map 4.LB.SGRA shows the locations of SGRAs in the municipality of Lucan Biddulph. SGRAs are not assigned a vulnerability score. There are no HVA areas identified in the municipality.

Since impervious surface, managed lands and livestock density are only mapped in vulnerable areas that have vulnerability scores of 6 or higher, none of these maps were required for Lucan Biddulph.

<u>Threats & Risk</u>

As there are no municipal residential drinking water sources, and no HVAs, there are no drinking water threats in this area (**Table 4.37**). There are no known conditions or issues in the portion of the municipality within the AB SPA (**Table 4.38**).

Table 4.37 Lucan Biddulph Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.38 Lucan Biddulph Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.7 Middlesex Centre

This municipality is located in the south eastern part of the Source Protection Area. The portion of the municipality within the study area represents approximately twenty-one percent of the land mass and 21% of the population, approximately 3,000 people. There are no municipal residential drinking water sources in this area. There is very limited access to the Lake Huron Primary Water Supply System pipeline as this area has a dispersed population which is rural in character. Therefore, the majority of the population relies on individual wells.

Map 4.MC.IP shows the percentage of impervious surface area; **Map 4.MC.ML** shows the location and percentage of managed lands; and **Map 4.MC.LD** shows the livestock density within vulnerable areas for Middlesex Centre.

4.5.7.1 Middlesex Centre – HVAs and SGRAs

Maps 4.MC.HVA and **4.MC.SGRA** delineate the locations of HVAs and SGRAs respectively in the Middlesex Centre. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score.

<u>Threats & Risk</u>

As there are no municipal residential drinking water sources, there are no significant risks in this area (**Table 4.39**). **Table 4.3** can be used in combination with **Map 4.MC.HVA** to determine where chemical, pathogen, and DNAPL threats can be moderate and low threats in HVAs in Middlesex Centre. There are no known conditions or issues in the portion of the municipality within the AB SPA (**Table 4.40**).

Table 4.39 Middlesex Centre Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.40 Middlesex Centre Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	**Threat**
None	None

4.5.8 North Middlesex

This municipality is located in the southern part of the Source Protection Area. The entire municipality is within the study area having a population of approximately 6,900 people. There are no residential municipal drinking water sources in this area. Eighty-five percent of the residents in North Middlesex are connected to the Lake Huron Primary Water Supply pipeline. This includes the largest community, Parkhill (pop 1,750), and the community of Ailsa Craig (pop 1,100). North Middlesex uses approximately 3,535 cubic metres of water per day. The remaining population relies on individual wells.

4.5.8.1 North Middlesex – HVAs and SGRAs

Maps 4.NM.HVA and 4.NM.SGRA delineate the locations of HVAs and SGRAs respectively in the municipality. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score.

Map 4.NM.IS shows the percentage of impervious surface area; **Map 4.NM.ML** shows the location and percentage of managed lands; and **Map 4.NM.LD** shows the livestock density within HVAs and SGRAs for North Middlesex.

<u>Threats & Risk</u>

As there are no municipal residential drinking water sources and the vulnerability scores for the HVA are less than 8, there are no significant drinking water threats in North Middlesex (**Table 4.41**). **Table 4.3** can be used in combination with **Map 4.NM.HVA** to determine where chemical, pathogen, and DNAPL threats can be moderate and low threats in HVAs in North Middlesex. There are no known conditions or issues in the municipality (**Table 4.42**).

Table 4.41 North Middlesex Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.42 North Middlesex Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	**Threat**
None	None

4.5.9 Perth South

This township is located in the central eastern part of the Source Protection Area. Only 2% of the land area is within the study area. The population in this area is approximately 80 people. There are no municipal residential drinking water sources in this area. The population relies on individual wells.

4.5.9.1 Perth South – HVAs and SGRAs

No HVA exist in the portion of the township within the study area. **Map 4.PS.SGRA** delineates the location of SGRAs.

Since impervious surface, managed lands and livestock density are only mapped in vulnerable areas that have vulnerability scores of 6 or higher, none of these maps were required for Perth South.

Threats & Risk

As there are no municipal residential drinking water sources or HVAs, there are no drinking water threats assessed in this area (**Table 4.43**). There are no known conditions or issues in the portion of the municipality within the AB SPA (**Table 4.44**).

Table 4.43 South Perth Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.44 South Perth Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.10 South Huron

The Municipality is located in the south western part of the Source Protection Area. The portion of the municipality within the study area is a mix of seasonal residential on the shoreline and agriculture inland. Approximately 92% of the municipality falls within the SPA and has a population of approximately 9,982 people (4,657 live in the community of Exeter). There is access to the Lake Huron Primary Water Supply pipeline throughout the municipality where there are population nodes and no municipal wells. Approximately 3,331 cubic metres of water per day is used in this municipality. However, some of the population continues to use individual wells.

Map 4.SH.IP shows the percentage of impervious surface area; **4.SH.ML** shows the location and percentage of managed lands; and **Map 4.SH.LD** shows the livestock density within vulnerable areas for South Huron.

4.5.10.1 South Huron – HVAs and SGRAs

Maps 4.SH.HVA and 4.SH.SGRA delineate the locations of HVAs and SGRAs respectively in South Huron. The HVA areas are scattered throughout the municipality but are more abundant on the eastern portion. Bands of SGRAs run parallel to the shoreline. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score.

Threats and Risks

Since the vulnerability scores for the HVAs are 6 or less, only moderate and low drinking water threats may exist in this area. **Tables 4.3** can be used in combination with **Map 4.SH.HVA** to determine where chemical, pathogen, and DNAPL threats can be moderate and low risks in HVAs in South Huron.

4.5.10.2 Intake Protection Zone

The Lake Huron Primary Water Supply System (LHPWSS) is over one kilometre off shore thus the IPZ-1 does not intersect with the land (**Map 4.SH.IPZ**). A small portion of the LHPWSS IPZ-2 runs along the shoreline in South Huron. As there are no issues at the intake, no IPZ-3 was modelled at this time. **Map 4.LHPW and Table 4.45** indicate the vulnerability scores for the intake, determined by the consultants and verified through peer review. Please see section 4.2 for more information about the Area Vulnerability Factor and Source Vulnerability Factor. The vulnerability score is 4 in this area; therefore no significant risks are identified.

Table 4.45 Vulnerability Score Summary

Location	Vulnerability Factor		Source Modifying Factor	Vulnerability Score	
	IPZ 1	IPZ 2		IPZ 1	IPZ 2
Lake Huron	10	8 Moderate	0.5 Low	5	4

<u>Threats & Risk</u>

Since the vulnerability scores for the IPZ are low, the potential is for low drinking water threats in this area. **Table 4.5** can be used in combination with **Map 4.LHPW** to determine where chemical, pathogen, and DNAPL threats can be low threats in the intake protection zones for the LHPWSS.

Table 4.46 shows that there are no significant drinking water threats within vulnerable areas in South Huron. **Table 4.47** shows that there are also no known conditions or issues. Using the events based approach, modelling was conducted to determine whether contaminants from the Grand Bend Sewage Treatment System, or a harbour marina could be transported to the intake during an extreme event. The modelling concluded that no contaminants transported to the intake during an extreme event would result in a deterioration of the water as a drinking water source. Thus no IPZ-3 was identified.

Table 4.46 South Huron Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.47 South Huron Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.11 Warwick

This Township is located in the south western part of the Source Protection Area and only two percent of the municipality is in the study area, having a population of about 260. There are no municipal residential drinking water sources in this area. This area has a dispersed population which is rural in character and the majority of the population relies on individual wells.

Map 4.WW.IS shows the percentage of impervious surface area; **Map 4.WW.ML** shows the location and percentage of managed lands; and **Map 4.WW.LD** shows the livestock density within vulnerable areas for Warwick.

4.5.11.1 Warwick – HVAs and SGRAs

Maps 4.WW.HVA and 4.WW.SGRA delineate the locations of HVAs and SGRAs respectively in the study area, for Warwick. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score.

<u>Threats & Risk</u>

As there are no municipal residential drinking water sources and the vulnerability scores for HVAs are less than 8, there are no significant drinking water threats in Warwick (**Table 4.48**). **Tables 4.3** can be used in combination with **Map 4.WW.HVA** to determine where chemical, pathogen, and DNAPL threats can be moderate and low risks in HVAs in Warwick There are no known conditions or issues in the municipality (**Table 4.49**).

Table 4.48 Warwick Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.49 Warwick Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

4.5.12 West Perth

This municipality is located in the north eastern part of the Source Protection Area. Approximately one third of the municipality is located within the SPA and the population in this area is approximately 2,600 people. There are no residential municipal drinking water sources in this predominantly rural area. Therefore, everyone in the area relies on individual wells.

Map 4.WP.IS shows the percentage of impervious surface area; **Map 4.WP.ML** shows the location and percentage of managed lands; and **Map 4.WP.LD** shows the livestock density within vulnerable areas for West Perth.

4.5.12.1 West Perth – HVAs and SGRAs

Maps 4.WP.HVA and 4.WP.SGRA delineate the locations of HVAs and SGRAs respectively in the municipality. The vulnerability score for all HVAs is 6, while SGRAs are not assigned a score. It should be noted that several karst features (sinkholes) are within this area and provide a direct conduit of surface water to ground water. The possible issues associated with these features are not known and further research is required.

<u>Threats & Risk</u>

As there are no municipal residential drinking water sources and the vulnerability scores for HVAs are less than 8, there are no significant drinking water threats in West Perth (**Table 4.50**). **Table 4.3** can be used in combination with **Map 4.WP.HVA** to determine where chemical, pathogen, and DNAPL threats can be moderate and low risks in HVAs in West Perth. There are no known conditions or issues in the municipality (**Table 4.51**).

Table 4.50 West Perth Risks to Drinking Water Summary

Threat	Circumstance	Number of Locations
None	None	None

Table 4.51 West Perth Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	Threat
None	None

Summary

Table 4.52 shows a summary of all of the potential significant threats for the AB SPA by parcel. These numbers were updated in 2022 and represent the best information available at the time of writing. It is anticipated that numbers will vary over time, according to changes in land use, and as additional information becomes available.

In 2018, Table 4.52 was revised to add threats enumerated for the Varna well system, and remove threats related to the Carriage Lane and Harbour Lights well systems.

In 2021, the Director's Technical Rules were amended, with numerous changes to circumstances for several threat activities. As a result, new salt and snow threats were enumerated. Other threat categories, such as waste and fuel threats, were reviewed to reflect the new Rules. These numbers are unverified at time of writing.

Table 4.52 All* WHPAs: Enumeration of Potential Significant Threats

Threat Type	Significant Instances		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
1. Waste Disposal Site	2	0	
2. Sewage System	4	62	
3. Agricultural Source Material Application	2	2	
4. Agricultural Source Material Storage	0	0	
6. Non-Agricultural Source Material Application	0	0	
7. Non-Agricultural Source Material Handling/Storage	0	0	
8. Commercial Fertilizer Application	0		
9. Commercial Fertilizer Handling/Storage	0		
10. Pesticide Application	5		
11. Pesticide Handling/Storage	0		
12. Application of Road Salt	11**		
13. Storage of Road Salt	12**		
14. Storage of Snow	16**		
15. Fuel Handling/Storage	4		

Threat Type	Significant Instances		
(numbered per Ontario Reg. 287/07)	Chemicals	Pathogens	DNAPL
16. Dense Non-Aqueous Phase Liquid Handling/Storage			14
21. Grazing/Pasturing Livestock	0	0	
Total:	56	64	14

* Brucefield, Clinton, SAM, Seaforth, Vandewetering, Varna

** Salt and Snow numbers are desktop estimation. It is anticipated that verified numbers will be much lower.

Certain types of activities on residential sites that are incidental in nature and may be significant threats are not enumerated. These activities include storage of DNAPLs, storage of road salt and application of road salt, on residential properties.

References

Author & Publisher	Title	Date	Purpose
Waterloo Numerical Modelling Corp, International Water Supply, and B.M. Ross & Associates (WNMC et al, 2010)	ABCA / MVCA Groundwater Model Updates And Capture Zone Delineation (final Report for Well Head Protection Area Delineation Project)	October, 2010	To provide delineation of WHPA's and details on methodologies, limitations and general characterization of the well systems
BM Ross Consulting	Source Protection Technical Study: Drinking Water Quality Threats Assessment	October, 2009	To provide an explanation of the methodology, limitations and an inventory of possible threats to water quality in keeping with MOE Technical Rules
Huron Geosciences	Transport Pathway Adjustments: Ausable Bayfield Maitland Valley Source Protection Region	April 2011	To provide the methodology and results of how transport pathways were located and how vulnerability and threats were affected.
WESA Inc.	Groundwater Vulnerability Assessment: Municipality of Huron East (Seaforth)	October, 2009	To provide the delineation of Seaforth WHPA and details on methodologies, limitations and general characterization of the well systems
Stantec	Phase 1 & 2 Reports, Lake Huron Primary Water Supply System Source Protection Technical Study	February 2009	To delineate the LHPWSS Intake Protection Zones and identify potential threats within these zones

Author & Publisher	Title	Date	Purpose
Statistics Canada	Population Counts, 2006. http://www12.statcan.ca/english/census0 6/data/popdwell/Table.cfm?T=302&PR=35&S=1&O=A&RPP=25	2007	Provincial census data
MOE / MECP	Technical Rules, 2008; 2017 and 2021	2008; 2021	Director's technical rules for assessing risks to drinking water sources
Matrix Solutions Inc. (Matrix, 2016)	Community of Varna, Municipality of Bluewater Wellhead Protection Areas Delineation, Varna Well 1	December 2016	To complete the WHPA delineation and vulnerability assessment for the Varna well

AUSABLE BAYFIELD: CHAPTER 5

POTENTIAL IMPACTS FROM CLIMATE CHANGE

Table of Contents

List of Tables

5.1 What is Climate Change?

Climate is not a static phenomenon, but rather an ever-changing natural system. Weather refers to the day-to-day atmospheric conditions that occur in a given location. Climate is the long term average of these atmospheric conditions, and often covers a larger region (Garbrecht and Piechota 2006).

Changes in climate are not a new trend. Variations and cycles in climate are common and natural events. For example, an ocean-atmospheric pattern that occurs naturally is the El Niño pattern. There can also be more abrupt shifts in the climate, as well as long term patterns. Climate change refers to progressive changes over a longer period of time (Garbrecht and Piechota 2006). To be considered an actual change in climate, and not simply a natural variation, the change must be persistent and measurable over time (Environment Canada 2008).

5.2 Causes of Climate Change

Climate change can be partially attributed to several natural processes. The Earth is dependent on solar radiation to sustain life (Prodonović 2008). However, any changes in solar output can have a profound impact on the amount of radiation reaching the Earth (Lemmen and Warren 2004). Other natural variations in Earth activity (i.e. volcanic activity) can also contribute to climate change.

It is commonly believed that anthropogenic, or human, activities over the last two centuries account for the drastic changes in the Earth's climate. One of the most commonly referred to activities is large-scale changes in land use, such as agricultural expansion and urbanization. These activities increase the amount of heat energy that is released into the atmosphere and reflected back to the Earth (Prodonović 2008; Environment Canada 2008).

One of the most frequently discussed human cause of climate change is an increase in the amount of greenhouse gases released into the Earth's atmosphere. Greenhouse gases include emissions such as carbon dioxide, nitrous oxide and ozone. These gases build up in the Earth's atmosphere making a layer that traps and reflects heat energy back to the Earth's surface; a process commonly known as the Greenhouse Effect (Lemmen and Warren 2004).

Greenhouse gases can also cause depletion in the ozone layer, exacerbating the effects of solar radiation (Environment Canada 2008). They are most significantly produced through the burning of fossil fuels, agricultural activities and forest clearing (Lemmen and Warren 2004). Additionally, greenhouse gases are increasing in abundance. Scientists have stated that the increase in the amount of greenhouse gases released into the atmosphere correlates with the change in human-related emissions (Environment Canada 2008). There is a general consensus among environmental scientists that human activity accounts for much of the change in climate that the Earth has experienced, although the amount is still unknown (Garbrecht and Piechota 2006).

5.3 Climate Change and Water

While climate change will undoubtedly affect many aspects of both the natural environment and human activity, it will have a profound impact on the world's water system. Water is an integral part of all aspects of the climate system, and is particularly sensitive to change. Most specifically, changes in temperature, precipitation and evapotranspiration affect the hydrologic cycle (de Loë and Berg 2006).

As previously mentioned, temperature increases are an effect of climate change. These changes directly impact the amount of precipitation that is received in any given region. Precipitation events are caused by several processes including the upward movement of air. Temperature increases tend to intensify air convection and foster the amount and intensity of precipitation (Bruce and Lean 2006). Evapotranspiration is also impacted by climate change. Due to more frequent and intense rainfalls in certain regions there is increased moisture on the Earth's surface. Increased temperature also serves to increase the atmosphere's moisture holding capacity. These two factors result in an increase in the amount of evapotranspiration (Bates, et. al. 2008). Other factors, such as population growth and pollution from human activities, influence the workings of the hydrologic cycle and quality of the water (Aerts and Droogers 2004). It is important to note that the hydrologic cycle is a closed system, and water is a finite resource.

5.4 Impacts of Climate Change on Water Quantity

Groundwater Quantity

Climate change is expected to influence the intensity, frequency and timing of precipitation events (Garbrecht and Piechota 2006). It is likely that the seasonal distribution of the precipitation events will also change, resulting in more precipitation in the form of rain in the winter months and less in the summer. These changes will lead to more extreme flooding and droughts (de Loë and Berg 2006). The seasonal shifts will cause most of the groundwater recharge to occur earlier in the year, resulting in less recharge during the dry summer months (Prodonović 2008).

These changes in climate are more likely to affect overburden aquifers rather than bedrock, as they are in part supplied by seasonal recharge. While deep aquifers will see little direct influence, their water supplies may be exposed to over-exploitation if a shallow aquifer fails (Lemmen and Warren 2004). Regions with current water shortages will likely face more severe problems.

Surface Water Quantity

Surface water is more vulnerable to climate change than groundwater. The majority of surface water flows are dependent on seasonal flows, such as those from yearly snowmelt. Any seasonal changes to precipitation will disrupt the nature of surface water flows. For example, peak runoff is expected to occur earlier in the year, meaning there will be less flow in ditches and municipal drains and streams in the summer months, reducing water supplies (Prodonović 2008). Indeed, there will be lower flows in all types of water basins that depend on surface water for their supply (Bates et al. 2008).

Lake Huron and other large bodies of water are expected to experience some water loss over the coming years due to climate change. As previously stated, rates of evapotranspiration are expected to increase, and the loss of water through this process is predicted to be highest on large bodies of water, such as the Great Lakes (de Loë and Berg 2006). Some models that have been used in recent years, estimate that the average levels of Lake Huron could drop as much as one metre within the next 50 years (Swart et al. 2004).

Water Quantity in the Ausable Bayfield Source Protection Area

The amount and availability of drinking water in the Ausable Bayfield SPA is not expected to be significantly impacted by changes in climate in the short term. Most of the small urban centres in this region are supplied with drinking water from municipal well systems. The majority of municipal well systems is fed by well-protected bedrock aquifers, and is not expected to experience any significant water loss. In recent years, five overburden wells existed in this region; two located in Exeter, and three in Hensall. However, all of these wells were decommissioned by 2009, and currently, no overburden wells exist in the Ausable Bayfield SPA.

There is one source of drinking water in this area that is supplied by surface water; the Lake Huron Primary Water Supply System (LHPWSS). This intake is also not expected to be significantly impacted by water loss. The location of the LHPWSS intake is far from the shoreline and in deep water. Therefore, it is unlikely to encounter any problems regarding water quantity, despite lowering lake levels.

Other municipal systems that may be impacted by surface water loss are any surface water retention ponds that may exist in the area. However, the amount of water loss and the significance of the loss are still unknown. Additionally, any private or municipal operations that draw water from surface sources (under a Permit to Take Water) may also experience a slight shortage. Again, the significance of the shortage is unknown. Further exploration of water quantity issues resulting from climate change are discussed in Chapter 3 – Water Budget.

5.5 Impacts of Climate Change on Water Quality

Groundwater Quality

Changes in climate will also have some bearing on the quality of water. Heavier rain events and increased flooding will increase the amount of water running off the land. Thus there is a higher potential of contamination of the water systems. While groundwater systems appear to be fairly well protected, there is a risk of contaminated water entering these systems through preferential pathways, such as abandoned or cracked wells and sinkholes (Garbrecht and Piechota 2006).

Waterborne diseases are also a concern in connection with climate change. During times of flooding, water is stirred up and runs across land collecting anything in its path. It is not unusual for floodwater to carry disease. If preferential pathways are present, the disease ridden water can make its way into groundwater, and eventually drinking water supplies (de Loë and Berg 2006). Various coliform bacteria, such as E. coli, can be found in such floodwaters. Additionally the water can carry intestinal parasites such as Giardia and Cryptosporidium.

Surface Water Quality

Surface water quality will experience similar impacts to groundwater quality as a result of climate change, but perhaps to a greater degree. Intense runoff from heavy precipitation will increase erosion and turbidity. Additionally if surface water bodies have lower water levels before these intense rainfalls, the bottom sediments will have more opportunities to be re-suspended (Prodonović 2008). Contamination entering a surface water system is rarely from just one source (referred to as point source), but rather is composed of non-point source pollution, meaning a combination of pollutants from various sources (Garbrecht and Piechota 2006).

Runoff from many sources can cause an increase in the bacteria counts in surface water. This happens on a seasonal basis, and may result in an increase in waterborne diseases carried in the surface water (Field et al. 2007). Higher water temperatures, heavier precipitation and high flows will not only cause an increase in bacteria, but also in sediments, nutrients, pesticides and salt. All of these can be detrimental to both human and aquatic life (Bates, et. al. 2008). In particular, stormwater retention ponds could prove to be a significant source of chemical and nutrient pollution. During expected heavy rainfalls, the turbidity in retention ponds will be increased causing sediment containing harmful chemicals and nutrients to rise. When retention ponds are flushed out during a heavy rain, the water will carry these pollutants into the surface water systems, further degrading water quality.

Water Quality in the Ausable Bayfield Source Protection Area

As with water quantity, the quality of drinking water in the Ausable Bayfield SPA is not expected to deteriorate severely. Some of the drinking water in this area comes from groundwater sources, by way of municipal wells. As most of these wells are sourced by bedrock aquifers, they are fairly well protected. However, there is always a risk that contaminated water could enter these sources through preferential pathways.

Drinking water supplied from surface sources, may experience more water quality problems. In this area, however, the LHPWSS is the only source of surface drinking water. As this intake is located far from shore, there are very few problems that could occur with respect to water quality, unless there is a drastic change in the quality of Lake Huron as a whole. While there has been little research into changes in water quality of the lake, the potential exists and should be further examined.

Over the past 10 years there has been a number of significant runoff events recorded for the Ausable Bayfield region. There has also been both significantly wet and dry years. The years 1999, 2002 and 2007 were all significantly dry with only one recorded runoff event noted (**Table 5.1**). Alternately, 2000 and 2008 were significantly wet years, with six runoff events of note. These intense runoff events have the potential to collect contaminants as the water runs over the land. If this water makes its way into the groundwater or surface water systems, there is a potential for poor drinking water quality.

Table 5.1 Notable Runoff Events in the Ausable River and Bayfield River Watersheds

Date	Event	Details
May 2000	Notable Runoff Event	Bayfield River Watershed
June 2000	Notable Runoff Event	Bayfield River Watershed
July 2000	Notable Runoff Event	Ausable River and Bayfield River Watersheds
July 30 – August 4 2000	Extreme Rain Event	Bayfield River Watershed
May 2002	Notable Runoff Event	Ausable River Watershed
March 2004	Extreme Snowmelt Event	Bayfield River Watershed
May 2004	Notable Runoff Event	Ausable River and Bayfield River Watersheds
June 2005	Notable Runoff Event	Ausable River Watershed
July 2005	Notable Runoff Event	Ausable River Watershed
July 2006	Notable Runoff Event	Ausable River Watershed
September 2008	Notable Runoff Event	Bayfield River Watershed
December 2008	Extreme Rain and Snowmelt Event	Ausable River and Bayfield River Watersheds

Source: Ausable Bayfield Conservation Authority

5.6 Other Impacts of Climate Change

Along with water quantity and water quality impacts due to climate change, there are also other impacts that need to be given some consideration. If any problem occurs at the LHPWSS intake in Lake Huron due to a change in climate, it may need to be extended or possibly relocated. However, due to the current location of this intake this is not an immediate concern. Any change to this system would require large amounts of funding (Swartz, et. al. 2004). If there are any negative changes to water quality in either surface water or groundwater, there may be costs involved in upgrading the water treatment systems (de Loë and Berg 2006). Similarly, there is a chance that municipal well systems will experience such problems. Changes may be needed in infrastructure (well depth and treatment), and the possibility exists of a need for new water supplies.

5.7 Conservation Authority Policy on Climate Change

Each conservation authority in Ontario has developed its own policies and position regarding the challenge presented by a changing climate. This is also true for the Ausable Bayfield Conservation Authority. The Ausable Bayfield Conservation Authority (ABCA) recognizes the challenges that climate change will pose to the management of the watershed, and is prepared to take actions to both mitigate against severe changes to climate, and implement methods to help the watershed and its residents adapt to a changing climate. The Authority intends to prepare for these inevitable changes through proactive planning and programming (ABCA 2007).

5.8 Climate Trends in the Ausable Bayfield Source Protection Area

In 2011, a climate trends analysis was completed for the Ausable Bayfield SPA by Huron Geosciences (2011). The goals of the project were to assemble, graphically display and analyze available meteorological data within the ABCA jurisdiction, in order to evaluate any impacts on the hydrologic system within the SPA.

Overall, the trends indicate that total annual precipitation is increasing, and notably that precipitation is increasing in the fall, winter and spring seasons. Precipitation intensity is increasing across the watershed, indicative of a change in the patterns of precipitation in the watershed. Daily maximum and minimum temperatures have been increasing throughout the SPA. An overall increase in temperature is the result of both of these increases.

In general, the impacts of the observed climate trends on drinking water sources will be low. In the SPA, most municipal systems are reliant on either deep bedrock aquifers or Lake Huron for their respective water supplies. From a water quantity perspective, increases in precipitation would lead to increases in the supply to these sources. It is important to understand that the increases in precipitation documented herein are small when compared with both the uncertainty of the data; and more importantly, the overall storage of these two systems.

Increasing amounts of precipitation coupled with increases in intensity of precipitation are often associated with increases in soil erosion and ultimately on water quality of surface water systems. In the Ausable Bayfield SPA there are no municipal systems which are exploiting riverine systems, and impacts on the overall quality of water in Lake Huron are buffered by the large volume of water in the system. Potential impacts of increased precipitation will be an important consideration in the development of Great Lakes Targets for Lake Huron.

5.9 Data Gaps Concerning the Changing Climate

The impacts of climate change on water quality and quantity are poorly understood. While there is a certain level of understanding concerning climate change at the larger scale, there is very little actually known about the impacts on a watershed basis. Better observational data is needed to complete inventories and local scale data sets (Bates et al. 2008).

In addition, groundwater has traditionally received less attention than surface water, despite its importance as a drinking water source worldwide. While groundwater has been well-monitored in the past, it has not been monitored and examined for the eventuality of a changing climate and its associated impacts. Therefore depletion levels and recharge rates have not been well modeled. The models that exist are based on limited data (Bates et al. 2008). Thus, more study is needed before confidently assessing the impacts of climate change on water at a watershed scale.

5.10 Conclusions

While large-scale changes in climate can be fairly confidently predicted, climate change on a watershed scale cannot be forecasted as easily. However, it is generally believed that the noted trends in climate in the Ausable Bayfield SPA will negatively affect the drinking water supply, although those impacts are not considered to be significant.

The effects on drinking water may not been seen immediately, and may not be a cause for concern in the short term. However, the negative impacts to drinking water quantity and quality will only increase over the next few decades, turning it into a much larger problem. Actions need to be taken to prevent significant drinking water loss and degradation due to the changing climate. While climate change may be slowed if significant action is taken, it will not be stopped. Therefore, the population of the ABMV region will need to learn to adapt to a smaller water supply and to conserve this precious resource.

References

Author	Title	Date	Publisher	Purpose
Aerts, J. and P. Droogers, eds.	*Climate Change in Contrasting River Basins*	2004	CABI Publishing	This text discussed the hydrologic cycle in depth, as well as the impact climate change, and other factors, have on this cycle.
Ausable Bayfield Conservation Authority	*Preparing for Change in Ausable Bayfield Watersheds*	2007		Outlines the ABCA's position on climate change.
Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, eds.	*Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change*	2008	IPCC Secretariat	This paper gave a general overview of climate change, with relevant sections detailing expected impacts on water quality and quantity.
Bruce, J.P. and D. Lean	*Planning for Extremes: Adapting to Impacts on Soil and Water from Higher Intensity Rains with Climate Change in the Great Lakes Basin*	2006	Ontario Chapter of the Soil and Water Conservation Society	This book explained the relationship between temperature changes and precipitation events.
de Loë, R.C. and A. Berg	*Mainstreaming Climate Change in Drinking Water Source Protection in Ontario*	2006	Pollution Probe	Generally good information about climate change and how it fits in with Drinking Water Source Protection.
Environment Canada	*Frequently Asked Questions About the Science of Climate Change: 2008 Update*	2008		A general guide to the science behind climate change.
Field, C.B., L.D. Mortsch, M Brklacich, D.L. Forbes, P. Kovacs, J.A.	*Climate Change 2007: Impacts, Adaptations and Vulnerability. Contribution of Working Group II to*	2007	Cambridge University Press	This text was helpful in understanding some of the impacts of

Author	Title	Date	Publisher	Purpose
Betz, S.W Running and M.J. Scott	*the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*			climate change, mostly related to water quality.
Garbrecht, J.D. and T.C. Piechota, eds.	*Climate Variations, Climate Change and Water Resources Engineering*	2006	Environmental and Water Resources Institute of the American Society of Civil Engineers	A good general overview of climate change and its potential impacts.
Huron Geosciences	*Climate Trends in the Ausable Bayfield Conservation Authority*	2011	Unpublished	A study outlining climate trends in the ABCA Jurisdiction.
Lemmen, D.S. and F.J. Warren, eds.	*Climate Change Impacts and Adaptation: A Canadian Perspective*	2004	Natural Resources Canada	A handy paper outlining climate change impacts for Canada.
Prodonović, P.	*Response of Water Resources Systems to Climate Change*	2008	University of Western Ontario	A recent research paper that explained the specific impacts on climate change on both water quality and quantity.
Swartz, R.C, P, Deadman, D. Scott, L. Mortch	*Modeling the Impacts of Water Level Changes on a Great Lakes Community.*	June 2004	Journal of the American Water Resources Association	This article was helpful in delineating expected impacts on surface water resources due to climate change.

AUSABLE BAYFIELD: CHAPTER 6

FUTURE WORK

TABLE OF CONTENTS

6.1 Future Work

The Assessment Report delineates vulnerable areas and identifies potential and actual threats to drinking water in these vulnerable areas. This is based on the best available scientific knowledge, the guidance of experts and the available data. Over the course of time, new techniques and data will emerge. Likewise, during the preparation of this report, the Source Protection Committee has identified a number of topics for future consideration.

Great Lakes

The *Clean Water Act, 2006* speaks to the possibility of the Minister setting targets for water quality in the Great Lakes. There are a number of benefits beyond those to drinking water which will accrue as efforts to maintain and improve water quality in the Great Lakes progresses. The shoreline population, tourist industry, and upland ecosystems will all benefit as better management practices take hold. As the Great Lakes Targets take shape, future source protection plans will have to address these.

Issues – Sinkholes & Seaforth

Issues based threats may also be identified in the Source Protection Area. Sinkholes are present in the eastern portion of the SPA and are surrounded by farms and rural residences. These features are enormous transport pathways of surface water to groundwater. Preliminary evidence reveals that post storm events alter water chemistry (increased nitrates) in local drinking water sources. Other work of the Conservation Authority has delineated the issue contributing area. As these areas are not in a wellhead protection area, and do not constitute significant risks, policies will likely be left for the next iteration of the source protection plan.

The Seaforth area is on a highly vulnerable aquifer and in the past radionuclide contamination has been detected. Recently the municipality has developed new water supplies in the Seaforth area and wish to protect these sources from contamination. Research suggests that there is a strong correlation between salt contamination and radionuclide concentration. Therefore, the SPC recommends a study be undertaken to focus firstly on evaluating the local radionuclide/salt relationship (e.g. non-decommissioned brine wells, road salt), and secondly on identifying and locating potential sources which may be impacting local drinking water sources. This work is to be completed for the next round of planning.

Clusters – Hamlet Well Fields

There are numerous hamlets or settlement areas within the SPA. The only ‘barrier’ for their water quality is the first barrier, source protection. These clusters/ hamlets are serviced by private individual wells and septic systems and therefore, these areas are vulnerable to cross-contamination because of the proximity of individual wells to septic systems and neighboring businesses, industries and agriculture. A review of best management practices suitable for these specific situations, effective policies, and areas where contamination is more common, is recommended. Municipalities would be solicited for interest or might lead the project. Based on these findings, policies would be developed to address threats.

Moderate Threats

The primary focus has been on addressing significant threats, however, over time, policies for moderate risks may be desirable. For example, there is concern about highly vulnerable aquifers and significant groundwater recharge areas and land uses. The presence of landfill sites, septic systems and other uses in these areas has raised questions and public concerns. Future plans should focus on these specific instances and work with the public to develop appropriate policies and an understanding of source protection.

Local Threats

The *Clean Water Act, 2006* anticipates that some regions may want to establish local threats. In this region, there was discussion of transportation routes and underground storage of natural gas as activities which may be worthy of further consideration as local threats. As scientific evidence becomes more available the importance of this local concern will be evaluated. The Committee is to consider these local threats in the next round of planning.

General Update

Since the inception of the work for the Assessment Report additional statistics and studies have been completed. This will continue to be the case. At the next review of the AR, the statistics for the Watershed Characterization should be updated. In addition, any new groundwater studies, aggregate or waste, salt, snow or emergency management plans should be reviewed in the context of source protection. New wells or well decommissioning may need to be modeled or deleted from the document. Future committees may also wish to investigate geothermal heat as a local threat. Naturally, the threats database will also need to be revised as land uses change, lots are created, and development and abandonment take place.

AUSABLE BAYFIELD: CHAPTER 7

CONSIDERING THE GREAT LAKES

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

The entire Ausable Bayfield Source Protection Area drains into Lake Huron through a variety of rivers and gullies (Map 7.1). This chapter deals with the requirements of *the Clean Water Act, 2006*, which pertain to source protection areas that drain into the Great Lakes. Section 14 of the *Clean Water Act, 2006* requires that source protection committees consider the Great Lakes in the light of three agreements; the *Great Lakes Water Quality Agreement*, the *Great Lakes Charter* (including the *Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement*) and the *Canada-Ontario Agreement* Respecting the Great Lakes Basin Ecosystem. Further, the *Technical Rules* 2(g) state the Assessment Report shall contain:

> "a description of how the Great Lakes agreements were considered in the work undertaken, if the source protection area contains water that flows into the Great Lakes or the St. Lawrence River."

The various chapters of this Assessment Report provide information and analysis on the water quality and quantity of Lake Huron. However, it is important to note that the Source Protection Committee has given specific consideration to Lake Huron at several of their meetings over the course of the past two years. As the information provided to the Committee was on the basis of the entire Source Protection Region, this chapter contains information that pertains to both the Ausable Bayfield Source Protection Area and the Maitland Valley Source Protection Area.

7.1 Consideration of the Great Lakes Agreements

The *Clean Water Act, 2006* requires that the Terms of Reference for Source Protection Areas that contain water that flows into the Great Lakes or the St. Lawrence River must consider the following documents: the *Great Lakes Water Quality Agreement*, the *Canada-Ontario Agreement Respecting the Great Lakes Ecosystem*, the *Great Lakes Charter*, and any other agreement to which the Government of Ontario or the Government of Canada is a party, that relates to the Great Lakes Basin and that is prescribed by the regulations (there are currently no other documents prescribed by the regulations). Further, the *Technical Rules* indicate that a written description of how these agreements were considered in the work undertaken in accordance with the *Technical Rules* must be included in the Assessment Report.

The length of the Lake Huron shoreline in the Ausable Bayfield Maitland Valley Source Protection Region (between Ipperwash to the south and Amberley to the north) is not subject to a lakewide management plan or a remedial action plan stemming from these agreements. Nonetheless, the Canada-Ontario Agreement/Great Lakes Divisional Project Manager for Lake Huron has both presented to the Source Protection Committee and received draft documents for comment.

Although all three prescribed documents share common goals with the source protection process, the *Great Lakes Water Quality Agreement* is the only prescribed document that has specific links to the preparation of this Assessment Report. The following sections describe the prescribed documents and indicate how they were considered during the preparation of this Assessment Report.

7.2 The Great Lakes Water Quality Agreement

The *Great Lakes Water Quality Agreement* is an agreement between the governments of Canada and the United States of America that expresses their commitment to restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin Ecosystem. It also reaffirms the rights and obligations of these two countries under the Boundary Waters Treaty. The Agreement outlines provisions for the development of cooperative programs and research and includes a number of objectives and guidelines to achieve its goals (Environment Canada, 2004a).

The SPC invited the Great Lakes Advisor for the Ontario Ministry of the Environment, Ted Briggs, to present information on how the agreements impact this section of Lake Huron (September 24, 2008). The lakewide management structure for the Great Lakes was given with particular emphasis on Lake Huron. The speaker provided information on the history of the *Great Lakes Water Quality Agreement* between the U.S. and Canada, the International Joint Commission, *Lake Wide Management Plans (LaMPs)*, and the *Canada – Ontario Agreement (COA)*. The key issues surrounding water quality and water quantity in Lake Huron were discussed. For example, questions regarding the levels of dioxins and the impact of humans on lake water levels were raised. It was explained that it is difficult to determine human impact on water levels and that standard levels of dioxins over time only occur in certain areas.

There are no LaMPs for Lake Huron within this Source Protection Region. However, another type of approach is being undertaken. Healthy Watersheds Coordinator for the Ausable Bayfield Conservation Authority (ABCA), Mari Veliz, gave a presentation on Community Action Planning for Lake Huron. The presentation focused on the broader Lake Huron issues and specific examples of recent projects were given. It was explained that with respect to bacteria, a library of microbes is being built but is time consuming and costly. With respect to nutrients, it was explained that monitoring needs to be conducted to determine the biggest threats. However, funding for monitoring is critical.

Deb Shewfelt, Mayor of Goderich, presented information on the Mayor's Collaborative Action Plan to protect the Great Lakes. This initiative functions within the framework of the International Joint Commission. The first step of the collaborative plan was to create an organization to exchange ideas on the Great Lakes. The memorandum of understanding for the organization was developed with the Province of Ontario with the aim of working closely together. One of the main initiatives of the group is to improve beaches by promoting tourism. The more a community reconnects people to the Lakes, the more support a community will receive. Some of the issues the organization is dealing with are; the removal of toxic algae from beaches and reducing the amount of untreated sewage and stormwater discharges into the Great Lakes.

7.3 Canada-Ontario Agreement Respecting the Great Lakes Ecosystem

The *Canada-Ontario Agreement Respecting the Great Lakes Ecosystem* is an agreement between the governments of Canada and the Province of Ontario that supports the restoration and protection of the Great Lakes Basin Ecosystem. It outlines how the two governments will cooperate and coordinate their efforts to restore, protect, and conserve the Great Lakes basin ecosystem, and it contributes to meeting Canada's obligations under the *Great Lakes Water Quality Agreement* (Environment Canada, 2004b). Although this agreement is geared towards the protection of water quality, it does not contain any specific technical information that was applicable to the preparation of this Assessment Report.

7.4 Great Lakes Charter

The *Great Lakes Charter* is a series of agreements between the provinces of Ontario, Quebec, and the eight Great Lakes States that set out broad principles for the joint management of the Great Lakes (Environment Canada, 2005). The original Charter was developed in 1985 in response to the growing use of water and proposals to divert large quantities of water out of the Great Lakes Basin (Ontario Ministry of Natural Resources, 2005). The purposes of the Charter are "to conserve the levels and flows of the Great Lakes and their tributary and connecting waters; to protect and conserve the environmental balance of the Great Lakes Basin ecosystem; to provide for cooperative programs and management of the water resources of the Great Lakes Basin by the signatory States and Provinces; to make secure and protect present developments within the region; and to provide a secure foundation for future investment and development within the region." (Council of Great Lakes Governors, 1985)

The *Great Lakes Charter* was supplemented in 2001 by the *Great Lakes Charter Annex*, which reaffirmed the principles of the Charter and committed the Governors of the Great Lakes States and Premiers of the Great Lakes Provinces to "developing an enhanced water management system that…protects, conserves, restores, and improves the waters and water-dependent natural resources of the Great Lakes Basin" (Council of Great Lakes Governors, 2001). The *Great Lakes Charter Annex* implementing agreements, including the *Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement*, attempt to provide this water management system (Environment Canada, 2005). Although this Charter is geared towards the protection of water quality and quantity, it does not contain any specific technical information that was applicable to the preparation of this Assessment Report.

Andrew Henry, Division Manager for the Regional Water Supply System, presented information on the impacts of the *Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement* on the Lake Huron Primary Water Supply System which provides drinking water for much of the Ausable Bayfield Source Protection Area. An overview of the evolution of the Agreement was given and the differences between inter-basin transfers and intra-basin transfers were clearly defined. Some of the major water quality and quantity issues for the Great Lakes were discussed and include:

- Monitoring and assessing the impacts to watersheds – water and wastewater volumes
- Monitoring consumptive use
- The quality and volumes of discharge back into the environment
- Long-term evolution of threats and risks
- Long-term impacts of recharge – e.g. 60% of low flow down the Thames River is generated from the City of London wastewater. If existing transfers are reduced it could have drastic impacts
- Adoption of “Water for Life” concepts – managing environmental resources

7.5 Great Lakes Targets

The *Clean Water Act, 2006* allows for the Ontario Minister of the Environment and Climate Change to establish targets relating to the use of the Great Lakes as a source of drinking water for any of the source protection areas that contribute water to the Great Lakes. If targets are set, policies and steps would need to be established to achieve these targets. No targets have been set at this time.

7.6 Lake Huron Working Group

The Source Protection Regions and Areas draining into Lake Huron are the North Bay, Lake Simcoe, Saugeen Grey Sauble Northern Bruce Peninsula, the Ausable Bayfield Maitland Valley, and Thames Sydenham source protection regions. The Chairs of the source protection committees and project managers have formed a working group to discuss and address common issues, share knowledge and engage in broader discussions on Great Lakes issues from a drinking water perspective.

7.7 Consideration of Lake Huron Intake Susceptibility

According to Ontario Ministry of the Environment guidance and the *Technical Rules* (2008) under the *Clean Water Act, 2006*, Great Lakes-based water supplies are not subject to analysis as part of the drinking water source protection water budgeting process and water quantity stress assessment. However, in order to provide consideration of the Great Lakes as prescribed in the *Technical Rules*, a sensitivity analysis was undertaken to determine how susceptible the Goderich and LHPWSS intakes are to fluctuating water levels in Lake Huron.

7.7.1 Determination of Optimal Intake Depth

Currently, no guidance is available to define what an optimal intake depth should be, based on water quantity and quality considerations. The updated Ministry of the Environment *Design Guidelines for Drinking-Water Systems (2008)* removed an existing recommendation of a minimum 10 m depth, and instead references a minimum depth of 3 m below historic low water levels based on navigational concerns. A survey of engineering design companies (Stantec; Riggs Engineering) who are typically involved with the siting and design of intakes revealed no agreed upon standards for the depth of a Great Lakes intake.

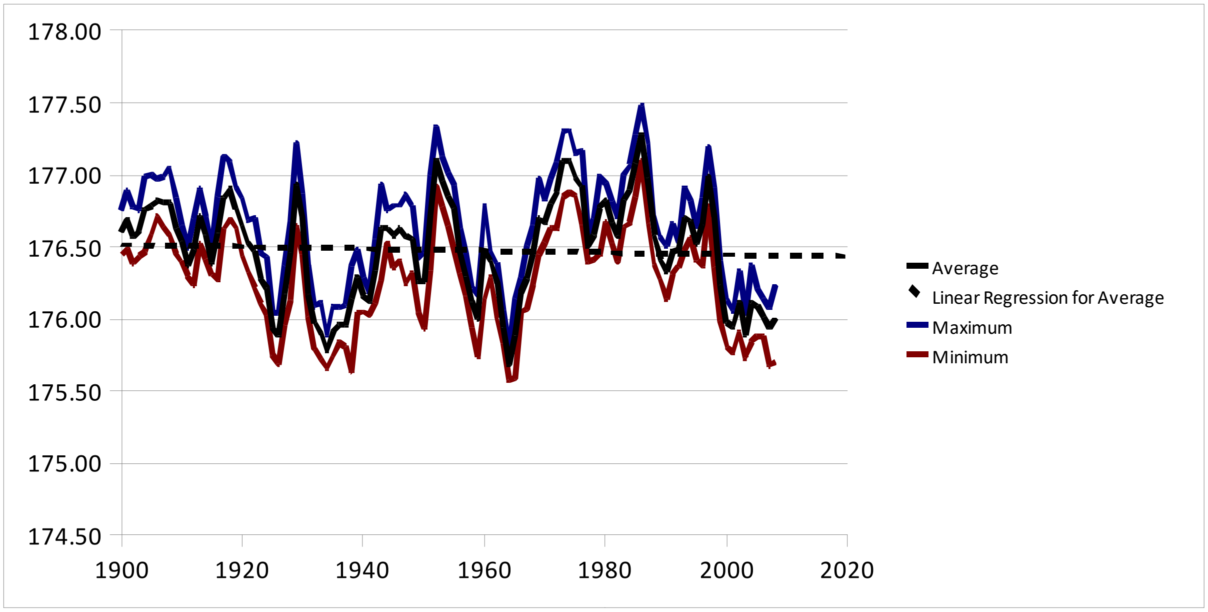
In the Saugeen, Grey Sauble, Northern Bruce Peninsula SPR, the consultants developing intake protection zones for the 10 Lake Huron outlets (Baird and Associates) used a wave breaking depth approach to develop recommended intake depths. This approach involves determination of the wave breaking depth, based on wave heights which are modeled using fetch and the 10-year return period winds from eight cardinal directions. This approach is based on the assumption that an intake developed below wave breaking depths will be subject to less turbidity due to wave/shore interaction. The results of this study indicate that the optimal depths for the Lake Huron intakes in the Saugeen, Grey Sauble, Northern Bruce Peninsula SPR range from 8 to 10 m.

The Lake Huron Primary Water Supply System intake (north of Grand Bend) is located at elevations of 166.2m a.s.l. (metres above sea level). Chart Datum for Lake Huron is set at 176m a.s.l which represents a depth of 9.8m for LHPWSS intake.

7.7.2 Lake Huron Water Levels

Lake Huron water levels for the period 1900-2008 are available from the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory (http://www.glerl.noaa.gov/). **Figure 7.1** below shows monthly average, maximum and minimum lake levels in this period expressed as metres above sea level (m a.s.l). In addition, a linear regression of the monthly data was developed from this data and is shown as the dashed line on the graph.

Figure 7.1 Monthly average, maximum and minimum water levels for the Lake Huron-Michigan system (GLERL, 2009) expressed in m a.s.l. Linear regression for average values shown with dashed line.



Based on the available information, a long term average lake level 176.27m a.s.l was determined, with the absolute minimum lake level for the period set at 175.58m a.s.l for April of 1964. A downward trend in overall lake levels was noted for the period of record, and as a result of this it seems prudent to provide for the possibility that levels may drop below this record low within the 25 year planning cycle. In order to estimate this, the difference between the long-term average and historic low (0.69m) was used as a safety factor and subtracted from the historic low – providing a low water level of 174.89m a.s.l for the sensitivity analysis.

7.7.3 Sensitivity Analysis

The sensitivity of the Lake Huron intakes to water level is summarized in the **Table 7.1**, below.

Table 7.1 Sensitivity of the LHPWSS intake to fluctuating water levels in Lake Huron

Intake	Depth (datum)	Depth at low	Depth at low – safety factor
LHPWSS	9.8 m	9.4m	8.7m

The information on the depth of the intakes indicates that even during an extremely low Lake Huron water level period, the intakes are located at sufficient depth for water quantity purposes. The LHPWSS intake seems to be well-situated, and in the absence of any wave-breaking depth calculations, meets all current guidelines for intake depth.

References

Author & Publisher	Title	Date	Purpose
Council of Great Lakes Governors	*The Great Lakes Charter: Principles for the Management of Great Lakes Water Resources*. Retrieved 2009 from: http://www.cglg.org/projects/water/docs/GreatLakesCharter.pdf	1985	Reviewed for Source Protection Action
Environment Canada	*Great Lakes Water Quality Agreement*. Retrieved, 2009 from: http://www.on.ec.gc.ca/greatlakes/default.asp?lang=En&n=FD65DFE5-1	2004a	Reviewed for Source Protection Action
Environment Canada	*The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem*. Retrieved 2009 from: http://www.on.ec.gc.ca/greatlakes/default.asp?lang=En&n=D11109CB-1	2004b	Reviewed for Source Protection Action
Great Lakes Environmental Research Laboratory (GLERL)	*www.glerl.noaa.gov*	2009	Lake Huron water levels for intake sensitivity analysis
Ministry of Natural Resources	*Frequently Asked Questions: Great Lakes Charter Annex Implementing Agreements*. Retrieved 2009 from: http://www.mnr.gov.on.ca/200071.pdf	2005	Reviewed for Source Protection Action

AUSABLE BAYFIELD: CHAPTER 8

KEY OUTCOMES

Table of Contents

8.1 Key Outcomes

8.1.1 Drinking Water Sources

In the Ausable Bayfield Source Protection Area (SPA) just over half the people receive their drinking water from municipal drinking water systems, while the remaining people have individual wells. The municipal systems can be classified as either surface water intakes or groundwater wells. The municipal systems have a varying degree of treatment facilities ranging from simple to state of the art facilities.

8.1.2 Water Quantity

The various stages of water budget analysis, carried out as part of the source protection work, have provided a much better understanding of the availability of water within the region. Overall, groundwater is plentiful in the region. Base flow, precipitation and evaporation are somewhat lower in the Ausable Bayfield SPA than the Maitland Valley SPA. Recharge is higher in the Parkhill than the Ausable or Bayfield watersheds. Consumptive takings are also low. However, in a small region of the gullies between Goderich and Bayfield, the Tier 1 Water Budget methodology triggered the need to proceed to a Tier 2 review of these subwatersheds. The Tier 2 review has demonstrated that there is no need to proceed to a Tier 3 review for that location.

The reliance on water from Lake Huron for much of the area has brought about a sense of security that there is ample water for well into the future. Barring significant changes in international agreements or catastrophic events, it would appear that stress on the water quantity is not an issue in the foreseeable future. One other potential concern might be the effect of climate change on the Great Lakes system in terms of water quantity. Should climate change result in consistently drier years the overall impact could mean less water would be available from the Great Lakes.

8.1.3 Water Quality

The scientific research and data collection carried out by the Ausable Bayfield Maitland Valley Source Protection Committee has found that while there are only minor water quality concerns throughout the region (generally naturally occurring abundance of fluoride), and the water quality is reasonable good. However, drinking water still requires treatment to safeguard the people relying on these sources.

Given the location of the Lake Huron Primary Water Supply System (LHPWSS) intake, there is little concern as the raw water quality is excellent. There are not the concerns about phosphorus, sediment or nitrates as there might be in other locations.

Any groundwater based system that was struggling with raw water quality issues has joined the Lake Huron Primary Water Supply System, thus addressing the drinking water quality issue. It does not however mean that the aquifers are no longer contaminated. Programs which encourage good land stewardship through incentive and education programs are needed to address these highly vulnerable aquifers.

8.1.4 Threats

When the *Clean Water Act, 2006* first became law there was a perception that it might directly impact every landowner in the source protection region. Now that the vulnerability mapping and scoring has been completed and the enumeration of significant threats has occurred, it has become evident that there are relatively few significant threats that have been identified for each municipal system. Twenty-two prescribed activity threats have been included in the *Clean Water Act*. A Table of Drinking Water Threats has been compiled which indicates when an activity in a particular vulnerable area under certain circumstances becomes a significant threat. The Technical Rules were amended in 2021, with significant changes to the circumstances in the Tables of Drinking Water Threats. The Technical Rules can be accessed at https://www.ontario.ca/page/2021-technical-rules-under-clean-water-act.

The threats have been identified by parcel. Possible threats were identified based on the intrinsic risk (beneficial management practices are not assumed). This provided the Source Protection Committee with the tools they required to generate source protection policies. Details on the risk assessment and enumeration of potential significant drinking water threats can be found in Chapter 4 of the Assessment Report. It is anticipated that numbers will vary over time, according to changes in land use, and as additional information becomes available.

8.1.5 Issues and Conditions

No issues or conditions were identified as being a significant risk at this time. There is interest in pursuing a better understanding of water quality influences in the Seaforth and sinkhole areas. The threshold for an issue was set by the Source Protection Committee as half the maximum allowable concentration of water quality parameter reached. Issues can be eliminated if it is treatable.

8.2 Consideration for the Source Protection Plan

This *Assessment Reports* form part of the foundation of the Ausable Bayfield and Maitland Valley Source Protection Plans. The Ausable Bayfield Maitland Valley (ABMV) Source Protection Committee has considered the scientific work that has been collected throughout the development of the *Assessment Report*, all the input and comments from stakeholder groups, and the cost-effectiveness of what is being proposed in the Plan.

The development of the Source Protection Plan is based on:

- **Public Involvement:** The participation in a number of opportunities throughout the development of the Terms of Reference; Assessment Reports; and Source Protection Plans has been crucial to the entire planning process.
- **Application of Source Protection Planning Tools:** The Province of Ontario developed a set of tools to be used in Source Protection Plans. These range from softer tools like education and outreach, and incentives, to more stringent tools like requiring risk management plans and prohibition of certain activities. The Source Protection Committee weighs options when determining which tools, or combination of tools, are best able to reduce or eliminate significant threats. They also consider the effectiveness and cost-effectiveness. For example, many activities identified as potential threats may already be governed by standards or provincial prescribed instruments. Duplication of such requirements in a source protection plan is not cost effective.
- **Monitoring:** The Source Protection Committee will develop monitoring policies as an ongoing activity. Monitoring has two components. The implementation of the plan requirements will be monitored. As well, the Committee will monitor the effectiveness of the tools used in the Source Protection Plan. If a particular tool like education and outreach is not effective in reducing threats to drinking water, then the committee will have to adapt and modify the plan so that whatever tool is used will be effective.
- **Three Time Frames:** The Source Protection Plan will reflect three types of goals:
    - **Future Threats;** this means the development of policies that will not allow activities to become drinking water threats
    - **Existing Threats;** this involves creating measures that correct an existing activity or circumstance which is a threat to drinking water sources
    - **Emergency Response;** it is clear that some threats are not incremental activity based threats, but threats that result from an emergency or unexpected situation like a spill. Therefore, the goal is to ensure that all existing and future emergency response plans in the area recognize the vulnerable areas that have been delineated through the source protection planning process

8.2.1 Consultation with Other Source Protection Committees

The Ausable Bayfield Source Protection Area has one other Source Protection Region that abuts its watershed boundaries. The Thames-Sydenham Source Protection Region lies to the south and east. Matters requiring additional consultation will include:

1) Common Information Management Protocols
2) Coordinated approached to Communication, Technical Work, and Source Protection Planning
3) Common approach to Great Lakes intakes policy matters
4) Addressing any Great Lakes targets when set

More details on these matters are available in the Terms of Reference, June 2009.