DRINKING WATER SOURCE PROTECTION

ACT FOR CLEAN WATER

Thames-Sydenham and Region Source Protection Committee

Lower Thames Valley Source Protection Area

Assessment Report

November 12, 2010
Amendments initiated under s.36 of the CWA - July 2023

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Thames-Sydenham and Region Assessment Report – Lower Thames

Updated July 2023

Assessment Reports for Lower Thames Valley, St. Clair Region and Upper Thames River Source Protection Areas

Thames-Sydenham and Region Source Protection Committee

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1.0 Introduction and Background

Following the tragedy in Walkerton (May, 2000) when the town's drinking water became contaminated with a specific strain of *Escherichia coli (E. coli)* and *Campylobacter* bacteria, Justice O'Connor presided over the Walkerton Inquiry. Justice O'Connor made 121 recommendations in a two part report which recommended a multi-barrier approach to protecting Ontario's drinking water. Many of Justice O'Connor's recommendations were implemented with the introduction of the Safe Drinking Water Act, 2002 (*SDWA*). The *SDWA* dealt with the treatment, distribution and testing of drinking water as well as the training of operators and notification protocols. The Clean Water Act, 2006 (*CWA*) addressed Justice O'Connor's recommendations pertaining to the watershed-based protection of drinking water sources referred to as Drinking Water Source Protection.

The Clean Water Act, 2006 required the establishment of Source Protection Committees to oversee the process locally. The Source Protection Committee developed and consulted on a work plan document called the Terms of Reference and submitted it to the Minister of the Environment for Approval. Based on the approved Terms of Reference the Source Protection Committee completed an Assessment Report and Source Protection Plan. The Assessment Report is a science-based document that forms the basis of the Source Protection Plan. The Plan contains policies to reduce the risk associated with threats to the drinking water sources identified in the Assessment Report.

The Clean Water Act, 2006 requires that Assessment Reports be completed for each Source Protection Area with a Source Protection Region (*SPR*). The Assessment Reports contain detailed information which identify *vulnerable* areas associated with drinking water systems, assess the level of vulnerability, identify *issues* related to the drinking water sources, identify activities within those vulnerable areas which pose threats to the systems, and assess the risk due to threats. These Assessment Reports have been completed for the three Source Protection Areas of the Thames-Sydenham and Region *SPR* as shown in the following Map 1-1.

1.1. Document Overview

This Assessment Report is modular in nature. It is comprised of several Sections and Appendices. The Sections are, in effect, a summary of various technical studies which are described later in this section. Each of the Sections is summarized in Section Summaries contained in Appendix 2. Material pertinent to a specific drinking water system is summarized in System Summaries included in Appendix 3. Maps form a large part of the content of the Assessment Report, and are contained in Appendix 1. Tabloid sized (11"x17") maps are included in this report, and may be printed on letter sized paper and remain mostly legible. The entire document is available on Compact Disk (CD) complete with the appendices to the Assessment Report.

Each Section of the Assessment Report is outlined below:

1.1.1.1. Introduction and Background (Section 1)

The first section provides an overview of the process and background behind the Assessment Report. It refers to mapping products related to the extent of the Source Protection Region and Source Protection Areas as well as the municipal partners involved in developing the Source Protection Plan.

1.1.1.2. Watershed Characterization (Section 2)

The Watershed Characterization Reports for the region were completed in 2008. A three volume report was produced for the Thames Watershed and Region which included the Upper Thames River Source Protection Area and the Lower Thames Valley Source Protection Area. A summary of the report was developed which included all of the mapping products used in the Watershed Characterization Report. The summary of the Thames Watershed and Region Watershed Characterization Report is included in Appendix 5. The summary and the full Watershed Characterization Reports are available in portable document format (Adobe PDF) on Compact Disk (CD).

1.1.1.3. Water Budget and Water Quantity Stress Assessment (Section 3)

A Conceptual Water Budget was developed for the Thames-Sydenham and Region. This report is included as Appendix 6 of this Assessment Report. The Conceptual Water Budget compiles

water quantity information from the region, such as precipitation and water takings, for use in the Tier 1 Water Budget. In the Tier 1 Water Budget, a preliminary stress assessment indicating the potential for water quantity stress in subwatersheds of the region is undertaken. The potential for stress determines whether additional work is required to refine the water budget in that *subwatershed*. If the potential stress could affect a drinking water system included in the Terms of Reference for the region (generally municipal drinking water systems), the additional refinement will be completed through a Tier 2 and potentially a Tier 3 Water Budget. If, however, the potential stress does not have an impact on the water systems in the area, the work should be undertaken through different programs. . As the Thames-Sydenham and Region Tier 1 Water Budget has not identified a potential for stress, which would affect a municipal drinking water system in the Lower Thames Valley Source Protection Area, no Tier 2 or Tier 3 Water Budgets are required in the Lower Thames Valley Source Protection Area.

1.1.1.4. Vulnerability Assessment (Section 4)

The Vulnerability Assessment section is a summary of the identification of the *vulnerable areas*, the assessment of vulnerability within those areas, and the *uncertainty* in that assessment as required by the Clean Water Act. The work related to this section was undertaken through a number of technical studies which were generally completed on the geographic scale of the upper tier municipalities (counties). This section summarizes the work completed on a Source Protection Area basis for each type of vulnerable area. The work is also summarized for each drinking water system in the System Summaries included in Appendix 3. A peer review of the vulnerability assessment work was undertaken.

1.1.1.5. Issues Evaluation (Section 5)

The Issues Evaluation Section describes the methods applied and the findings of the *issues* evaluation process across the Source Protection Area. The detailed methodology for the *issues* evaluation process is included in Appendix 8. A table of *issues* identified is included in the Issues Evaluation section as well as a description of the impact of identifying an *issue* and additional work required to determine the activities which may be contributing to the issue. The findings reported in this section are also included in the System Summaries in Appendix 3.

1.1.1.6. Conditions Assessment (Section 6)

The Conditions Assessment section of the Assessment Report includes a description of the

work undertaken to assess the potential *conditions* (drinking water threats due to past activities) which have been identified to date. This is an ongoing process requiring additional work.

1.1.1.7. Threats and Risk Assessment (Section 7)

The Threats and Risk Assessment section of this Assessment Report includes a list of the types of *threats* which are or would be a risk to drinking water systems in the region and the number of locations where significant threats are believed to exist. It is not the intent of this report to identify individuals who are believed to be engaged in those activities nor is it intended to identify specific properties where those activities exist. Policies developed in the Source Protection Plan will be focused on general types of activities which 'are or would be' *threats* to drinking water. This section also outlines the additional work required to investigate activities believed to be threats. An overview of this information is presented in the System Summaries included in Appendix 3.

1.1.1.8. Great Lakes (Section 8)

The Great Lakes section includes the required references to other work undertaken in the region related to Great Lakes water quality and how the Assessment Report supports and complements that work and vice-versa. It identifies additional work required in this area once all the Assessment Reports for Source Protection Areas that drain into the Great Lakes are completed. Of special relevance to this section are the drinking water quality *issues* identified at Great Lakes intakes in the Lower Thames Valley SPA, which can be found in Section 5 of the Assessment Report.

1.1.1.9. Data Gaps and Next Steps (Section 9)

Data gaps and next steps are listed in this section. Data gaps such as infrequent groundwater sampling or inaccurate tile drainage network information were identified through the technical studies and have been included in this Assessment Report so that they may be considered in the future.. Many of the next steps involve work plans to fill the data gaps or additional work required to reduce the *uncertainty* related to various components of the Assessment Report. Data gaps and next steps pertaining to an individual system are listed in the System Summaries included in Appendix 3.

1.2. Clean Water Act Rules and Regulations

The Clean Water Act, 2006 established the requirements to develop a Source Protection Plan and set up the framework to develop that plan. In order to define the work and enable aspects of the work to be completed, regulations and *rules* were required. The development of these *rules* and regulations was led by the Drinking Water Source Protection Branch of the Ministry of the Environment. These regulations were developed through consultation with stakeholders including the Source Protection Committee chairs and committees and the staff of the Conservation Authorities working with the Source Protection Committees. Many consultation sessions were held with sector representatives of those who may be impacted by the *rules* and regulations.

1.2.1. Regulations

A regulation established Source Protection Areas and Regions (O. Reg. 284/07). This regulation established the Thames-Sydenham and Region Source Protection Region and the three Source Protection Areas described in the sections to follow. This Source Protection Region recognized in regulation a partnership established by the Conservation Authorities to prepare for the work which the Clean Water Act requires.

A regulation was introduced to establish Source Protection Committees (O. Reg. 288/07). The regulation described the make-up of the committees and also the process for establishing the committees. The regulation required that the Source Protection Authorities in the region form the committee while the chair is appointed by the Minister of the Environment.

A General Regulation (O. Reg. 287/07) provides requirements for the Terms of Reference, Assessment Reports and Source Protection Plans. The General Regulation also establishes the 21 activities which can be considered drinking water *threats*. The requirements of the Act, Regulation and *rules* are summarized in the Assessment Report Checklist which is included in Appendix 7. The checklist indicates where the requirements have been satisfied in this Assessment Report.

1.2.2. Technical Rules

In order to fully define the contents of, and methodologies used in developing Assessment Reports, the Ministry of the Environment, Conservation and Parks(MECP) released *Technical Rules*: *Assessment Report* (December 12, 2008). During the drafting of the Proposed Assessment Report, the Director (MECP) was in the process of amending those *rules* (November 2009). Amendments not addressed in that report were incorporated into the Amended Proposed Assessment Report and are still reflected in the current Updated Assessment Report.

The *Technical Rules 2013: Assessment Report* replaced interim guidance which was developed by MECP to guide much of the technical work initiated in 2006 and 2007. The guidance was developed in a modular manner with each module describing a specific component of the work. Much of the technical work followed those guidance modules which provided the basis for the organization of many of the technical studies. The guidance modules were detailed and descriptive. The organization of this report is partially reflective of those modules.

This Assessement Report aligns with 2017 Technical Rules.

1.2.3. Local Guidance Documents

The *rules* and regulations leave room for local discretion by the Source Protection Committee and system operating authorities. In many cases, local guidance documents were required to provide consistent guidance across the region. This local guidance developed by the Thames-Sydenham and Region in consultation with municipality staff and consultants includes:

- Issues Evaluation Methodology
- Threats and Risk Assessment
- Transport Pathways Consideration

1.2.4. Tables of Drinking Water Threats

Along with the *Technical Rules 2013: Assessment Report,* the province released 'Tables of Drinking Water Threats', which list the vulnerability and establish the circumstances under which threats can be considered significant, moderate or low risk. Two tables are provided which

describe the activities related to chemical and pathogen threats separately. The MECP threats tables, as they are commonly called, describe specific circumstances which affect the risk level of the activity. Circumstances include such factors as the volume of contaminant, the method of release into the environment, the type of contaminant, and the area in which the activity is undertaken. The tables are organized by Prescribed Drinking Water Threats (activities) established in the General Regulation (O. Reg. 287/07).

These circumstances, along with the vulnerability assessment of the vulnerable areas, determine the level of risk associated with an activity in a particular location.

1.2.5. Mapping Symbology

Along with the *Technical Rules 2013: Assessment Report*, the province also released and updated guidance on Assessment Report mapping standards, called the Mapping Symbology for the Clean Water Act (Version 3.0, April 2009). This guidance facilitates consistency in mapping products produced in the 19 Source Protection Regions in the province. This guidance has been used to develop the various mapping products included in this Assessment Report and the supporting studies. As the *mapping symbology* has been updated over the period that much of the work was undertaken, it is likely that not all aspects of the mapping products meet the current MECP guidance. As such, care must be taken in comparing mapping products in the Assessment Report to the Technical work from which they are sourced.

1.2.6. Source Protection Plan

Following the completion of the Assessment Report, a Source Protection Plan must be developed by the Source Protection Committee. The focus of the Source Protection Plan is to reduce or manage risks to drinking water sources. The Source Protection Plan contains policies focused on activities which are identified as threats. Ontario regulation 287/07, among other things, defines the scope and content of a Source Protection Plan. The regulation outlines the nature of the policies which would be included in a Source Protection Plan. These policies may include:

- education and outreach programs (leading to voluntary risk reduction)

- incentive programs (leading to voluntary risk reduction)
- land-use planning approaches (e.g., official plans, zoning bylaws, site plan controls, development permits)
- new or amended provincial instruments (e.g., Certificates of Approval)
- risk management plans
- prohibition
- restricted land uses.

The regulation indicates that the more restrictive policies listed above would only be applied to significant drinking water threats. Similarly, the policies related to significant threats are mandatory and must be implemented, whereas the policies related to moderate and low risk drinking water threats leave some discretion to the implementer. The Source Protection Plan may also include various policies related to monitoring.

1.3. Source Protection Committee

In the Thames-Sydenham and Region, the Conservation Authorities are required to form a Source Protection Committee (SPC) for the region as part of their responsibilities as Source Protection Authorities. They are also required to provide support to that committee. In order to carry out their responsibilities, each Conservation Authority meets individually as a Source Protection Authority. While many of their responsibilities can be undertaken individually, Conservation Authorities (and Source Protection Authorities, as appropriate) established various committees to undertake those items which required collective involvement.

A Management Committee was established to undertake the day-to-day administration related to the program. The Management Committee includes the General Managers of the three Conservation Authorities who meet regularly with the Source Protection Project Manager. The Management Committee, among other things, ensures that the Source Protection Committee has the resources to undertake their responsibilities as funded by the MECP.

A striking committee was formed to provide appointment recommendations to the Source Protection Authorities.

The Clean Water Act identifies the general make-up of the Source Protection Committee as having one third of its members representing each of the municipalities, sectors and other stakeholders. The Conservation Authorities in the region further refined the make-up of each third. A discussion paper was developed and distributed to the municipalities in the region for their input. Discussions with First Nations encouraged their participation on the Source Protection Committee. Those discussions led to the appointment of three First Nations members on the Source Protection Committee. These members were appointed by the London District Chief's Council to represent the eight First Nations in the region.

The make-up and representation of the Source Protection Committee are summarized in Table 1-1.

Table 1-1 SPC members and representation

Chair		Robert Bedggood
Municipalities	Chatham-Kent	Sheldon Parsons
	Lambton	Darrell Randell
	London	Patrick Donnelly
	Middlesex	James Maudsley
	Elgin	Brent Clutterbuck
	Oxford	Pat Sobeski
	Perth, Stratford, St. Marys, Huron	Joe Salter
Sectors	Agriculture	John Van Dorp
		Patrick Feryn
		Don McCabe
	Industry/Commercial	Dean Edwardson
		Earl Morwood
	Aggregate and Quarries	Paul Hymus
	Oil and Gas	Hugh Moran
Other		George Marr
		Doug McGee
		Joseph Kerr
		Carl Kennes
		Valerie M'Garry
		John Trudgen
		Charles Sharina
First Nations		Kennon Johnson
		Augustus Tobias
		Darlene Whitecalf
Liaisons	Medical Officers of Health	Jim Reffle
	Province	Teresa McLellan
	Source Protection Authority	Murray Blackie

Once established, the Source Protection Committee was required to establish rules of order and

operating procedures. The Source Protection Committee's rules of order are posted on the region's web site at the address included in the footers of this report. In order to guide them through the Source Protection planning process, the Source Protection Committee developed a Mission Statement and Guiding Principles. The Source Protection Committee's guiding principles and mission statement are summarized as follows:

Table 1-2 SPC Mission Statement and Guiding Principles

Mission Statement Protect sources of drinking water by developing a plan based on science and local cooperation.
Guiding Principles We value: • Fair and reasonable solutions • Consensus within our diverse area group • Clarity of information • Open communication • Respecting diversity of opinion

More detail on the committee's Mission Statement and Guiding Principles are posted on the region's web site, listed in the footer of this page.

The Source Protection Committee meets regularly to review and assess work conducted for the Assessment Report, to consider amendments to the Terms of Reference, and to discuss source protection planning for the region. The meetings are open to the public. The meeting agenda and minutes are available at the region's web site.

1.4. Role of the Conservation Authorities

The Conservation Authorities provide the resources to the SPC to complete their work. This includes the provision of technical and administrative staff such as hydrogeology, engineering, geographic information system and communications specialists. This team is led by the Source Protection Project Manager, Chris Tasker, and technical leads at each of the Source Protection Authorities. The lead at the Lower Thames Valley Source Protection Authority is Jason Wintermute, Water Management Supervisor.

1.5. Terms of Reference

The first major task of the Source Protection Committee was to develop a work plan to guide the source protection planning process for the following five years. The work plan – called the Terms of Reference, was developed with input from municipalities and stakeholders.

The Terms of Reference outlines who does what, when it will happen and how much it will cost. It guides the Source Protection Committee through the completion of the Assessment Report and the Source Protection Plan.

Two municipal working groups, for surface water and groundwater related studies, were established to help complete the work plan for the Terms of Reference. The groups were chaired by SPC members and comprised of municipal staff and water treatment plant operators, who provided technical input.

Public Open Houses on the Terms of Reference were held in September of 2008 at Ridgetown, St. Marys and Wyoming. A follow-up Public Meeting was held in London. In addition, comments were received through the posting of the Terms of Reference on the region's web site. The SPC submitted the proposed Terms of Reference to the Source Protection Authorities on December 18, 2008. Comments were received by the SPAs and submitted to the Minister of the Environment for approval. The Terms of Reference for the Lower Thames Valley Source Protection Area were approved by the Minister of the Environment and the notice of approval posted on the *Environmental Registry* on April 20, 2009. This approval set the due date of the Assessment Report one year from the posting of the approval of the Terms of Reference, April 20, 2010, which was met. The report was amended to produce the Amended Proposed Assessment Report, dated November 12, 2010. It has since been updated to the current *Updated* Assessment Report due to be submitted for approval in early 2015.

1.6. Thames-Sydenham and Region Source Protection Region

The Thames-Sydenham and Region Source Protection Region is located in southwestern Ontario bounded by Lake Erie in the south and by Lake Huron to the north of the western end of the region. It is surrounded by the Lake Erie Source Protection Region to the east and the Essex Region Source Protection Area to the west of its southern end. To the north and west of the northern part of the region is the Ausable-Bayfield Maitland Valley Source Protection

Region. The region is shown in Map 1-1.

The Thames-Sydenham and Region is comprised of three Source Protection Areas. The Upper Thames River Source Protection Area is to the north and east of the region. The Lower Thames Valley Source Protection Area is to the south and west of the Upper Thames River Source Protection Area while the St. Clair Region Source Protection Area is north of the Lower Thames Valley Source Protection Area. The three Source Protection Areas are also shown in Map 1-1.

1.6.1. Lower Thames Valley Source Protection Area

The Lower Thames Valley Source Protection Area (*LTVSPA*) includes parts of the municipalities listed in Table 1-3 below.

Table 1-3 Municipalities in the LTVSPA

Chatham-Kent	Lakeshore
Elgin	Leamington
Essex	London
Middlesex	Middlesex Centre
Dutton/Dunwich	Newbury
Southwold	Southwest Middlesex
St. Thomas	Strathroy-Caradoc
West Elgin	

The region also includes four First Nation reserves as shown on Map 1-1. Caldwell First Nation is also established in the area between Leamington and Rondeau Bay; however they currently do not have a reserve. Table 1-4 lists the First Nation communities in the region.

Table 1-4 First Nations of the LTVSPA

Chippewas of the Thames First Nation
Delaware Nation Council
Munsee-Delaware Nation
Oneida Nation of the Thames

The municipalities receive most of their drinking water from intakes on Lake Erie. There are two municipal groundwater systems located in the region. The Fisrt Nations reserves with community water systems rely on groundwater as their source of water. Private wells supply

water to the remainder of the residents in the region. Map 1-3 shows the location of the intakes and wells in the area.

The largest settlement in the area is Chatham, however parts of London, Middlesex, Lambton and Elgin Counties are in the region. Settlement areas are shown in Map 1-4. The approximate population of these settlement areas is indicated by the relative size of the symbol indicating the location of the settlement. These populations have been included based on available information or estimated based on the number of parcels in the settlement area.

More details on the area, its water systems and the population of the area are included in Section 2.0 - Watershed Characterization.

1.7. Technical Studies

The Assessment Report is a summary and compilation of a number of technical studies including:

- Watershed Characterization
- Conceptual Water Budget
- Various levels of Water Budgets (Tier 1, 2 or 3)
- Municipal Technical Studies

The Municipal Technical Studies were completed through partnerships between the municipalities and the Conservation Authorities. Leads for each study were established. The studies were led by the Conservation Authorities (CAs) or by a municipality. Most of the municipal technical studies (such as the vulnerability assessment, issues evaluation and threats assessment studies) were organized based on the geographic extent of the upper tier municipalities (counties). Drinking water system operating authorities or municipal staff participated in the studies through steering committees for those projects which were not led by the municipalities directly. The watershed characterization and the conceptual water budget studies were led by the CAs and completed by CA staff.

Vulnerability Assessment technical reports were peer reviewed by a four member peer review committee comprised of hydrodynamic and groundwater modelling experts with experience in

vulnerability assessment studies. This peer review is described in more detail in Section 4.0 – Vulnerability Assessment. The water budget work was also subject to a peer review process. The Ministry of Natural Resources (MNR) also participated in the peer review as well as people who have been involved in water budget work of the neighbouring Source Protection Areas. Components from the studies have been compiled into these Assessment Reports.

1.8. Consultation

Regulations require consultation on the Assessment Reports. This consultation, much like that of the Terms of Reference, requires a public meeting and for posting of the draft proposed Assessment Report for comment. Two posting periods are required: one posted by the Source Protection Committee for consultation on the draft proposed Assessment Report; and the second posted by the Source Protection Authority for comments on the proposed Assessment Report. The proposed Assessment Report is then submitted to the Ministry of the Environment along with comments received in the final posting period. The Director may then approve the Assessment Report or require changes to the report which has been referred to as the amended proposed Assessment Report. Once approved any revisions are included in an updated Assessment Report.

The Source Protection Committee identified the need to undertake a more detailed and locally focused consultation on the contents of the Assessment Report. A multi-phase consultation plan was developed and is included in Appendix 4 (and on the web site). The plan identifies three consultation phases. The first two phases of consultation provide a more local focus on the vulnerable areas associated with the municipal water supplies. The first phase includes the (peer reviewed) vulnerability assessment of the areas while the second phase adds discussion on the threats and issues identified in the vulnerable areas. Both phases include individual correspondence with property owners in the proposed vulnerable areas as well as advertisements in local newspapers. Maps of the areas and fact sheets were distributed with invitations to attend the local meetings. These materials were also made available on the region's web site.

The third phase of consultation is the required public meeting and posting of the draft proposed Assessment Report, and then the proposed Assessment Report for comment. This phase is

more regional in scope involving open houses in each of the Source Protection Areas.

The draft proposed Assessment Report must be published on the Internet for a 35 day comment period, and copies made available to stakeholders including the public. A copy of the notice of the posting of the draft proposed Assessment Report must be published in newspapers and distributed to the municipal clerks, First Nation band chiefs, landowners (engaging in an activity known by the SPC that is or would be a significant threat), other SPCs listed in the Terms of Reference, persons or bodies related to Great Lakes Water Quality Agreements, Remedial Action Plans and Lake wide Management Plans for their comments. At least 21 days after publishing the draft proposed report on the Internet, the required public meeting must take place.

The proposed Assessment Report must be published on the Internet for a 30 day comment period, and copies of the report submitted to municipal clerks and band chiefs. Amendments required by the Director are incorporated into an amended Proposed Assessment Report which involves local consultation of those affected by the changes made to the report.

Once approved any revisions to the Assessment Report are referred to as an Updated Assessment Report. As with the Amended Proposed Assessment Report, an Updated Assessment Report requires consultation with those affected by the updates. As some of the current updates are considered broad updates local consultation has been carried out in those areas where new vulnerable areas have been defined. A broad regional consultation has also been planned for the updated Assessment Report which exceeds the requirements for consultation on either the Draft Proposed or Proposed Assessment Report consultation including an open house in each area and a consultation period of approximately a month and a half.

Table 1-5 Summary of planned LTVSPA Assessment Report Consultation

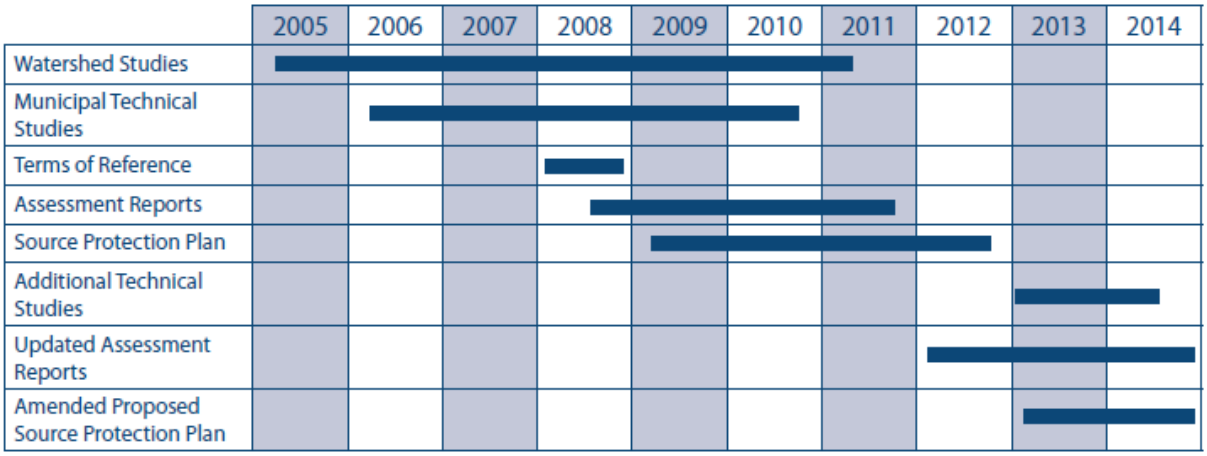
• Please refer to Assessment Report Consultation in Appendix 4 for details on Assessment Report Consultation

Future phases will involve similar consultation on updates to the Assessment Reports, which includes Early Engagment with MECP, Pre-consultation and public consultation.

1.9. Schedule

The due date of the Assessment Report was set with the posting of the approval of the Terms of Reference for the Source Protection Area. The Clean Water Act identifies that Assessment Reports are to be submitted within one year of the posting of the approval of the Terms of Reference. Amendments were made to the *Technical Rules 2013: Assessment Report*, which allow for certain data gaps provided a work plan is included to fill those data gaps. These amendments were an acknowledgement that in many cases it would not be possible to complete the Assessment Report in the time allowed by the Clean Water Act. The following schedule describes at high level the work required to complete the Assessment Report and Source Protection Plan including the current update of the Assessment Report and amendments to the Source Protection Plan before approval of the first Source Protection plan for the Thames-Sydenham and Region.

Figure 1-1 Source Protection planning schedule overview



1.10. Local Acceptance, Approvals and Next Steps

The Assessment Report consultation plan illustrates a number of review and acceptance stages in the development of the Assessment Reports for the Source Protection Areas. This ultimately culminates in the approval of the Assessment Reports by the Director of Source Protection Planning for the Ministry of the Environment.

Local acceptance of the Assessment Reports is also included in the consultation process. Prior to inclusion in the Assessment Report the components have been reviewed and accepted by the Source Protection Committee. This review included:

- involvement of municipal operators in the technical studies;
- peer review of the work;
- presentations to the Source Protection Committee by those undertaking the work;
- review of the products from the technical studies which are to be included in the Assessment Report;
- review of summary level information included in the Assessment Report in the form of section summaries and system summaries;
- consideration of municipal, First Nation and stakeholder comments on the draft proposed Assessment Report; and
- ultimately, the acceptance of the Assessment Report by the SPC.

Municipal and other local involvement in the development of the Assessment Report has been included in many ways. Municipalities have been involved in many of the technical studies throughout the region, especially those which are focused on the sources of drinking water for their municipal systems. Operating Authority staff participated in technical steering committees on these projects. Where appropriate, operating Authority staff kept their commissions or councils up to date on the completion of the technical work. Updates on the progress of Source Protection Planning have been distributed to municipalities throughout the work stages of the Assessment Report. Municipal comments were also requested on the Watershed Characterization Reports and the Conceptual Water Budget. Representatives on the Source Protection Committee have been instrumental in keeping their representation updated on the Source Protection Planning process including organizing and attending meetings with stakeholders.

During the first two phases of the consultation, municipal staff and councils were circulated invitations to the open houses and offers were made of presentations to municipal councils. Municipal Planners were invited to attend a municipal planners forum where the materials included in the Assessment Reports were discussed.

The third phase of consultation is comprised of two steps: consulting on the draft proposed Assessment Report, and then on the proposed Assessment Report. In the third phase of consultation, the notice of publishing of the draft proposed Assessment Report must be sent to municipal clerks and band chiefs. The draft proposed Assessment Report was distributed on Compact Disk (CD) to the municipalities and First Nations for their comments. Through ongoing involvement in the Assessment Report development process as discussed above, the municipal input has been incorporated into the Assessment Report. Municipalities, First Nations and other stakeholders had 35 days from the time the notice was posted to review and provide comments on the draft proposed Assessment Report. These comments were considered by the Source Protection Committee in finalizing the proposed Assessment Report.

The proposed Assessment Report was posted on the Internet for a 30 day comment period. This posting asked for comments to be submitted to the Source Protection Authority. Further, a

copy of the proposed Assessment Report was submitted to the municipal clerks and band chiefs.

The current report is an Updated Amended Proposed Assessment Report which fills in many of the data gaps identified in the previous Assessment Reports. Local consultation with those affected by the updates will be conducted.

In submitting the Assessment Report to the Ministry of the Environment, the Source Protection Authority is to include any outstanding comments including any municipal or First Nations concerns over the Assessment Reports. The Director can approve the Assessment Report as submitted or require further amendments to the Assessment Report.

1.10.1. Engaging First Nations

First Nations have been encouraged to participate in the development of the Assessment Report in a number of ways. Participation has been rather limited and very informal in nature. First Nations forums were set up in 2008-2009 across the region. First Nations participation on the Source Protection Committee has recently begun with the appointment of two of the three First Nations members. Previously various staff and councillors of the First Nations and the Southern First Nations Secretariat have participated in various ways including informal participation in tours and meetings of the Source Protection Committee, forums and workshops held at various stages in the Source Protection planning process. A First Nations liaison hired by the Conservation Authorities has been instrumental in the involvement of First Nation communities in many aspects of Source Protection Planning. A First Nations Liaison Committee was established to engage interested First Nations in the Source Protection Planning process. The Chippewas of Kettle & Stony Point First Nation (in St. Clair Region Source Protection Area) passed a band council resolution requesting the Minister to include their intake in the Terms of Reference for the region and allow them to undertake the technical work to include Intake Protection Zones for their intake. Other First Nations in the Lower Thames Valley Source Protection Area participated in a study to assess the WHPA-E associated with their GUDI wells. The First Nations Liaison Committee also explored potential policies which the First Nation could put in place on reserve to afford their groundwater a similar

level of protection to municipal systems under the Source Protection Plan. They did not, however, formally request to have their systems added to the Terms of Reference.

1.10.2. Amendments to the Assessment Report

As there were a number of data gaps identified in previous versions of the Assessment Report updates to the Assessment Report were anticipated The Data Gaps section of this report identifies the gaps and discusses plans to fill those gaps.

The Assessment Report can be updated at any time that the Source Protection Committee becomes aware of the need to update the report. Further, changes in understanding or factors such as land use which may have an impact on the Assessment Report may be brought to the attention of the Source Protection Committee. As a result of this new information or understanding, the Source Protection Committee may update the Assessment Report. Any updates to the Assessment Report would require consultation of those affected by the updates. The Source Protection Committee will also need to consider updates to the Assessment Report when the Source Protection Plan is reviewed. The period for review of the Source Protection Plan is established by the Minister in the approval of the Source Protection Plan.

The current report is an Updated Assessment Report which fills in some of the previously identified gaps. Local consultation with those affected by the updates will be conducted.

The terms ‘updated’ or ‘amended’ used throughout the report may refer to a future Assessment Report following approval of this Updated Assessment Report or to this Updated Assessment Report itself.

2.0 Watershed Characterization

Justice O'Connor recommended that watershed-based *Source Protection Plans* be developed. The recommendations were part of the inquiry which investigated the May 2000 bacterial contamination of the Town of Walkerton's water supply. Compiling a summary of information pertinent to drinking water sources is one of the first steps in developing a *Source Protection Plan*.

Under the Clean Water Act (2006), the Assessment Report must identify all subwatersheds in the source protection area and characterize the water quality and quantity across the watershed. The Regulations and *rules* under the Clean Water Act (2006) require that the physical and human geography also be characterized. This information is contained in a watershed characterization report.

2.1 Watershed Characterization Report

The Watershed Characterization Report for the Thames Watershed and Region, completed in 2008, is based on information available at the time. Updated characterization information is included in other sections of the Assessment Report. Some of the water budget related mapping products are available in the Conceptual Water Budget, which is included as an appendix to the Assessment Report.

The Watershed Characterization Report summarizes information on the physical, social and economic characteristics of the Thames Watershed & Region. It reviews surface water and groundwater quality, and summarizes known issues and concerns pertaining to drinking water sources. A series of maps help to illustrate the information presented in the report. Each of the components of the watershed characterization report will be described in the sections that follow.

The summary of the Watershed Characterization Report for the Thames Watershed and Region is included in Appendix 5 in the Lower Thames Valley and Upper Thames River Source

Protection Area Assessment Reports; complete with all maps. The entire Watershed Characterization Report is available on compact disk (CD).

2.2 Data Sources

A wide range of data sources have been used as resources to prepare the Watershed Characterization Report and the accompanying maps. Data used to characterize the Thames watershed is provided in the Table 2-1 below.

Table 2-1 Watershed Characterization Report Data Sources

Component	Data Source
Bedrock Geology	Waterloo Hydrogeologic. 2005. Six Conservation Authorities FEFLOW Groundwater Model: Conceptual Model Report.
Surficial Geology	Waterloo Hydrogeologic. 2005. Southwestern Region Edge-Matching Study. Surficial Geology of Southern Ontario. Ontario Geological Survey Miscellaneous Release –Data 128.
Physiography	Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario, 3rd edition.
Soils Information	Ontario Ministry of Agriculture and Food and Agriculture Canada, Soils Ontario Version 1.0. Ontario Soils Surveys
Groundwater Hydrogeology	Waterloo Hydrogeologic. 2005. Six Conservation Authorities FEFLOW Groundwater Model: Conceptual Model Report. Waterloo Hydrogeologic. 2005. Southwestern Region Edge-Matching Study. Municipal Groundwater Studies. MOE.
Surface Water Hydrology	Ontario Ministry of the Environment and Ontario Ministry of Natural Resources. 1975. Thames River Basin Water Management Study. Stream Gauge Data. Ontario Ministry of Agriculture and Food and Agriculture. Municipal Drain Classification (Fisheries and Oceans Canada project) data. UTRCA. 1991. Dam Inventory and Reservoir Assessment.
Naturally Vegetated Areas	Ministry of Natural Resources Aerial Mapping 2001 and 2003.
Aquatic Ecology	Species at Risk Recovery Plan. Fisheries and Oceans Canada. Ontario Ministry of Natural Resources. Royal Ontario Museum. Ontario Ministry of the Environment. COA and COA partners - Thames River Habitat Assessment and Monitoring Program. Thames watershed Species at Risk data from Cudmore, B., C. A MacKinnon and S. E. Madzia. Dec. 2004. Aquatic Species at Risk in the Thames River Watershed, Ontario. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 2707. Thames River Recovery Team. 2004. Recovery strategy for the Thames River

Table 2-1 Watershed Characterization Report Data Sources

Component	Data Source
	Aquatic Ecosystem: 2005-2010. December 2004 Draft. 145 pp. Natural Heritage Information Centre
Human Characterization	Statistics Canada. Censuses of Population, 1901-2001 and 1996-2006. Indian and Northern Affairs Canada website: http://ainc-inac.gc.ca Ontario Ministry of Finance Ontario Population Projections, 2006-2031. Municipality Official Plans. Ministry of Environment. June 1991. Waste Disposal Site Inventory. Census Canada. Ontario Ministry of Agriculture and Food and Agriculture.
Drinking Water Sources	Ministry of Environment Permit To Take Water (PTTW) database. Municipal Groundwater Studies. MOE.
Water Quality	Provincial Water Quality Monitoring Network. Provincial Groundwater Monitoring Network. Drinking Water Surveillance Program. Drinking Water Information System. Annual Drinking Water System Reports. Ministry of Environment Inspection reports. Water treatment plant laboratory data. Ambient Groundwater Chemistry Study of the Thames River and St. Clair Region Watersheds. Waterloo Hydrologic Incorporated, 2008.

2.3 Components of the Watershed Characterization Report

2.3.1. Watersheds and Subwatersheds

The source protection area (*SPA*) watershed boundary within the source protection region (SPR), as well as the subwatersheds within the *SPA*, are identified and described. The Thames watershed and region is comprised of the Lower Thames Valley Source Protection Area (*LTVSPA*) and the Upper Thames River Source Protection Area (*UTRSPA*). Map 1-1 in Appendix 1 illustrates the Thames-Sydenham and Region boundary and the Source Protetcion Area watershed boundaries within the Region.

The Lower Thames Valley Source Protection Area includes those lands draining into the Thames River from the community of Delaware to Lake St. Clair. It also includes the lands that drain into Lake Erie lying south of the lower Thames River subwatershed and a small triangle of land north of the mouth of the Thames draining directly into Lake St. Clair. The Lower Thames Valley Source Protection Area covers approximately 3,274 square kilometres.

2.3.2. Physical Geography

This component describes the location and types of natural vegetative cover, aquatic habitats, and species habitats within the source protection area that are on the Species at Risk in Ontario List. It also describes the history, structure and composition of the surface, just below the surface, and deep beneath the surface (geology). In addition, this component describes natural landscape features (physiography), soil types, and surface shape and features (topography). Water movement on the surface (surface hydrology), such as rainfall, and water movement below the ground (groundwater hydrogeology), and climate, including air temperature and flooding are also included. A few details are given below but do not provide a complete picture of the characterization. For accurate descriptions, refer to the Thames Watershed and Region Watershed Characterization Report (2008).

Geology, Physiography and Soil Types

Bedrock is the rock formation deep under the ground, over which lies the overburden rock formation. In the Lower Thames Valley Source Protection Area, the bedrock topography is slightly depressed in the Chatham area between Lake St. Clair and Lake Erie, and is commonly called the 'Chatham Sag'. The bedrock geology formations in this source protection area are mainly the Hamilton group (shale and limestone) and Kettle Point (organic rich shale with silty shale). The surficial geology (physiography) is influenced by the type and nature of overburden. Map 7 in Appendix 5 shows the Thames watershed physiography. In the Lower Thames Valley Source Protection Area, diamicton/till and silt dominate. Ridges of gravel are seen around the till moraine, near the communities of Ridgetown and Highgate. In the Lower Thames Valley Source Protection Area, 'silt & clay' type of soil is predominant (51%), with sand loams (24%) and 'silt & clay loams' (12%) following.

Topography, Hydrology and Hydrogeology

The lower portion of the Thames River consists of flat plains of clay and sand. Downstream of Chatham, the river is so shallowly entrenched below the old lake plain that dykes are constructed to control flooding of the adjacent lands. The ditches that drain the farmland in the Chatham area are often pumped to their outlets since there is limited flow by gravity over the flat terrain. In the lower portion of the Thames River, the flow is 60% surface runoff and 40% 'base flow'. Base flow includes contributions from groundwater, tile drains, flow augmentation from

reservoirs and treated sewage effluent discharge. An aquifer is a water bearing layer under the surface, which can be tapped by drilling groundwater wells. The depth of the bedrock aquifer to the surface is shown in Map 12 of Appendix 5.

Hydrology and climatic conditions are monitored locally by a combination of Environment Canada monitoring stations, including one at Chatham in the Lower Thames Valley Source Protection Area. From plotting 10 year running averages over the data years of 1950 to 2005, an increase in the precipitation linear trend line is seen at Chatham.

Natural Vegetative Cover

Wetlands make up 49.7 square kilometres or 1.5% of the LTVCA watershed area, as shown in Map 23b of Appendix 5. There are approximately 426 square kilometres of woodland/forest cover within the entire LTVCA watershed, equating to 13% of the total watershed, as shown in Map 25b of Appendix 5. Table 2-2 shows the distribution of wetland and woodlands in the *LTVSPA* subwatersheds.

Table 2-2 Distribution of Wetlands and Woodlands within the LTVSPA

LTVSPA Subwatershed	Area (sq km)	Wetland (sq km)	Wetland (%)	Woodland (sq km)	Woodland (%)
Thames River subwatershed	2,280	11.6	0.5	279.8	12.3
Lake St. Clair subwatershed	174	12.6	7.3	1.5	0.9
Lake Erie subwatershed	820	25.5	3.1	145.0	17.7
Entire LTVSPA Watershed	3,274	49.7	1.5	426.3	13

The area of land adjacent to streams is often called the riparian zone or buffer zone. Within the *LTVSPA* watershed, both urban and rural land uses have resulted in a loss of a vegetated riparian zone of forested, prairie habitat and wetland land forms. In some areas of the region, streams have been diverted, straightened and vegetation removed from the entire length and width of the channel. In the eastern part of the *LTVSPA,* there are many incised watercourses that cut through the higher elevation surrounding lands. These result in extensive riparian cover as these ravines are unsuited for urban or rural development. Thus, Elgin and Middlesex Counties have more stream corridor vegetation than Essex and Chatham-Kent. Also, both Elgin and Middlesex Counties have tree cutting bylaws, while Essex and Chatham-Kent have no

means of woodlot protection. From approximately Thamesville west to the mouth of the Thames River at Lake St. Clair, the drop in gradient is minimal as there is almost no slope. This low gradient has resulted in minimal buffers adjacent to stream systems as the land adjacent to the watercourses is more accessible. Channels that used to meander or form wetland pockets have been straightened to allow for straighter row-cropping and low areas drained and filled in for urban development. From historic records, it is known that very little to no riparian forest cover was present downstream of the City of Chatham.

The Rondeau Provincial Park and the St. Clair National Wildlife Area are two designated Significant Protected Areas. These areas are protected from developmental changes that could alter their natural characteristics.

Aquatic Ecology and Habitats

In the Thames Watershed & Region, the wide variety of habitats, favourable climate, nutrient-rich waters, and connection with the Great Lakes result in a particularly diverse aquatic community. The Thames River and its tributaries support one of the most diverse fish communities in Canada. Records exist for approximately 94 fish species in the Thames River subwatershed, which represents more than half of all of Ontario's 165 species. Table A5-1 (Appendix 5 Addendum) lists the fish species recorded in the Thames River subwatershed. There have been 39 fish species found in the Lake St. Clair tributaries and 57 species in the Lake Erie tributaries of the *LTVSPA* watershed. Table A5-2 (Appendix 5 Addendum) lists the fish species in the Lake Erie Tributaries of the Lower Thames Valley *SPA*, while Table A5-3 (Appendix 5 Addendum) lists the fish species in the Lake St. Clair Tributaries of the Lower Thames Valley *SPA*. Table A5-4 (Appendix 5 Addendum) lists the mussel species found in the Thames River.

Aquatic invertebrates, especially the benthic macroinvertebrates (BMI) that inhabit watercourse substrates, are abundant in all Thames reaches and tributaries. BMI communities consist of insect larvae, aquatic worms, crustaceans, and many other species. Most have fairly well known tolerances to pollution and disturbance. Table A5-5 (Appendix 5 Addendum) lists the benthic species commonly found in the Thames River and tributaries.

Introduced fish species found in the Thames such as the common carp and round goby are considered invasive species. In the Great Lakes, native freshwater mussel populations have been decimated by zebra mussels (from certain water bodies in Asia).

In the Lower Thames Valley Source Protection Area (*LTVSPA*), there are approximately 1,950 drainage works constructed under the Drainage Act of Ontario. In order to classify these drains, the Authority undertook approximately 850 habitat assessments on these drains, temperature assessments at a total of 45 sites and fish sampling at 36 locations. There are 328 warm water, one cold water and 513 intermittent habitat classifications. 36 of those assessments suggested that further information regarding fisheries was required. 19 of the 36 sites sampled for fish were found to provide suitable habitat and water quality for sensitive species. Table 2-3 lists the fish sampling results of the 36 sites sampled in the *LTVSPA*. Map 26 of Appendix 2 shows the fish sampling locations. Table 2-4 shows the results of the habitat and temperature assessments.

Table 2-3 Fish Sampling Results from Drain Classification Project in the LTVSPA

1 site with a salmonid present (Rainbow Trout)
11 sites with top-level predators (Northern Pike, Smallmouth Bass, Largemouth Bass, Yellow Perch) or top-level predator indicator species (Rock Bass, White Crappie)
23 sites with baitfish only
1 site with no fish present

Table 2-4 Habitat and Temperature Assessments in the Lower Thames Valley SPA

Municipality	Township	Permanent Flow	Intermittent Flow	Cold water	Warm water
Chatham-Kent	Camden	7	2	0	9
	Chatham	10	5	0	15
	Dover	28	14	0	42
	Harwich	25	110	0	135
	Howard	31	65	0	96
	Orford	33	27	0	60
	Raleigh	38	44	0	82
	Romney	0	8	0	8
	Tilbury East	15	47	0	62
	Zone	7	17	0	24
Dutton/Dunwich	Dunwich	39	24	0	63

Table 2-4 Habitat and Temperature Assessments in the Lower Thames Valley SPA

Lakeshore	Tilbury North	6	16	0	22
	Tilbury West	5	13	0	18
Leamington	Mersea	0	12	0	12
London-Middlesex Centre	Delaware	1	5	0	6
	Westminster	0	2	0	2
Southwest Middlesex	Ekfrid	10	33	0	43
	Mosa	7	24	0	31
Southwold	Southwold	12	11	0	23
Strathroy-Caradoc	Caradoc	2	14	0	16
West Elgin	Aldborough	52	19	1	71

Currently, 13 of the 94 fish species found throughout the Thames River subwatershed are considered Species At Risk (*SAR*), under the Species at Risk Act. In the Thames River subwatershed, there are 27 aquatic species with SAR status. Lake Erie and the many tributaries that flow into it have approximately 19 species of fish, 6 species of freshwater mussels and 13 species of reptiles and amphibians listed. Map 29 of Appendix 5 shows the number and locations of SAR in the Thames watershed. Table A5-6 (Appendix 5 Addendum) lists the aquatic and semi-aquatic *SAR* in the Thames River subwatershed (May 2010), and Table A5-7 (Appendix 5 Addendum) lists the aquatic *SAR* in the Lake Erie Tributary subwatershed.

The Watershed Characterization Report also discusses the impacts human activities have had on aquatic ecology. The Thames River is situated in a highly developed part of southern Ontario. The aquatic community faces many pressures from urban and rural land uses and human activities. Most of the watercourses have been greatly altered by human influences. On larger watercourses, many of the influences accrue from urban development, including channel alteration, bank hardening, storm water runoff, and sewage effluent input. Rural influences often involve smaller watercourses where habitat changes and alterations such as drains and channelization are aimed at improving agricultural operations. In general, species that prefer clear, fast flowing water are declining (Thames River subwatershed Species at Risk data from Cudmore, B., C. A MacKinnon and S. E. Madzia. Dec. 2004. Aquatic Species at Risk in the Thames River Watershed, Ontario. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 2707).

Intermittent drain systems actually provide a significant function to the watershed. They provide fish habitat when wet and, in many cases, significant spawning areas during spring flooding. In recent years, many of these intermittent watercourses have been converted to closed systems. The trend to close drain systems has altered the hydrograph, hydrologic regime and fluvial dynamics of the receiving watercourses and has led to an increase in erosion in downstream watercourses. Changes such as cobble being removed from the channels and the lack of pool riffles result in aquatic communities limited to hardy warm water species.

From Delaware to the Thamesville area and on to near Chatham, the main Thames is characterized by somewhat turbid and very stable flows. Occasional shallower stretches are critical areas for the survival of significant freshwater mussel populations. These areas are also important fish feeding and spawning areas. This portion of the river supported a large but declining run of walleye and was once home for all six endangered freshwater mussel species recorded in the Thames. It is also the location of the only two Canadian records for the extirpated gravel chub. Species At Risk that are still present in this area include the endangered northern madtom and the threatened eastern sand darter. The last stretch of the Thames flowing from Chatham to Lake St. Clair supports a fish community adapted to slow flowing, turbid waters. It is an important travel conduit between Lake St. Clair and upstream spawning habitat and some migratory aquatic species travel to the Thames from Lake Huron and Lake Erie.

According to the Chatham District Fisheries Management Plan 1987-2000 (Ministry of Natural Resources, 1990),

- In Chatham district, habitat degradation occurs in a number of ways. High intensity agricultural land use practices have severely degraded most inland fisheries habitat and water quality to a point where the cost of rehabilitation is potentially very high and involves application of soil conservation and review of drainage procedures across whole watersheds. These types of agricultural practices coupled with industrial and other municipal pollution sources along the Great Lakes waterways within the district continues to threaten water quality and fish habitat when effluent disposal is conducted contrary to existing legislation.
- Great Lakes shoreline marshes and inshore fish habitats have been reduced by the

combined impacts of poor water quality, inflows from inland subwatersheds, high water levels, dyking and developments along shorelines.

In 1986, Holm and Crossman completed a study comparing current (1985) information to historic surveys from the 1920s and 1940s. They identified water quality and fish habitat as conditions that had deteriorated significantly in the Thames River. They noted that turbidity and siltation had increased, and that stream flow rates had changed as a result of habitat disruptions such as impoundments. They also indicated a decline of species with a preference for clear, fast water and an increase in abundance of species more tolerant of turbidity.

The watershed characterization report discusses the interaction between human and physical geography. Gravel and sand deposit extraction takes place at Pinehurst in the community of Harwich, near Cedar Springs, again in the Community of Harwich and in the hamlet of Clachan. There are a few other isolated areas near the Thames River east of Thamesville in the Bothwell Sand Plain where extraction takes place. Chatham-Kent has the largest component of brownfield lands within the lower Thames watershed. The municipality is actively seeking alternative uses for the buildings and lands, i.e. multiple users within an existing building, until a more permanent solution can be achieved.

In Chatham-Kent, the Brownfield Strategy and Community Improvement Plans (*CIP*) cover the entire Municipality, not just older industrial areas. The Strategy and CIP need to address several communities that exist within the broader community since the Municipality of Chatham-Kent was created from the amalgamation of a number of municipalities (both urban and rural). The Strategy and CIP address brownfields that result from urban activity, as do most municipal strategies, and also address brownfields that are a legacy of agriculture and agi-business.

Southwestern Ontario has a long history related to the oil and gas industry. Map 31 of Appendix 5 shows the concentration of oil and gas wells across the area. The oil field in Bothwell was one of the earliest fields in North America. The gas field near Port Alma was so prolific that at one point it provided natural gas to the Cities of Windsor, Chatham and London. It also provided the base for the incorporation of the Union Gas Company, whose head office is still in Chatham. Chatham-Kent remains the second largest producer of oil and gas in Ontario. Two of the largest

oil pools in Ontario are located partially in the community of Romney, with other oil production taking place in the community of Dover. There is also some natural gas production in Lake Erie, with a natural gas field in Lake Erie of sufficient size to support a natural gas processing plant near Morpeth.

While the Thames River is quite deep (approximately 6 metres) from Chatham to the river mouth, the generally shallow eastern basin of Lake St. Clair as well as the naturally formed 'sandbar' at the mouth of the river prohibits the river's use for commercial boat traffic. For this reason the Thames River itself, while it has had a long history of being used as a commercial transportation route, is no longer capable of being economic. The only commercial shipping in the region is now based out of Erieau on Lake Erie. The primary commercial purpose of the harbour is as a fishing port and charter fishing destination. The recent past has seen the shipping of sand and gravel to the dock. Recreational boating takes place from many centres on Lake St. Clair and Lake Erie with the primary areas being Lighthouse Cove, Chatham, Wheatley, Erieau, Rondeau Bay and Port Glasgow. The Thames, although not navigable for large craft, still provides a picturesque locale for recreational boating, canoeing, rowing, and kayaking.

Due to a number of factors, including moderate temperatures, adequate rainfall, adequate growing season and good soil, the major land use in the region is agricultural and, more specifically, cash crop land. Farmland makes up over 80% of the land use in the region. Also, most of this farmland is used in the raising of field crops. Soybeans, corn and wheat are the three main crops. Most of the soybeans and corn are sold for commercial use. Other significant crops include tomatoes, sweet corn, peas, and other vegetables or fruits grown for sale to the consumer or the food processing industry. In Essex and other areas of the region, extensive greenhouse operations grow a variety of vegetables. Another major component of the agricultural industry in Ontario is the raising of livestock. Hog and poultry production is cost-efficient due to the reliable supply of locally-grown feed grain. Over the last 40 years, a significant trend in the agriculture industry has been the conversion from a mixed land use (livestock pasture and crop cultivation) to crop cultivation land use. Notably, the land area used in the production of soybeans has increased dramatically in the last 40 years. The other major field crop is corn and the land area used in the production of corn has only slightly increased.

Therefore, the land area used for producing soybeans has resulted in significant reductions in the production of wheat, oats, dry beans and hay.

There are 24 private and municipal/conservation authority campgrounds in the Lower Thames Valley Source Protection Area. There are numerous public and private golf courses located throughout the Thames Watershed & Region including several that incorporate lands (flood plains) adjacent to local watercourses. Chatham-Kent is host to 11,500 hectares of provincially significant wetlands along Lake St. Clair, including the St. Clair National Wildlife Area, which is a globally important bird area. As mentioned earlier, the St. Clair National Wildlife Area and the Rondeau Provincial Park are two Significant Protected Areas in the *LTVSPA*.

2.3.3. Human Geography

The current population and estimated growth rate in each municipality are presented. First Nation reserves populations are also provided. The Lower Thames Valley Source Protection Area (*LTVSPA*) includes most of the municipality of Chatham-Kent, the western portion of Elgin County, part of southwestern Middlesex County (including some of the City of London) and a portion of eastern Essex County. The area covers approximately 3,274 square kilometres with a total watershed population (2001) of about 107,000. Five First Nations are in the Lower Thames Valley Source Protection Area watershed, of which four have reserves.

Types of settlements (urban and rural centres) and land use (such as agricultural, residential and industrial) across the watershed are discussed. Map 1-4 of Appendix 1 shows the Areas of Settlement (as per the Places to Grow Act, 2005) in the Lower Thames Valley Source Protection Area. The largest urban centre within the Lower Thames Valley Source Protection Area is the former City of Chatham, with an approximate population of 44,000 in 2001, now a part of the Municipality of Chatham-Kent. Table 2-5 shows the population by municipality, for the years 2006, 2001 and 1996. Table 2-6 shows the population of the First Nations reserves in the *LTVSPA*. Map 2-1 in Appendix 1 shows the population density across the Lower Thames Valley watershed. Growth rate projections for municipalities in the *LTVSPA* are discussed in the Watershed Characterization Report.

Table 2-5 Population Density of Municipalities in the Lower Thames Valley SPA Watershed

Census Division	2006 Population	2001 Population	1996 Population	1996 to 2001 Population Change	2001 to 2006 Population Change
Middlesex (incl. City of London)	422,333	403,165	389,616	3.50%	4.70%
Elgin	85,351	81,553	79,159	3.00%	4.70%
Chatham-Kent	108,589	107,709	109,350	-1.50%	0.80%
Essex (incl. City of Windsor)	393,402	374,975	350,329	7.00%	4.90%

Table 2-6 First Nations in the Lower Thames Valley SPA and their Populations (Data from Indian and Northern Affairs Canada website: http://ainc-inac.gc.ca)

First Nation	Number of Registered Males and Females on Own Reserve (December 2009)
Chippewas of the Thames First Nation	896
Delaware First Nation	237
Munsee-Delaware First Nation	154
Oneida Nation of the Thames	Unknown
Caldwell First Nation	2

Map 30 of Appendix 5 shows the generalized land cover in the Thames Watershed & Region. Agriculture is the dominant land use, but a wide variety of industrial, commercial and institutional land uses also provide employment for people. Chatham-Kent has developed a strong industrial land base due to its proximity to Highway 401 and other major urban centres in Ontario and the United States. General locations of federal lands in and around the Lower Thames Valley Source Protection Area are shown in Figure 2-1. The Figure was generated using an on-line tool available at the Treasury Board of Canada Secretariat website (http://www.tbs-sct.gc.ca/dfrp-rbif/home-accueil.asp?Language=EN), map navigator page.

Figure 2-1 Federal Lands in and around the Lower Thames Valley SPA

2.3.4. Water Quality

This component describes the water quality across the *SPA*. The selection of indicator substances (parameters) is discussed. The watershed inland surface water, the ambient groundwater, municipal well raw (untreated) water, and the municipal surface water intake raw water quality data is reviewed and assessed using certain standards or guidelines. Where possible, trend lines are shown and statistical analyses performed.

Both drinking water quality standards and aquatic protection guidelines are used to assess water quality. The comparison is only intended to provide a means of quality assessment by using an established value and is not intended to judge conformance of raw (untreated) water to the standards or guidelines. The operation of a water treatment plant, including treated and distributed water quality, is governed separately under the Safe Drinking Water Act.

To evaluate inland surface water quality, data from eight surface water quality monitoring stations across the Lower Thames Valley Source Protection Area were reviewed for certain parameters. These stations are monitored under the Provincial Water Quality Monitoring

Network (*PWQMN*) program. In general, phosphorus and nitrate levels are higher than the respective established guideline (0.03 mg/L-phosphorus) and standard (10 mg/L-nitrate). Chloride levels at all stations in the Lower Thames Valley Source Protection Area are lower than the standard (250 mg/L) and the guideline (210 mg/L). A review of data for *Escherichia coli (E. coli)*, a bacterial indicator, shows that the indicator is consistently above the recreational use guideline (100 counts per 100 mL) at most of the monitoring stations. Copper and zinc levels are lower than the guidelines at all stations. A review of lead levels indicates that lead is higher than the standard (0.01 mg/L) at some stations, but below the standard at all stations since 2000.

To evaluate the groundwater quality, data from 12 groundwater monitoring wells across the Lower Thames Valley Source Protection Area were reviewed. The monitoring is part of the Provincial Groundwater Monitoring Network (*PGMN*) program. The sodium and chloride levels in the *aquifers* of the Lower Thames Valley Source Protection Area are naturally high. There are a few parameters above the provincial drinking water standards (provided in brackets) in the untreated well water: fluoride (1.5 mg/L), sodium (200 mg/L), chloride (250 mg/L), hardness (80 to 100 mg/L), total dissolved solids (500 mg/L), iron (0.3 mg/L), manganese (0.05 mg/L), lead - one instance (0.01 mg/L), barium - one instance (1 mg/L), alkalinity – one instance (30 to 500 mg/L) and zinc - one instance (5 mg/L).

In the Lower Thames Valley Source Protection Area, there are two municipal groundwater and three surface water drinking water systems. Data used to evaluate water quality of raw water to the drinking water systems were: Drinking Water Surveillance Program (*DWSP*), Drinking Water Information System (*DWIS*), Annual Drinking Water System Reports, Ministry of Environment, Conservation and Parks Inspection reports and minimal water treatment plant laboratory data. Similar to the findings of the groundwater monitoring data review, fluoride and sodium in raw (untreated) municipal well water are higher than the drinking water standard. Bacterial indicator total coliform is present in the wells of both groundwater systems, but *E. coli* is not present.

Raw water data available was reviewed for the Lake Erie municipal intakes at West Lorne, Erie Beach and Wheatley Harbour. The review indicates the presence of phosphorus above aquatic health guidelines (0.03 mg/L), and aluminum, turbidity and hardness above the respective

standards at the Erie beach intake. A lack of comprehensive chemical parameter data for the Wheatley and West Lorne intakes does not allow for a thorough/detailed review. Total coliform and *E. coli* are found at all intakes as is typical of surface water sources.

2.3.5. Water Quantity

In this component, the water use across the Source Protection Area is discussed. Section 34 of the Ontario Water Resources Act (*OWRA*) requires anyone taking more than a total of 50,000 litres of water per day to acquire a Permit To Take Water (*PTTW*). Water taking includes uses which return the water to the source, as well as those which do not. Water taking also includes taking water into storage. In Section 3 – Water Budget and Water Quantity Stress Assessment water use is considered in more detail, including quantifying how much of the water taking is consumptive.

Water takers have a responsibility to ensure that the amount of water they use does not threaten the environment or existing water users. Some water takings are exempt from the requirement to obtain a permit. These include takings by an individual for ordinary household purposes, and water takings for the direct watering of livestock or poultry or for firefighting purposes. The approximate water taking (use) by sector (agricultural, commercial, industrial, municipal, water supply, dewatering, remediation, construction) is presented and described. The water taking for each subwatershed catchment area is also presented. These catchment areas are delineated through the Conceptual Water Budget study, which is described in a Section 3 – Water Budget and Water Quantity Stress Assessment.

In the Thames watershed and region, while the agricultural sector has around 33% of the total permits, the percent of total maximum volume permitted is only 5%. This difference probably reflects the seasonal nature of the water taking associated with crop irrigation. Water supply makes up about 24% of the water taking permits, and includes takings by municipalities, campgrounds and communal uses.

2.3.6. Drinking Water Systems

There are eight municipal drinking water systems which service people living in the Lower Thames Valley *SPA* of which two are located outside the *SPA*. The drinking water supply systems servicing the Lower Thames Valley *SPA* are shown in Map 1-3 of Appendix 1. Details are provided in Table 2-7. The 5 municipal drinking water systems located within this *SPA* are included in the Lower Thames Valley Source Protection Area Terms of Reference document, and therefore in this Assessment Report. These are the Chatham, South Chatham-Kent, Wheatley, West Elgin and Ridgetown water treatment plants.

There are also three groundwater supply systems that service First Nations in the *SPA* which have not been assessed as part of the Lower Thames Valley Source Protection Area Assessment Report. For First Nations' drinking water sources to be included in the Terms of Reference, and therefore the Assessment Report and Source Protection Plan, a regulation must be passed. The Director (MECP) must receive a resolution of the band council requesting the First Nation's system be included in source protection planning. This is yet to happen in the Lower Thames Valley *SPA*. As a result no assessment of First Nations' drinking water sources is included in this Assessment Report.

Table 2-7 Municipal Drinking Water Systems Serving the Lower Thames Valley Source Protection Area

Drinking Water System	Source Water	Operating Authority	Approx. Popula-tion Served	Pumping Rates (cubic meter per day)			
				Intake or Well	Maximum Annual	Average Annual	Average Monthly
Chatham*	Lake Erie	Municipality of Chatham-Kent Public Utilities Commission (PUC)	47,815	Primary Intake	11,553,858	11,117,375	926,447
South Chatham-Kent*	Lake Erie	Municipality of Chatham-Kent PUC	12,108	Primary Intake	2,488,410	2,352,900	196,075
West Elgin**	Lake Erie	Ontario Clean Water Agency	13,680	Primary Intake	1,554,191	1,434,038	119,503
Wheatley **	Lake Erie	Municipality of Chatham-Kent PUC	10,700	Primary Intake	3,048,280	2,920,668	243,389

Ridgetown	Ground-water	Municipality of Chatham-Kent PUC	3400	Well #1	36,305	34,230	2,853
				Well #2	148,643	139,364	11,614
				Well #3	244,292	225,228	18,769
				Well #4	19,091	17,219	1,435
				Well #5	27,338	25,181	2,098
				Well #6	108,188	102,449	8,537
Union***	Lake Erie						
Stoney Point***	Lake St. Clair						
*These systems share one intake **These systems also have an emergency intake each **Located outside of Lower Thames Valley Source Protection Area and therefore not included in this Assessment Report; see the Essex Region Source Protection Area Assessment Report for information							

The drinking water systems included in this Assessment Report are briefly described below.

The Chatham and South Chatham-Kent water treatment plants share one intake which is located at Erie beach on Lake Erie. The Chatham water treatment plant serves the areas of Chatham, Pain Court, Grande Pointe, Mitchell's Bay, Dresden, Tupperville and Thamesville. The South Chatham-Kent water treatment plant serves the areas of Southern Chatham, Blenheim, Charing Cross, Erie Beach, Merlin, Port Alma, Rondeau Bay Estates, Shrewsbury, and South Buxton.

The Wheatley water treatment plant has two intakes, a primary and an emergency, located at Wheatley Harbour in Lake Erie. The Wheatley water treatment plant serves the areas of Wheatley, Tilbury, part of Lakeshore, part of Mersea Township, part of Romney and Wheatley Provincial Park.

The West Elgin water treatment plant also has two intakes, a primary and an emergency, located at West Lorne in Lake Erie. The West Elgin water treatment plant serves the areas of West Elgin, Dutton /Dunwich, Southwest Middlesex, Bohwell and Newbury.

A primary intake is located away from shore and is used regularly except in certain situations or conditions. These primary intakes may be subject to freezing, resulting in the build-up of frazzle ice (crystallized but fluid ice, like runny slush) around the intakes, reducing their capacity or completely blocking them. The emergency intakes can be used during periods of frazzle ice

conditions, and maintenance or repair when the primary intake is closed.

In the Lower Thames Valley Source Protection Area, there is also one groundwater well supply system at Ridgetown (6 pumping wells, 2 standby wells and 1 monitoring well). It serves the communities of Ridgetown and Highgate.

2.4 Data Gaps

The Data gaps encountered during the preparation of the watershed characterization report are listed in Table 2-8 below.

Table 2-8: Watershed Characterization Data Gaps relevant to the Lower Thames Valley Source Protection Area

Subject	Data Gaps
Aquatic Ecology	
Fisheries Evaluation	Cold water refuges in natural water systems, fish sampling data from DFO and OMNR Lake Erie Management Unit needs to be incorporated into database, historic evidence of cold water streams has not been investigated, application of indices such as the Index of Biological Integrity (IBI) to existing fish data.
Aquatic Macroinvertebrates - Habitat Conditions & Water Quality	Simpson's Diversity Index should also be considered, Analysis of physiography & land use to identify potential communities and groundwater quality/quantity stressors and impacts.
Reptile - Survival habitat and population dynamics	Lack of data for Lower Thames Valley CA watershed; extent , abundance and population demographics of prey (needed for some species); lack of species information, habitat identification, seasonal dispersal, population isolation, reproductive success, past distribution.
Species At Risk - Range and numbers of fish species at risk	Sections of the Thames River have little or no sampling (especially Lower Thames Valley Source Protection Area sections), population, abundance, distribution or status unknown for some species.
Water Quality	
Inland surface water quality - physical, chemical and microbial	Data from 1997 to 2001 from the commonly used provincial water quality monitoring network (PWQMN) dataset does not exist.
Additional sources of information	COA, Health Unit, sediment analysis and Research data have not been reviewed.
Municipal Intakes surface raw water quality - physical and chemical	Commonly used Drinking Water Surveillance Program (DWSP) data for West Elgin and Wheatley water treatment plants does not exist.
Municipal Intakes surface raw water quality - microbial	Commonly used Drinking Water Information System (DWIS) microbial indicator data (E. coli and total coliform) for Wheatley water treatment plant is missing.

Table 2-8: Watershed Characterization Data Gaps relevant to the Lower Thames Valley Source Protection Area

Subject	Data Gaps
Inland and intakes surface water and groundwater quality – emerging pollutants	Not enough data on emerging contaminants (fire retardants, pharmaceuticals, algae toxins, etc.).
Groundwater monitoring well data	Data in the commonly used provincial groundwater monitoring network (PGMN) dataset only goes back to 2003.
Municipal groundwater well physical and chemical data	Comprehensive data not available; alternate sources of data used.
Wildlife impact on water quality	Locations of large populations of wildlife and the resulting effect on water quality (pathogen contamination and nutrient loading) require a better understanding.
Water Quantity	
Permit To Take Water Data	Data out of date - Many permits in database have expired dates and it is unclear if they have been renewed.
Water uses	Data Incomplete - Older permits only have maximum water taking per day. Difficult to determine actual usage.

3.0 Water Budget and Water Quantity Stress Assessment

The Clean Water Act is intended to reduce the threats to the quality and quantity of drinking water sources. In order to do this, threats within *vulnerable areas* are identified and assessed to determine the relative *risk* to the drinking water source. The Clean Water Act and its regulations identify 21 activities which can be drinking water *threats*. These activities include two which are related to the quantity of drinking water. One is 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. The other water quantity threat is an *activity* that reduces the recharge of an aquifer. To determine the risks to drinking water quantity from either of these threats, it is necessary to understand the level of *stress* on a drinking water system's source. The Water Budget is the tool used to understand the level of *stress* on a system or within a *watershed*.

Where there is little potential for *stress*, there are no *threats*. On the other hand, where there is a significant potential for *stress*, activities contributing to the *stress* will be significant threats. The Clean Water Act requires that the *Source Protection Committee* develop a *Source Protection Plan* that reduces the *risk* associated with *significant threats* so that they cease being significant and prevents new *significant threats* from being undertaken in these areas.

The Water Budget looks at the balance of water within an area known as a *watershed*. A Water Budget can be assessed at different scales, but generally this is undertaken on a *watershed* or parts of the *watershed* refered to as a *subwatershed*. It considers inputs or supply to the *watershed* or *subwatershed* which include: precipitation (rain and snow), flow into the watershed from up river, flow into the watershed through groundwater and flow imported into the watershed such as that which is piped water from the Great Lakes. The Water Budget balances these inputs with removals from the *watershed*, or *demand*, which include: discharges into the next *watershed* through stream flow or groundwater, use of water which is consumptive in nature (and therefore does not return the water to the same source from which it was removed), evaporation and transpiration (use of the water by plants). The water budget considers a balance between supply and *demand* that includes a *reserve* quantity that is removed from the supply in the stress calculation. The components of the water budget are described in detail in

the Conceptual Water Budget (attached as Appendix 6), the Tier 1 Water Budget and summarized in the following sections.

The Water Budget is developed in stages referred to as tiers. These tiers involve more detailed analysis and refined data as they progress. In this manner, only those areas with the potential to be stressed require detailed modelling and analysis; those which appear not to be stressed receive a less detailed screening. Each of these tiers is described in the following sections. *The Lower Thames Valley Source Protection Area* is included with the other Source Protection Areas in the Thames-Sydenham and Region in the Conceptual Water Budget and the Tier 1 Water Budget. Only areas where there is a moderate or significant *potential for stress* on drinking water systems included in the Terms of Reference (only municipal systems in the *LTVSPA*) proceed to a Tier 2 Water Budget. Only those areas which are confirmed to have a significant or moderate stress level in the tier 2 assessment proceed with a Tier 3 Water Budget. It is only through a Tier 3 Water Budget that water quantity threats are assessed. As the potential for *stress* on drinking water sources was determined to be low through the Tier 1 Water Budget, a Tier 2 or Tier 3 Water Budget is not required for the Lower Thames Valley Source Protection Area. As a result, there are no water quantity *threats* to drinking water sources in the Lower Thames Valley Source Protection Area.

3.1 What is a Water Budget?

A water budget quantifies and compares the components of the hydrologic cycle. Much like a bank account, if more water is leaving than is entering, the water in the *watershed* will be depleted over time. If in balance, the water use is sustainable. Each component of the water budget must be quantified so that the *demand* can be compared to the supply. If the *demand* is greater than the supply, the reserves, like the savings in a bank account, will be depleted. Over time this would result in reduced water levels in water bodies and aquifers. Normal and cyclical fluctuations in water level make it necessary to look at the components of the water budget over long periods of time rather than looking at short-term trends in levels. This is especially true in groundwater systems where changes in water levels are more difficult to monitor and analyze.

3.2 Components of the Water Budget

3.2.1. Precipitation

Precipitation, or rain and snow, is the primary component of the supply component of the water budget. Long-term precipitation was analyzed from various meteorological stations around the region. Map 3-2 illustrates the precipitation stations used in the water budget and the spatial variation of the average annual precipitation over the region. Annual average precipitation decreases moving east to west along the LTVSPA from about 950 mm/a at the extreme east to about 850 mm/a at the extreme west. On average, the Lower Thames Valley Source Protection Area receives 900 mm per year of precipitation.

3.2.2. Evapotranspiration

Evapotranspiration (or ET) is the precipitation which either evaporates into the atmosphere or is used by the plants. Water used by plants is also given back to the atmosphere through a process known as transpiration. Together the evaporation and transpiration are known as Evapotranspiration. There is little variation across the region other than as a result of the variation in precipitation. Map 3-3 shows the evapotranspiration across the region. Water which evaporates or is used by the plants is not available as supply and is therefore subtracted from the precipitation in the supply calculations. ET accounts for more than half of the precipitation in the region.

Irrigation, although also used by plants and lost back to the atmosphere through evaporation and transpiration, is considered in the *demand* part of the water budget. Irrigation water is removed from a groundwater or surface water source, and is consumptive to that source. ET, on the other hand, is loss from the precipitation component of the water budget. Another important distinction is that irrigation occurs only in very localized areas where it is required by a crop. ET is directly related to precipitation, temperature and is fairly uniformly distributed across the watershed.

3.2.3. Surface Runoff

Precipitation which falls in the watershed and does not evaporate or get absorbed into the plants either infiltrates into the ground or runs off into streams and rivers. The runoff from the

watershed is not available for the supply as it leaves the watershed quickly. Although some of the water which infiltrates into the ground also leaves the watershed relatively quickly, most of the water which seeps deeper into the ground is said to recharge the aquifers which is discussed in the following section.

3.2.4. Recharge

Recharge is the water from precipitation which soaks into the ground and recharges the aquifers in the ground. This is the water which maintains stream flow during periods between runoff events and is referred to as base flow. The water budget assumes that over time the recharge is equivalent to the base flow discharge from the watershed. This relationship is considered more closely in Tier 2 and 3 of the water budget work where calibrated surface and groundwater models are used to describe the components of the water budget including recharge. In the absence of these calibrated models, the average base flow from a watershed is the best indication of the recharge in the watershed.

In order to establish the recharge in a subwatershed the stream flow records are reviewed and runoff is removed from the records to calculate the base flow. Various methods can be used to separate base flow from runoff. In the Tier 1 Water Budget the second pass of the BFLOW filter was applied. This is a method which was developed by Arnold et. al. (1995) and is well accepted in this area. The effects of low flow augmentation reservoirs in the Upper Thames River Source Protection Area, as well as pollution control plant discharges, are taken into account in separating the base flow. This prevents recharge estimates derived from base flow estimation from being artificially elevated from that of natural conditions. In areas where stream flow information was not available, records from a nearby stream flow station (where hydrologic conditions are similar) were used to estimate base flow for the un-gauged *subwatershed*. Monitoring programs in these areas would improve base flow estimates in these *subwatersheds*. However, as with any monitoring program, they must be established sufficiently in advance of undertaking the work to have collected sufficient data for meaningful analysis. This should be considered for future updates to the water budget.

Once base flow was determined for each subwatershed being analyzed, the base flow was distributed across the subwatershed using an infiltration model developed by Ministry of Environment and Energy (MOEE, 1995). This method uses soil type, slope and land use to

calculate the infiltration factors across the watershed.

In the Tier 2 Water Budget for the Upper Thames River Source Protection Area, recharge is calculated using surface water and groundwater models. These models use surficial geology and land use characterized in hydrologic response units. Following the completion of the Tier 2 Water Budget for the Upper Thames River Source Protection Area, the MECP method was reapplied to the Lower Thames Valley and St Clair Region Source Protection Areas where detailed computer models are not available. The county soils maps used in the Tier 1 analysis are completed to different levels of detail in different counties, and some have been updated more recently than others. As such, there can be discontinuities across county boundaries, and, as they were created mainly for agricultural purposes, they were not completed in urban areas. Surficial geology mapping has the advantage of being continuous across the study area, and includes urban areas, In reapplying the MECP method, surficial geology was used in place of soils for constancy with the more detailed work undertaken in the Tier 2 Water Budget to provide an improved representation of recharge.

3.2.5. Water Use (Demand)

Water use in the water balance and stress calculations is referred to as *Demand*. While *demand* would be the simplest of the terms to monitor, records of water use are not required, except where permits for the use are required. Water use of more than 50,000 L/day, other than domestic and livestock watering, requires a Permit to Take Water, however until recently, records of water used were not required to be recorded and submitted. Even where the records are required as part of the permit process, they have only been required for the past few years. This recent record keeping is undertaken by the permit holder with little or no quality control on the data entered. This information is submitted by the permit holder and has only become available to the water budget team near the completion of much of this water budget work. In future revisions to the water budget the actual use records will provide a better estimate of the *demand*. For the Tier 1 Water Budget, estimations of actual use were based on adjusted maximum permitted values, or other sources of estimation in some cases. Large water users were polled to provide a better estimate of water *demand*.

Estimates of water use not requiring a permit to take water (often referred to as *non-permitted* water use) were also included in the calculations of *demand*. While municipal systems require a

permit to take water and records of this *demand* is well established through municipal pumping records, an estimate of the water used from private water systems is also required. Generally, this *demand* is minor; however it is important that it not be neglected in the water budget and stress assessment. Non-municipal system domestic *demand* is estimated based on per capita consumption estimations multiplied by population reported in census data.

Livestock watering also does not require a permit. This *demand* was estimated in a similar manner using livestock census data and typical water use by livestock type (Kreutzwiser & de Loë, 1999).

Both of these non-permitted uses are assumed to be distributed evenly across groundwater and surface water sources.

The Permit to Take Water information was analyzed to determine the *demand* in each *subwatershed* and combined with the *non-permitted demand* discussed above. Water use was considered separately for surface water and groundwater as required by the *Technical Rules 2013: Assessment Reports*. Consumptive factors were applied to the surface water *demand* based on the use of the water taken. These factors were recommended by the province in the water budget guidance. The consumptive factors applied to water use are shown in the Tier 1 Water Budget. Consumptive factors were generally not applied to groundwater use as water removed from aquifers is generally not returned to the same aquifers. Groundwater is usually returned to surface water bodies after it is used, resulting in the use being completely consumptive. Water taken for aggregate washing and wildlife conservation are exceptions where consumptive factors were applied. In these cases, permits allow for large quantities to initially fill ponds, but then only a small amount is taken to compensate for evaporation and/or water removed in product in the case of aggregate extraction.

Irrigation *demand* is estimated based on permitted values. As discussed in the section on evapotranspiration, most of the water applied to crops is used by the crops or evaporates back into the atmosphere. This is even truer for irrigation where the amount of water applied is intended to saturate the root zone and not result in any significant runoff or recharge. As such, the consumptive factors for irrigation reflect that little, if any, water is returned to the source from

which it was taken.

Table 3-1 summarizes the water *demand* in the area by type and source. It is important to realize that water use by industry and institutions supplied by municipal systems does not require a separate permit and is therefore included in the permitted values for the municipal system.

Table 3-1 Water demand in the LTVSPA (m3/day)

Groundwater Use	SW Code	Agricultural	Commercial	Construction	Dewatering	Industrial	Institutional	Miscellaneous	Recreational	Remediation	Water Supply	Non-Permitted	**total**
Thames R. between the Forks and Dutton*	11T*	3439	2423	0	0	720	0	0	0	0	1755	2002	**10339**
Central Thames	12T	692	0	0	0	68	0	286	0	0	274	1186	**2506**
Indian-McGregor Creek Area	13T	64	307	0	0	0	0	0	0	0	1544	1716	**3631**
Southwest Thames	14T	460	181	0	0	0	0	0	0	0	0	1471	**2112**
Lake St. Clair	15T	0	0	0	0	0	0	0	0	0	0	756	**756**
Talbot Creek Area	16T	0	0	0	0	0	0	0	0	0	0	307	**307**
Rondeau Bay	17T	0	0	0	0	0	0	0	0	0	42	463	**505**
Central Lake Erie	18T	286	0	0	0	0	0	339	0	0	0	874	**1499**
Total		**4941**	**2911**	**0**	**0**	**788**	**0**	**625**	**0**	**0**	**3615**	**8775**	**21655**

Surface Water Use	SW Code	Agricultural	Commercial	Construction	Industrial	Miscellaneous	Recreational	Water Supply	Non-Permitted	**Total**
Thames R. between the Forks and Dutton*	11T*	3633	2708	0	0	183	44	0	430	**6998**
Central Thames	12T	2355	141	0	0	0	236	0	416	**3148**
Indian-McGregor Creek Area	13T	930	668	0	50	197	0	0	305	**2150**
Southwest Thames	14T	3494	232	375	0	1560	0	1364	157	**7182**
Lake St. Clair	15T	181	217	0	0	6806	0	1363	11	**8578**
Talbot Creek Area	16T	0	0	0	0	0	0	0	108	**108**
Rondeau Bay	17T	395	173	0	0	0	0	0	177	**745**
Central Lake Erie	18T	121	0	0	0	12	12	0	182	**327**
Total		**11109**	**4139**	**375**	**50**	**8758**	**292**	**2727**	**1786**	**29236**

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

3.2.6. Water Budget Summary

Each *subwatershed* in the region is examined in terms of the water budget components for both surface and ground water systems on an annual average basis. Components include:

Q_P, precipitation,
$Q_{SW\text{-}in}$, surface water flows in,
$Q_{GW\text{-}in}$, groundwater flows in, (assumed zero in Tier 1)
Q_{ET}, Evapotranspiration,
$Q_{SW\text{-}out}$, surface water flows out,
$Q_{GW\text{-}out}$, groundwater flows out, (assumed zero in Tier 1)
$Q_{GW\text{-}C}$, consumptive groundwater use,
$Q_{SW\text{-}C}$, consumptive surface water use, and
ΔS, change in storage (assumed zero in Tier 1)

The water budget equation can be summarized as:

$$Q_P + Q_{SW-in} + Q_{GW-in} = Q_{ET} + Q_{SW-out} + Q_{GW-out} + Q_{GW-C} + Q_{SW-C} + \Delta S$$

Table 3-2 summarizes the annual water budget in units of annual average m3/day. Water budget balances are compared to the total water supply for each subwatershed (i.e. Precipitation + SW supply), and the error is less than 10% of the estimated supply, which indicates that estimates are reasonable, given the inherent uncertainties in each individual component. Although stress calculations rely on monthly information, average annual water budget components are included as a summary to demonstrate the balance.

Table 3-2 Water budget summary (m^3/day)

Code	Subwatershed	Q_{ET}	Q_P	$Q_{sw\text{-}out}$	$Q_{sw\text{-}in}$	$Q_{gw\text{-}c}$	$Q_{sw\text{-}c}$	ΔS	Balance	%error (of total supply)
11T*	Thames R. between the Forks and Dutton	1167292	1998777	4224578	3402509	10337	6999	0	-7920	-0.1%
12T	Central Thames	998379	1630469	4756196	4224578	2506	3148	0	94819	1.6%
13T	Indian-McGregor Creek Area	641220	1004704	5390464	4756196	3631	2149	0	-276564	-4.8%
14T	Southwest Thames	1352084	2058262	5990752	5390464	2112	7182	0	96595	1.3%
15T	Lake St. Clair	266845	404032	164731	0	756	8579	0	-36879	-9.1%
16T	Talbot Creek Area	246598	421669	172866	0	307	108	0	1791	0.4%

17T	Rondeau Bay	269848	432122	166972	0	505	745	0	-5947	-1.4%
18T	Central Lake Erie	533434	847338	321127	0	1500	327	0	-9049	-1.1%

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

3.3 Phases of Water Budget Work

3.3.1. Conceptual Water Budget

The Conceptual Water Budget, or conceptual understanding, is the first phase of the water budget development. In this stage, background information is collected on the components of the water budget. The information is analyzed to determine the various components of the water budget based on historical and readily available data on a coarse scale. The conceptual Water Budget was completed for the entire region. The region was divided into 6 *subwatersheds* for the purposes of this analysis. The Conceptual Water Budget is included as Appendix 6 of the Assessment Report.

3.3.2. Tier 1 Water Budget

The Tier 1 Water Budget utilizes the information collected and analyzed in the Conceptual Water Budget. In Tier 1, the potential for stress is assessed in *subwatersheds* within the region. As with the Conceptual Water Budget, the Tier 1 Water Budget was documented in one report for the entire Thames-Sydenham and Region. For the purposes of the Tier 1 Water Budget, the region was subdivided into 32 *subwatersheds*, as shown in Map 3-1. A water budget and stress assessment was calculated for each of these *subwatersheds*. Map 3-5 indicates the potential for stress on surface water sources, while Map 3-6 illustrates the potential for stress on the groundwater sources.

3.3.3. Tier 2 Water Budget

Although a Tier 2 Water Budget is required for the Upper Thames River Source Protection Area, one is not necessary for the Lower Thames Valley Source Protection Area as no municipal systems are in *subwatersheds* which have a moderate or significant potential for stress.

3.3.4. Tier 3 Water Budget

The Tier 3 Water Budget is a local area water balance undertaken on the scale of a single water

supply system and is intended to examine the reliability of that supply. As no *subwatersheds* in the Lower Thames Valley Source Protection Area advanced to a Tier 2 Water Budget, a Tier 3 Water Budget is not required.

3.3.5. Peer Review of the Water Budget

Each phase of the water budget is subject to a peer review process. The project team and consultants work closely with the peer reviewers to ensure that the work undertaken is technically sound and meets the requirements of the *technical rules 2013* and relevant provincial guidance. As work on the project progresses, the materials are presented to the peer review committee for their comments. Those comments are considered by the peer review team and consultants and are generally incorporated into the final report. The comments, along with their responses, are also incorporated into a peer review record which becomes part of the water budget report. Following completion of the peer review, the draft water budget document is submitted to the Ministry of Natural Resources for acceptance.

The Conceptual Water Budget and Tier 1 Water Budget successfully completed the peer review process and have been accepted by the MNR.

3.4 Water Quantity Stress Assessment

The level of potential for stress is calculated based on the following formula as defined in the *Technical Rules 2013: Assessment Reports*:

$$\%\ \text{Water Demand} = \frac{Demand}{Supply - Reserve} x100$$

Percent Water Demand is calculated separately for groundwater and surface water as are the other terms in the above *percent water demand* equation.

For surface water, *Demand* is the monthly estimated *demand* of all surface water sources, *Supply* is the monthly estimated median daily flow, and *Reserve* is the 90th percentile monthly flow, or the flow that is exceeded 90 percent of the time for the month being analyzed.

For groundwater, supply includes a number of components as discussed above. For the Tier 1 Water Budget, supply is simplified to include recharge and groundwater flow into the watershed. As discussed above, recharge is estimated using base flow. Groundwater flow into the watershed can be calculated through the use of a calibrated groundwater model. Developing and calibrating a groundwater model is however not part of the scope of the Tier 1 Water Budget. As a large scale regional groundwater model was available for the region, it was planned to use it for this purpose. It was, however, determined that it was not adequate for the purposes of describing flows between *subwatersheds* at the scale required for the Tier 1 Water Budget. In the absence of a good estimate for groundwater flow into the subwatershed, it is possible to neglect the inflow of groundwater in the supply term. This results in a conservative estimate of the percent water *demand*. It was felt that in *subwatersheds* where there is considerable *demand* and the *subwatersheds* are relatively small, a large portion of the supply could be coming from adjacent *subwatersheds* as groundwater flows in and, therefore, the *percent water demand* could be overly conservative. As there were no *subwatersheds* which indicated a moderate or significant potential for stress, an estimation of groundwater inflow is not necessary.

Groundwater reserve is 10% of the supply, as required in the *Technical Rules 2013: Assessment Reports*. A water reserve estimate is intended to protect a portion of water from being considered within the stress calculations, adding a conservative element to this calculation. This water is removed from the supply in the stress assessment.

The *Percent Water Demand* is used as an indication of the stress level in the *watershed* or *subwatershed*. This stress level is described in this document as the "potential for stress" as it better describes the situation given the *uncertainty* associated with the calculations. Generally, a tier 1 *stress assessment* is understood to have considerable *uncertainty* associated with the *percent water demand* calculations which would be reduced through subsequent analysis in the Tier 2 or 3 Water Budgets, where warranted. At the completion of the Tier 1 Water Budget, it is important to understand that conclusions drawn from this analysis are indicative of whether more analysis is required; not an absolute determination that there is *stress*. Given the level of conservatism, as discussed above, this is especially important when considering the

subwatersheds which are being described as having a significant potential for *stress*. However, for the *subwatersheds* which are described as having a low potential for *stress*, this conservatism clearly indicates that they do not have a significant level of *stress*. The sensitivity analysis required for *subwatersheds* which are almost moderate gives even more confidence in this conclusion. *Subwatersheds* with a moderate potential for *stress* also advance to the next stage of analysis, along with those identified with a significant potential for *stress*. At the next stage, additional analysis is required to determine the *percent water demand* and, therefore the *stress* level, with a higher level of confidence. If this moderate or significant potential for *stress* affects a municipal water supply, additional analysis would be undertaken through the Source Protection program. However, in the Lower Thames Valley Source Protection Area, *subwatersheds* which show a significant or moderate potential for *stress* do not contain municipal drinking water sources. Therefore, additional analysis is recommended to adequately determine the potential for *stress* in these *subwatersheds*. This work will need to be undertaken through other programs before the water budget and, specifically, the *percent water demand* can be used in the implementation of other programs such as the Permit to Take Water program.

In assessing the potential for *stress*, various scenarios as identified in the *technical rules 2013* must be considered. These scenarios consider current and future municipal *demand* under both average and drought scenarios. Drought scenarios are not considered in the Tier 1 Water Budget. Scenario A and B discussed in Table 3-3 below relate to the current and future municipal *demand* (respectively). As there are no additional planned systems in the Lower Thames Valley Source Protection Area, the scenario related to planned systems (scenario C) is not applicable and therefore not included in Table 3-3. Table 3-4 describes the potential for *stress* based on the *percent water demand* for the applicable scenarios which must be compared to the ranges shown in Table 3-3. Additional criteria as described in Rule 32 and 33 are also considered in the stress assessment. If the intake or well was not able to operate due to insufficient quantity of water or a low water level, the potential for *stress* is described as moderate and the *subwatershed* would advance to the next tier.

Table 3-3 potential for stress based on *percent water demand* under current and future municipal water demand

Potential for Stress	Surface Water % Water Demand	Groundwater % Water Demand

Based on	Max'm monthly	Max'm monthly	Avg annual
Significant	Greater than or equal to 50%	Greater than or equal to 50%	Greater than or equal to 25%
Moderate	Less than 50% but greater than 20% (or between 18 and 20%, inclusive, but under sensitivity analysis increases to greater than 20%)	Less than 50% but greater than 25%	Less than 25% but greater than10% (or between 8 and 10%, inclusive, but under sensitivity analysis increases to greater than 10%)
Low	Less than or equal to 20% (after sensitivity analysis if between 18 and 20%, inclusive)	Less than or equal to 25%	Less than or equal to 10% (after sensitivity analysis if between 8 and 10%, inclusive)

Table 3-4 Surface water potential for stress based on Tier 1 stress assessment

Subwatershed	Code	Supply (Q_{50})	Reserve (Q_{90})	Demand	Potential for stress
Thames River between the Forks and Dutton	11T*	933120	606874	29659	low
Central Thames	12T	1010880	630720	15039	low
Indian-McGregor Creek Area	13T	1122854	736214	7838	low
Southwest Thames	14T	1161259	754713	22853	low
Lake St. Clair	15T	7690	2851	9823	Significant
Talbot Creek Area	16T	10454	4709	108	low
Rondeau Bay	17T	7776	2938	2759	Significant
Central Lake Erie	18T	19354	8770	941	low

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

Table 3-5 Groundwater potential for stress based on Tier 1 stress assessment (Average Annual Conditions)

Subwatershed	Code	Q_{supply}	$Q_{reserve}$	Q_{demand}	Potential for stress
Thames River between the Forks and Dutton	11T*	232027	23203	5384	low
Central Thames	12T	291274	29127	2506	low
Indian-McGregor Creek Area	13T	79825	7982	3631	low
Southwest Thames	14T	141855	14186	2112	low
Lake St. Clair	15T	41577	4158	756	low
Talbot Creek Area	16T	51712	5171	307	low
Rondeau Bay	17T	42880	4288	505	low
Central Lake Erie	18T	95967	9597	1500	low

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

Table 3-6 Groundwater potential for stress based on Tier 1 stress assessment (Maximum Monthly Conditions)

Subwatershed	Code	Q_{supply}	$Q_{reserve}$	Q_{demand}	Potential

					for stress
Thames River between the Forks and Dutton	11T*	445491	44549	34032	low
Central Thames	12T	291274	29127	5556	low
Indian-McGregor Creek Area	13T	79825	7982	4896	low
Southwest Thames	14T	141855	14186	4740	low
Lake St. Clair	15T	41577	4158	756	low
Talbot Creek Area	16T	51712	5171	307	low
Rondeau Bay	17T	42880	4288	563	low
Central Lake Erie	18T	95967	9597	2931	low

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

Although some *subwatersheds* in the Lower Thames Valley Source Protection Area have potential to be stressed, that *stress* does not affect any municipal drinking water systems. Map 3-5 shows the potential for *stress* in surface water of the *subwatersheds* within the Lower Thames Valley Source Protection Area. Map 3-6 shows that there are no *subwatersheds* with more than a low level of groundwater stress in the Lower Thames Valley Source Protection Area.

Thus, for the purposes of the Clean Water Act, the potential for *stress* on municipal drinking water systems in the Lower Thames Valley Source Protection Area is LOW.

3.4.1. Uncertainty in the Stress Assessment

As the *stress* assessment for the Lower Thames Valley Source Protection Area was completed as part of a Tier 1 Water Budget, some uncertainty in the data and analysis is expected. Surface water stress assessments for the *subwatersheds*, which include direct tributaries to the Great Lakes or Lake St. Clair, are likely over estimating the percent water demand, and therefore the potential for stress. This is expected as some of the water takings near the Great Lakes are likely drawing their water from the Great Lakes rather than drawing water from the subwatershed being assessed. Although permits where this is likely to be the case have been removed from the *demand* used in the *stress* calculations, it is suspected that more, especially in areas with little topographic relief from the lake level, are also effectively drawing water from the lake. Unfortunately, the permit to take water database coordinates are not reliable enough to make further judgments as to whether the permit reflects a *demand* from the subwatershed being assessed or from the Great Lake which is beyond the study area. Although a full Tier 2

Water Budget would not be required to reduce the uncertainty in these *subwatersheds*, further analysis would be necessary to gain a better understanding of the *demand* in these areas and whether they rely on water from the lake rather than the subwatershed being considered. In these *subwatersheds*, the potential for *stress* does not affect municipal drinking water systems, thus this work must rely upon other programs to undertake a more detailed assessment of the potential for *stress*.

Although this *uncertainty* has little effect on the Source Protection Plan it is of considerable importance in interpreting this analysis for use in other programs such as the Permit to Take Water Program. Therefore there are no water quantity *threats* in the Lower Thames Valley Source Protection Area.

3.5 Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas (SGRA) are delineated through the water budget work. These areas are determined through the use of the recharge calculated in the Tier 1 Water Budget and discussed in Section 3.3 above. Recharge is compared to both the average recharge of the area and to the effective precipitation (precipitation less evaporation) of the area to determine if the recharge at that location is significant. Rule 44 identifies the criteria for determining whether a recharge area is significant:

- 44(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
- 44(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.

Table 3-7 below summarizes the recharge and the conditions which must be met for an area within a particular subwatershed to be deemed significant. It is worth noting that in most cases rule 44(1) provides a more conservative criterion for SGRA declaration than does rule 44(2).

Table 3-7 Criteria for Significant Groundwater Recharge Areas

Subwatershed		Annual Average recharge (mm/a)	Effective Precipitation (mm/a)	SGRA Criteria Rule 44(1) (based on annual recharge)	SGRA Criteria Rule 44(2) (based on effective precipitation) mm/a
Thames River between the Forks and Dutton	11T	198	404		
Central Thames	12T	173	351		
Talbot Creek Area	16T	120	388		
Central Lake Erie	18T	103	336		
Central Thames Valley		**165**	**352**	**190**	**194**
Indian McGregor Creek Area	13T	70	331		
Southwest Thames	14T	61	304		
Lake St. Clair	15T	84	305		
Rondeau Bay	17T	84	344		
Lower Thames Valley		**69**	**301**	**79**	**166**

Rule 45 indicates that the area must have "a hydrological connection to a surface water body or aquifer that is a source of drinking water for a drinking water system". For the purposes of this rule it is important to realize that a drinking water system can be single residential water well. Map 34 in Thames Watershed Characterization Report summary included as Appendix 5 illustrates that wells are located throughout the region. In areas where shallow sandy deposits provide for recharge areas, well installation is simple through the use of sand points driven to a modest depth. These types of water wells are, in most cases, installed without a permit and therefore not included in the water well information system used to produce Map 34. Further, it is not intended by the *technical rules 2013* that the connection be direct or immediate, but rather that there is a "hydrologic connection". This recognizes that water not only flows vertically through the ground but also flows laterally from areas of higher levels to areas of lower water levels. Thus, it is generally accepted that aquifers are recharged from areas up gradient from the aquifer as well as directly above. Although through Tier 2 and 3 Water Budget a much better interpretation of the extent of aquifers will be understood, currently in the Lower Thames Valley Source Protection Area there is little information on a localized scale on the extent of the aquifers. Thus, a precautionary, conservative approach is warranted and all areas which meet the criteria for significance are included as *SGRA*.

Map 4-8 illustrates the *Significant Groundwater Recharge Areas* in the Lower Thames Valley

Source Protection Area updated based on surficial geology as discussed above.

3.6 Data Gaps and Next Steps

Table 3-8 summarizes data gaps identified through the Tier 1 Water Budget and Water Quality Stress Assessment. This table has been updated to reflect the completion of the Tier 1 peer review and improvements to the SGRA. As the *stress* assessment was completed through a Tier 1 Water Budget, it is expected that data gaps would remain. If work was to proceed to a Tier 2 Water Budget, many of these gaps would need to be addressed at that time. As the potential for *stress* has no effect on municipal water systems, additional work is not required through Source Protection Planning. These gaps become more of a problem for other programs, such as the Permit to Take Water Program, which would benefit from results with a lower level of uncertainty.

These gaps do not affect the reliability of the analysis for use in the development of the Source Protection Plan.

Table 3-8 Data gaps related to Water Budget and Water Quantity Stress Assessment

Gap	Description
Determine Inland takings drawing from great lakes	• Confirm location and watercourse conditions related to water takings near Lake Erie and Lake St. Clair • Recalculate percent water demand • Reassess potential for stress in these areas • Update Assessment Report only if warranted
Improved understanding of water use	• Obtain actual water use data from all significant water users through the PTTW reporting system • Requires reassessment after sufficient data has been reported, perhaps when Assessment Report requires future update
Un-gauged Areas	• Temporary stream gauging on small lake draining tributaries to improve understanding of how these behave • Surface Water Model to better understand distribution of flows in un-gauged subwatersheds
Climate Change	• Consider the impact of Climate change on the water budget and the stress assessment
Refine ET	• Improve calculation of ET to include consideration of soil types and land use at a local level

4.0 Vulnerability Assessment

In order to protect drinking water sources it is necessary to identify areas where activities can affect the drinking water sources. The Clean Water Act refers to these areas as *Vulnerable Areas* and requires that they be identified in the Assessment Report. The Vulnerability Assessment section of the Assessment Report summarizes the work to delineate these *vulnerable areas* which was undertaken through various studies. The studies involved the operating authorities of the water systems and were undertaken through partnerships involving the Conservation Authorities in the region. The Clean Water Act also requires that these *vulnerable areas* be assessed to determine their relative level of vulnerability. There are three types of *vulnerable areas* which must be identified and assessed:

- *Intake Protection Zones* (*IPZ*)
- *Wellhead Protection Areas* (*WHPA*)
- *Highly Vulnerable Aquifers* (*HVA*)

Activities in these *vulnerable areas* will be reviewed to determine the *risks* that they pose to the drinking water sources. The vulnerability of the area, combined with the hazard associated with the activity, provide a relative indication of the level of *risk* associated with a *threat*. The *Source Protection Plan* is focused on reducing the level of *risk* associated with *threats*. As such, the identification of the *vulnerable areas* and the assessment of vulnerability are cornerstones to the development of the *Source Protection Plan*.

Each type of *vulnerable area* is described in the following sections which summarize the identification and assessment of the vulnerability within the areas.

4.1 Peer Review of Vulnerability Assessment

All aspects of the vulnerability assessment are subject to a thorough peer review process. This process is described in Peer Review of Vulnerability Assessment, Terms of Reference (March 2008). This process includes the forming of a peer review committee comprised of four professionals with extensive experience in one or more of the areas related to the vulnerability

assessment of the *vulnerable areas*. Two members of the committee are professional geoscientists familiar with the assessment of groundwater vulnerability; one with experience related to *Groundwater Under the Direct Influence* (*GUDI*) wells, while the other is also a member of the peer review committee for the Water Budget work. The third member of the peer review committee has extensive experience related to the surface water vulnerability assessment and is working on similar projects in other regions. A fourth member joined the committee in the peer review of vulnerability assessment studies of groundwater systems spanning the Oxford and Perth Counties in the Upper Thames River Source Protection Area (*SPA*) and the Lake Erie Source Protection Region (*SPR*). The peer review committee reviewed each technical report with the exception of the recent IPZ-3 technical work, met with the consultants and project teams to discuss the project and submitted comments based on their review and the discussion. Comments were considered and responded to by the consultant or project team members. These comments and the responses form part of the peer review record along with the terms of reference for the peer review committee discussed above. Work initiated following the completion of the peer review process, including the IPZ-3 work, was undertaken with assistance from technical staff at the Ministry of Environment, Conservation and Parks to ensure that the was undertaken with a thorough understanding of the technical requirements and science. Also ongoing involvement of the project teams of the Thames-Sydenham and Region and Essex Region and the Technical Advisory Committee formed by the Thames-Sydenham and Region SPC provided additional peer review of the work. The peer review process added considerable value to the technical report by ensuring that the work was well documented.

One point that involved considerable discussion by the peer reviewers was the uncertainty analysis undertaken in the technical studies. The *rules* allow for uncertainty to be determined as either high or low. While it was generally reported that the uncertainty associated with the vulnerability assessment or delineation of the *vulnerable areas* was acceptable for the intended purpose, there was a wide variation in what consultants viewed as a low level of uncertainty. The uncertainty reported in this report reflects that which has been identified in the technical reports. However, following the completion of the peer review of all of these studies, it was suggested that the peer reviewers provide a relative comparison of the uncertainty of the projects so that a consistent interpretation between studies is available.

4.2 Intake Protection Zones

An *Intake Protection Zone* (*IPZ*) is delineated around an intake in a surface water body. An Intake Protection Zone is comprised of an IPZ-1, IPZ-2 and IPZ-3. In the Lower Thames Valley Source Protection Area, the intakes draw water from Lake Erie. The Stoney Point water treatment plant intake, located in Lake St. Clair in the Essex Region Source Protection Authority, has an IPZ-3 that extends into the Lower Thames Valley Protection Area. Map 4-1 shows the location of the intakes and the *IPZ* around the intakes. The IPZ in the Lower Thames Valley Source Protection Area were delineated through three projects as discussed below. IPZ-3 delineation and assessment for the West Elgin and Chatham/South Kent intakes may be considered in a future update to the Assessment Report.

4.2.1. Surface Water Vulnerability Assessment Projects

A large project, led by the Essex Region Conservation Authority (*ERCA*) was initiated through a partnership between *ERCA* and the Conservation Authorities in the Thames-Sydenham and Region and the plant operators. This project included 7 intakes in the Essex Region and 3 Chatham-Kent intakes in the Thames-Sydenham and Region. Stantec Consulting Limited was the primary consultant and retained Baird and Associates to undertake the hydrodynamic modelling work. The Municipality of Chatham-Kent Public Utilities Commission (*PUC*) was an active partner in the project and participated in the technical steering of the project.

Another project was led by the Municipality of West Elgin with the Ontario Clean Water Agency (*OCWA*) providing technical and project management services for the municipality. The West Elgin water treatment plant is owned by the Municipality of West Elgin and is managed by the Tri-County Water Management Committee. The vulnerability assessment study was also undertaken by Stantec Consulting Limited, who retained Alex McCorquodale for the hydrodynamic modelling work.

A third project was led by the Lower Thames Valley Conservation Authority staff to assess the IPZ-3 for the Stoney Point water treatment plant intake that extends into the Lower Thames Valley Source Protection Area. This work was based on prior work conducted by Baird and Associates and used similar methodologies to assess how far upstream the impacts could be realized at the intake.

A further project was lead by the ERCA to assess fuel spill in Lake Erie tributaries as they pertain to systems in the Essex Region. This work included tributaries in the ERSPA which could result in a threat to the Wheatley intake in the LTVSPA. The in lake modelling was completed by Baird and linear dispersion analysts was completed by ERCA staff with input from LTVCA staff.

The above referenced technical reports are peer reviewed as described in the peer review section and included in the Assessment Report. The technical studies are listed below In Table 4-1. The May 2008 West Elgin vulnerability assessment technical study was updated in an addendum report in November 2009, in order to meet current *technical rules 2013*.

Table 4-1 Technical Studies on Vulnerability Assessment

Drinking Water Systems	Technical Study on Vulnerability Assessment
Wheatley, Chatham and South Chatham-Kent	Technical Memorandum: Delineation, Vulnerability and Uncertainty Level Analysis for the Thames, Sydenham & Region Water Treatment Plants. Essex Chatham-Kent Source Protection Planning Technical Study. Final Report. Stantec Consulting Ltd. November 2009
West Elgin	1. Intake Protection Zone Delineation, Vulnerability Assessment Study and Uncertainty Analysis. West Elgin Water Treatment Plant. Municipality of West Elgin Source Protection Planning Technical Study. Final Report. Stantec Consulting Ltd. May 2008. 2. Surface Water Vulnerability Assessment Addendum. West Elgin Water Treatment Plant. Municipality of West Elgin Source Protection Planning Technical Study. Final Report. Stantec Consulting Ltd. November 2009. 3. Surface Water Vulnerability Assessment Report for the West Elgin Water Treatment Plant Emergency Intake. Municipality of West Elgin Source Protection Planning Technical Study. Draft. Stantec Consulting Ltd.July 2010. 4. Technical Memorandum: West Elgin WTP Intake Protection Zone Update. October 2010.

4.2.2. Intake Characterization

The intakes of the Lower Thames Valley Source Protection Area (*LTVSPA*) are described in Table 4-2. All intakes in the *LTVSPA* draw Lake Erie water. Basic characteristics including depth of the intake from the lake's surface and distance from shore are included below. The

depth to the intake is based on depth from the top of the intake crib to the low water level in the lake. The type of the intake is assigned based on the types indicated in the *Technical Rules 2013*: *Assessment Report*.

Table 4-2 Intake Characteristics

Intake		West Elgin		Chatham/South Kent		Wheatley	
		Primary	Emergency	Chatham plant	South Chatham-Kent plant	Primary	Emergency
Intake Type		A (Great Lake)		A (Great Lake)		A (Great Lake)	
Approximate Population Served		13,680		47,815	12,108	10,700	
Pump Rate (cubic metre per day)	Maximum Annual	1,554,191		11,553,858	2,488,410	3,048,280	
	Average Annual	1,434,038		11,117,375	2,352,900	2,920,668	
	Average Monthly	119,503		926,447	196,075	243,389	
Rated (design) Capacity of Plant, (cubic metres per day)		12,160		68,190	22,800	23,864	
Distance from Shore		575 m	7 m	701 m		747 m	291 m
Depth to Intake		4.2 m	0.4 m	7.3 m		4.5 m	0.9 m
Intake Location		West Lorne		Erie Beach		Wheatley Harbour	

Vulnerable areas must be defined for all intakes connected to municipal drinking water systems. West Elgin and Wheatley treatment plants each have 2 intakes: primary and emergency. A primary intake is located away from shore and used regularly. These primary intakes may be subject to freezing resulting in the build-up of frazzle ice (crystallized but fluid ice, like runny slush) around the intakes, reducing their capacity or completely blocking them. The emergency intakes can be used during these frazzle ice conditions, as well as during maintenance or repair when the primary intake is closed.

The intake at Erie Beach, referred to as the Chatham/South Kent intake, supplies two water treatment plant facilities ─ the South Chatham-Kent plant near the intake, and the Chatham plant located in Chatham.

An *Intake Protection Zone* (*IPZ*) is comprised of an *IPZ-1*, and an *IPZ-2*. A third zone around intakes can also be delineated, referred to as an *Intake Protection Zone-3* (*IPZ-3*).

4.2.3. IPZ-1 Delineation

The vulnerability within an *Intake Protection Zone* is first assessed by delineating an *IPZ-1*. On the Great Lakes, an *IPZ-1* is a circle with a radius of 1 km, centred on where the intake draws its water from the lake. Where the circle touches shore, the zone is extended 120 m or to the regulatory limit, where water from that area drains into the in-lake part of the *IPZ-1*. The regulatory limit is defined by Conservation Authorities pursuant to the Conservation Authorities Act to include areas which are flooded under a severe regulatory event. This area also includes slope and erosion hazard areas along lakeshore and watercourses. An *IPZ-1* must be delineated for all intakes which are connected to drinking water systems.

4.2.4. IPZ-2 Delineation

A second zone, called the *Intake Protection Zone-2* (*IPZ-2*) is delineated based on travel time to the intake under moderate flow and wind conditions. Determining the extent of the *Intake Protection Zone-2* in the lake is the first step. The upland extent from the shore is then delineated for areas draining into the in-lake portion of the *IPZ-2*.

In the Thames-Sydenham and Region, hydrodynamic computer models were used to simulate currents driven by wind and wave action within the Great Lakes and connecting channels in order to delineate the lake extent of the *Intake Protection Zone-2*. The Chatham/South Kent and Wheatley intakes are part of a larger model (developed by Baird) which includes the western end of Lake Erie, the Detroit River, Lake St. Clair and the St. Clair River. Numerical modelling was undertaken in support of the preliminary *IPZ-2* delineation using Baird's proprietary three-dimensional hydrodynamic model named MISED. Wind data was used to define the boundary conditions, initial conditions, and external forcing mechanisms for the model. A statistical analysis was undertaken to define the directional wind speeds for varying return period events, for use in the model runs. Event based model runs were undertaken and reverse particle tracking was used to delineate the preliminary in-water *IPZ-2*s for the intakes. The model was run for a range of conditions using combined 10-year return period events considering wind and water flow. The MISED model was calibrated and validated with measured water level and current (flow) data. The model named HYDROSED was used to conceptualize the mixing inshore of the surf zone at Wheatley, and further analysis of the shoreline connection was conducted where tributaries were located within close proximity to the *IPZ-2* in-water limits. The

work related to delineating the *IPZ-2* for the Wheatley and Chatham/South Kent intakes is described in the report 'In-water *IPZ-2* Delineation for Essex Region and Chatham-Kent Intakes-Phase II Study', Baird 2009, which is contained as an appendix to the technical studies identified above.

A separate model was used for the delineation of the *IPZ-2* for the West Elgin primary and emergency intakes. The in-lake extent of the primary intake *IPZ-2* was delineated based on a model called ECOMSED (Estuarine Coastal and Ocean Model with Sediments). A whole lake model was developed to avoid problems at a local open boundary. The West Elgin emergency intake is located within the surf zone. Therefore the emergency intake was delineated using the ECOMSED model (to estimate the currents due to wind stress) and the Longuet-Higgins equation (to estimate the wave induced longshore currents). The model validity was checked in two ways: (1) a correlation between the measured currents near the site and wind data from London Airport was used to estimate initial *IPZ-2*s; (2) the velocities near Port Stanley were compared with those presented by consultants Hall Consultant Canada Limited (*HCCL*) for the Port Stanley *IPZ-2*. The *IPZ-2*s have been developed using the 10-year winds that were developed by *HCCL* for Port Stanley.

The models were used to delineate in-water extents of *IPZ-2*, simulate particle movement in the water body and determine time of travel to the intakes. Various scenarios are run to determine areas which can contribute water or potential contaminants within the time required to close the intake. In the Thames-Sydenham and Region, all operators determined that they could close intakes within two hours of being notified of a situation which might cause a deterioration of the drinking water. Two hours is the minimum time allowed by the Clean Water Act.

Once the in-lake extent of the *Intake Protection Zone-2* was delineated, the upland extent of the *Intake Protection Zone-2* could be determined. Where the in-water portion of the *IPZ-2* touches shore, the time remaining from the two hours is used to determine the distance the *IPZ-2* extends up tributaries. For example, if a tributary outlet is 1 hour and 30 minutes from the intake then the remaining 30 minutes is used to determine how far the zone should extend up the tributaries. The remaining time is referred to as residual travel time. Estimates of the water course velocities under bank full conditions are used to determine distance up the tributaries for

the residual travel time. Bank full conditions usually occur during a runoff event which occurs, on average, every two to five years (generally referred to as a two or five year storm). Along the parts of the tributaries that contribute water to the intake within the two hour period, the *IPZ-2* extends 120 m from the high water mark or to the extent of the regulatory limits.

Storm Sewersheds and Transport Pathways

IPZ-2 is also extended to include any storm sewersheds which drain within the *IPZ-2*. Storm sewersheds are areas drained by storm sewers and catch basins. Areas where *transport pathways* allow water to drain to the *IPZ-2* may also be included within *IPZ-2*, again to the extent that they can contribute water within the two hour response time used to define the extent of *IPZ-2*. *Transport pathways* could include natural or man-made pathways such as drains, creeks, agricultural tile drains, or overland flow. While areas contributing to the *IPZ-2* could be determined by topographic information, this has often been artificially altered by agricultural and urban drainage. Information on these drains is available, however the property- specific information, especially related to tile drainage, is not considered to be accurate enough for the purposes of establishing *transport pathways*. As a result, the Source Protection Committee (*SPC*) chose to include all parcels abutting on the buffered watercourses where there was the potential that they drain, either naturally or artificially, to the watercourse in the *IPZ-2*. Through the Tier 2 (site-specific) Risk Assessment, if these areas are found to be beyond the time of travel or drain away from the *IPZ-2*, the inclusion of these areas will be reconsidered. These changes would be made through an amended Assessment Report.

Maps 4-2, 4-3 and 4-4 show the *IPZ-1* (as well as *IPZ-2*) for the intakes in the Lower Thames Valley Source Protection Area. The 120 m setback and regulatory limits are indicated on the maps.

Chatham/South Kent Transport Pathways

There are six municipal drains discharging within the alongshore extent of the *IPZ-2*; two closed systems and four systems which include both open and closed parts. They are Unnamed Drain 1, Unnamed Drain 2, County Road 10 Drain, JA Smith Drain, Carswell Drain and Story Drain.

All municipal drains discharge to Lake Erie as closed systems. As mentioned above, parcels abutting the buffered watercourses were included as *transport pathways*. Seven storm sewer outfalls exist within the alongshore extent of the *IPZ-2* and their associated networks were included in the upland *IPZ-2* in their entirety.

Chatham/South Kent Sewersheds

A small storm sewershed to the west of County Road 10 was included due to the small drainage area and its quick response to rainfall.

The individual components of the Chatham/South Kent *IPZ-1* and *IPZ-2* are illustrated on Map 4-2.

West Elgin Transport Pathways

The up-tributary extents of the primary and emergency intakes' *IPZ-2* were estimated for the Hauser Drain, Brock Creek, Mumford Drain, Bonn Drain, Lindeman Drain, and Government Drain No. 1. As discussed above, parcels abutting the buffered watercourses were included.

West Elgin Sewersheds

There are no storm sewersheds in the primary and emergency intakes' *IPZ-2*.

Map 4-4 shows the components of the West Elgin *IPZ-1 and IPZ-2* for both the primary and emergency intakes.

Wheatley Transport Pathways

At Wheatley, there are seven municipal drains within the upland part of the primary and emergency *Intake Protection Zones*. The up-tributary extents of the *IPZ-2* for both the primary and emergency intakes were estimated for the Atwell Drain, Collision Drain, Detan Drain, Muddy Creek/Wheatley Harbour, Two Creeks West and Two Creeks East. If the full extent of the watercourse was less than the calculated distance up-tributary, the delineation terminated at the headwaters of the watercourse with a circular cap radius of 120 m. As mentioned above, parcels abutting the buffered watercourses were included in the *IPZ-2* as *transport pathways*.

Six storm sewer outfalls exist within the alongshore extent of the *IPZ-2* and their associated

sewersheds were included in the upland *IPZ-2* in their entirety. Pulley Drain has two outfalls in the alongshore extent, and were also included. The full extent of Pulley Drain is contained within the 120 m lake setback.

There is one municipal storm water ditch located between Detan Drain and Two Creeks West Branch. The upland *IPZ-2* was extended to include the entire length of the ditch, inclusive of its Two Creeks West Branch outfall, and the 120 m setback has been applied.

Wheatley Sewersheds

As mentioned above, a 120 m setback was applied to one municipal storm water ditch located between Detan Drain and Two Creeks West Branch. This resulted in the inclusion of a storm sewershed to the west of Two Creeks West Branch. A storm sewershed to the east of the wider portion of the Two Creeks West Branch, and which drains towards Lake Erie, is included. A storm sewershed between the Two Creeks West and East Branches is also included.

Map 4-3 shows the components of the Wheatley *IPZ-1 and IPZ-2*.

Revisions to the Wheatley IPZ

It is important to point out that while the Wheatley intake is located within the Lower Thames Valley Source Protection Area, the western portion of the *IPZ* is largely within the neighbouring Essex Region Source Protection Area. As discussed earlier, the project for the delineation of the *IPZ* for the Wheatley and Chatham/South Kent intakes was undertaken through a joint partnership between project teams from both regions. The maps illustrate the portions of the *IPZ* in both *SPAs*, however it is important that the reader refer to the appropriate Assessment Report for the official *IPZ* portion relevant to the watershed of interest. Although the project for the delineation and vulnerability scoring of the *IPZ* was undertaken by the same consultant, the Assessment Reports have been completed at different times. As a result, it is possible that final amendments in one *SPA* are not reflected in the Assessment Report for the other *SPA*. It is also important to note that both source protection committees considered similar methodologies for the consideration of *transport pathways*. However, late changes to the methodologies used in the Essex Region Source Protection Area were not adopted in the Thames-Sydenham and Region by the Thames-Sydenham and Region Source Protection Committee. The committee

preferred the more conservative and precautionary approach of including the entire parcels where there was no information suggesting an area should be excluded from the *IPZ-2*. The committee acknowledged as part of their consideration that this is unlikely to have much impact on these properties due to the low vulnerability scores, but preferred the more conservative approach rather than excluding areas which may contribute within the two hour travel time. If, however, during subsequent *risk* assessment or policy development, it is found that parts of the properties should be excluded from the *IPZ-2*, revisions to the lines would be required or otherwise acknowledged in the policies affecting these properties.

4.2.5. IPZ-3 Delineation

A third zone around intakes can also be developed. This zone is referred to as an *Intake Protection Zone-3* (*IPZ-3*).

As per Rule 68 an IPZ-3 may be delineated if modelling demonstrates that a release of a chemical parameter or pathogen from an activity or a proposed activity during an extreme event would be transported to the intake and result in the deterioration of the water for use as a source of drinking water. The Technical Rules 2013 define an extreme event as a period of heavy precipitation or up to a 100 year storm, or a freshet. General approaches to the modelling were provided in the MECP's Technical Bulletin: Delineation of Intake Protection Zone-3 Using Event Based Approach (EBA) dated July 2009.

In order to delineate the extent of the IPZ-3 it is necessary to establish the concentration of contaminant which would result in a deterioration of the water for use as a source of drinking water. The Ontario Drinking Water Quality Standards were selected as the benchmark to be applied to the IPZ-3 delineation. This is consistent with the benchmarks used for identifying an Issue.

A model was developed by Baird and Associates through the IPZ-2 work which was also used in the delineation of IPZ-3. This model was used to explore the possible extent of boundaries to an IPZ-3 through reverse particle tracking. The model was then used to determine concentrations of a contaminant which would arrive at an intake following a spill. The model was used to simulate the contaminant travel within Lake Erie or Lake St. Clair while an analytic approach described in MECP's Technical Bulletin was used to consider the dispersion and

dilution within the tributaries flowing towards the lakes.

The following sections address the work conducted for those portions of the IPZ-3 in the Lower Thames Valley Source Protection Area for the Wheatley intake and for the Stoney Point intake in the Essex Region Source Protection Area. IPZ-3 work for the Chatham/South Kent and West Elgin intakes has not been undertaken and may be included in a future Assessment Report update.

4.2.5.1. Wheatley IPZ-3

The Wheatley intake is located very close to the Lower Thames Valley Source Protection Area's boundary with the Essex Region Source Protection Area and as a result the IPZ-3 is delineated in both Source Protection Areas.

In the case of the Wheatley intake, the concern is fuel spills and the parameter chosen to model was the benzene component of the fuel. The modelling completed for the Wheatley IPZ-3 followed the general approach outlined in the MECP Technical Bulletin (July 2009). Based on previous IPZ-2 work, it was decided that modelling one spill upstream on a tributary in Pelee/Hillman Creek (west of the intake in the Essex Region Source Protection Area) would be sufficient as the results could be extrapolated to other nearby tributaries. A fuel spill of 34,000 L of gasoline (with 2% benzene content) was chosen as this roughly corresponds to the volume contained in a tanker truck. However, the modelling would be equally applicable to a fixed storage of equal size. The location of the spill was chosen to be the Highway 77 crossing, 12.3 km upstream from the lake, near the headwaters of the watershed. The spill location is shown on Map 4-3b. Modelling was used to determine contaminant concentrations arriving at the intake from the spill under 5 different extreme events. The extreme events were selected as 100-year return period events using a joint probability analysis on wind direction, speed and duration as well as tributary flows.

Three of the extreme events modelled found that contaminants from a 34,000 L spill near the headwaters of Pelee/Hillman Creek reached the Wheatley primary and emergency intakes at a concentration above the benzene Ontario Drinking Water Quality Standard of 0.005 mg/L. As a result, Baird and Associates recommended delineating an IPZ-3 from the mouth, throughout all

the upstream tributaries, all the way to headwaters of Pelee/Hilllman Creek. They also recommended including the smaller tributaries between Pelee/Hillman Creek and the intake as spills in these locations would be expected to result in similar or higher concentrations arriving at the intake.

The concentrations arriving at the intake were sufficiently high that it was concluded that a 15,000 L spill would also produce an exceedance of the Ontario Drinking Water Quality Standard. As a result, both Source Protection Authorities have moved forward using a potential 15,000 L spill for Threat and Risk Assessment work.

Based on the results of modelling in Pelee/Hillman Creek, it was determined that the Two Creeks watershed, located east of the intakes in the Lower Thames Valley Source Protection Area, should also be included in the IPZ-3. Two Creeks is a smaller watershed than Pelee/Hillman and its longest path up the drainage network is also shorter than Pelee/Hillman. As a consequence there would be less in-stream dilution in Two Creeks for the same size spill.

The outlet of Two Creeks is also closer to the intakes than the outlet of Pelee/Hillman. Two Creeks is approximately 1.5 km from the intakes whereas Pelee/ Hillman is approximately 4.0 km away. In terms of in-lake travel times, the outlet of Two Creeks is also closer as it lies within the Wheatley IPZ-2 whereas Pelee/Hillman lies outside the IPZ-2. As a consequence there would also be less in-lake dilution in Two Creeks for the same size spill.

While these arguments are largely qualitative, they all indicate that, based on the modelling undertaken for Pelee/Hillman Creek, for the same size spill anywhere along the Two Creeks drainage network, there would be an exceedance of the Ontario Drinking Water Quality Standard at the intake.

The next Lake Erie tributary east of Two Creeks is Yellow Creek. This drainage system is extremely flat and has multiple outlets to Lake Erie. As such, the simple inferences made to include Two Creeks in the IP-3 can't be applied in the case of Yellow Creek. It is possible that future modelling work may show that this tributary should also be included in the IPZ-3.

As specified in the Technical Rules 2013, the IPZ-3 extends on to the land a distance of 120 metres, or to the Floodplain Regulation Limit whichever is greater (as long as water from the land actually flows to the watercourse). While the IPZ-3 extends the IPZ to include the extent of the Event Based Area (EBA) the EBA also includes the areas of IPZ-1 and IPZ-2. Transport pathways were not considered in the IPZ-3 delineations. The extent of the Wheatley IPZ-3 is shown on Map 4-3b.

4.2.5.2. Stoney Point IPZ-3

The Stoney Point intake is located in the Essex Region Source Protection Area very close to the boundary with the Lower Thames Valley Source Protection Area. As a result, the IPZ-3 is delineated in both Source Protection Areas.

In the case of the Stoney Point intake, the concern is fuel spills and the parameter chosen to model was the benzene component of the fuel. The modelling completed for the Stoney Point IPZ-3 followed the general approach outlined in the MECP Technical Bulletin (July 2009). The modelling used to delineate the IPZ-3s for Essex Region Source Protection Area Lake St. Clair tributaries will not be discussed in this report as the IPZ-3 delineation in the Lower Thames Valley Source Protection Area is not dependant on that work.

Based on previous IPZ-2 work and some preliminary IPZ-3 work conducted by the Essex Region Source Protection Authority, Baird and Associates modelled 3 spills in the downstream portion of the Thames River watershed. Two fuel spills of 34,000 L of gasoline (with 2% benzene content) were chosen as this roughly corresponds to the volume contained in a tanker truck and one fuel spill of 68,000 L was chosen as it roughly corresponds to the volume contained in a rail tanker. While the spills chosen were transportation related, the modelling would be equally applicable to a spill from a fixed storage of equal size. Results of this early modelling indicated that the IPZ-3 would extend substantially further upstream in the tributaries. Therefore, staff at the Lower Thames Valley Conservation Authority expanded the Baird and Associates work by conducting additional modelling in the tributaries using the analytic approach described in MECP's Technical Bulletin.

Modelling in Lake St. Clair was conducted to determine contaminant concentrations arriving at the intake from a spill leaving the mouth of the Thames River under 2 different extreme events. The extreme events were selected as 100-year return period events using a joint probability analysis on wind direction, speed and duration as well as tributary flows. Those events include a 10-year return period wind event, 2 year return period flow in the St. Clair River and mean flow from the Thames River. This modelling showed that for one of the events, a 0.49 mg/L peak benzene concentration at the mouth of the Thames produced a 0.18 mg/L peak benzene concentration at the intake. This is an exceedance of the of the Ontario Drinking Water Standard (0.005 mg/L benzene) by a factor of 36.

Two spill locations for a 15,000 L gasoline spill and three spill locations for a 34,000 L spill were modelled using the analytical approach to determine the resulting concentrations at the mouth of the Thames River. The spill locations for the 15,000 L spills were 1) on the Thames River 1 km upstream of the Big Creek confluence and 2) on Big Creek 250 m upstream of the Baptiste Creek confluence. The spill locations for the 34,000 L spills were 1) on the Thames River 2 km upstream of the Prairie Siding Bridge approximately where the diking stops, 2) on Jeanettes Creek at the Forbes Internal Drain pump station, and 3) at the furthest upstream confluence in the Big Creek watershed on the West Ogle Drain in the Municipality of Leamington. The spill locations are shown on Map 4-10.

The 5 modelled fuel spills each produced a peak benzene concentration at the mouth of the Thames River of 0.20 mg/L or greater. This is approximately two-fifths of the concentrations used for the in-lake modelling that produced a 36 times exceedance at the intake. As a result, two Event Based Areas (EBA), one for a15,000 L fuel spill and one for a 34,000 L fuel spill have been delineated upstream from the mouth of the Thames River to these locations. IPZ-3 are delineated to include the EBAs beyond IPZ-1 and 2.

As the West Ogle Drain location was the furthest upstream confluence in the Big Creek watershed, all other branches and tributaries in the watershed were included in the 34,000 L EBA delineation. Spills on these watercourses should all produce similar or greater concentrations at the mouth of the Thames River since they all would have shorter travel times in the drainage network and smaller flows which would produce less dilution and dispersion

between the spill and the mouth of the Thames River.

The area of the lower Thames River watershed, including the Big Creek and Jeanettes Creek watersheds, through which this EBA (and IPZ-3) is being delineated, presents some particular challenges for modelling. The area is extremely flat and the elevation of the land is very similar to Lake St. Clair water levels. In order to keep the land dry enough for agriculture, much of the area is covered by dikes and pumping schemes. The pump stations are essentially dams that keep Lake St. Clair water from backing up the drainage network. The dams have pumps associated with them to pump the water from the upstream side of the dam to the lake side of the dam. The existence of these pumps present some challenges in applying the simple analytical models outlined in the MECP Technical Bulletin.

Preliminary exploratory modelling of the pumping schemes using the simple analytical models led to the conclusion that the watercourses behind the pumping schemes should be excluded from the EBA. The operation of the pumps are not tied directly to flow in a tributary nor necessarily related to flows in the Thames River. No particular pump can be assumed to be in operation just because a mean flow situation exists in the downstream tributary. If the pump is running, that means there is a significant depth of water accumulated on the upstream side of the pump. These depths far exceed what would be expected under gravity driven flows. Preliminary exploratory modelling using a modest upstream depth of 1 m when a pump is sending out mean flows suggested that this additional volume behind the pump was creating enough dilution that watercourses behind the pump scheme should be excluded from the EBA, especially when combined with the substantial dilution incurred when the smaller tributary exits into the much larger Thames River.

As specified in the Technical Rules 2013, the IPZ-3 (and therefore the EBA) extends on to the land a distance of 120 metres, or to the Floodplain Regulation Limit whichever is greater, as long as water from the land actually flows into the watercourse. The extensive diking system though this area limits the extent to which the IPZ-3 extends onto the land. As a result the director granted the SPC permission to use an alternative method to better delineate the extent of the IPZ-3. This resulted in not extending the IPZ-3 to the regulatory limit, but rather extending only to the top of the dykes as demonstrated by the event based modelling discussed above.

The Director's letter is included in Appendix 13. Throughout much of the downstream portion of the Thames River and Big Creek watersheds, the 34,000 L EBA only extends to the top of the dike, not the full 120 m nor to the Regulation Limit.

The upstream extents of the 34,000 L EBA on Thames River and Jeanettes Creek were determined primarily based on where the uncertainty was too great to include areas further upstream in the IPZ-3, rather than specific numeric results from the modelling areas upstream of these locations. On Jeanettes Creek, the EBA terminates at a large wetland pond area with a couple of islands in the middle. The simple analytical methods used for modelling dispersion and dilution in the watercourses were not designed for this situation. Rather than introducing additional uncertainty into the calculation by making a series of assumptions to deal with this area, the EBA terminates at that location. On the Thames River, the 34,000 L EBA was terminated at the upstream end of the dike system, about 5 km downstream from the City of Chatham. The additional uncertainty introduced by modelling through an urban area containing a complex storm drainage system, is not appropriate given the density of properties and uses within the area. As a result the EBA was terminated downstream of Chatham. The 15,000 L EBA was terminated at a location that produced the same peak benzene concentrations at the mouth of Thames River as that determined from the 34,000 L spill located on the Thames River. More thorough and site specific modelling should be considered in the future which might demonstrate that areas further upstream should be included in the EBA as part of a future update to this assessment report.

It is also possible that the EBA should extend further north and east along the Lake St. Clair shoreline. However, the next few outlets into the lake are controlled by pump schemes. Based on the preliminary exploratory modelling on pump schemes, it didn't seem likely that these drainage systems would be included.

It should be noted that the technical report by Baird and Associates also showed that a spill in the Thames River could reach the Belle River intake in the Essex Region Source Protection Area with a concentration exceeding the Ontario Drinking Water Quality Standard. Should consideration be given to delineating an EBA and IPZ-3 into the Lower Thames Valley Source Protection Area for that intake at some point in the future, it should be noted that the Stoney

Point IPZ-3 would be larger and be assessed a higher vulnerability. Source Protection Plan polices could be written to address these concerns at the Belle River intake by applying similar policies designed to protect the Stoney Point intake. System operators should however be aware that some spills resulting in an exceedance at the Stoney Point intake could also result in an exceedance at the Belle River intake.

Transport pathways such as agricultural tile drainage were not used to extend the EBA inland beyond regulatory limits or the 120 m setback as was done in IPZ-2. The extent of the Stoney Point EBAs are shown on Map 4-10.

4.2.6. Vulnerability Assessment of Intake Protection Zones

Within the *Intake Protection Zones*, the vulnerability must be assessed based on a number of factors. These factors include the vulnerability of the source and the area in the *Intake Protection Zone*.

Area Vulnerability factor: According to Rule 88, *IPZ-1* is assigned an area vulnerability factor of 10, while according to Rule 89, the factor for *IPZ-2* is between 7 and 9, where a higher number corresponds to a higher vulnerability. The area vulnerability factor for *Intake Protection Zone-2* is dependent on the percentage of area that is land in the *IPZ-2* (a higher percentage of land contributes to a higher area vulnerability factor) land cover, soil type and permeability of the land, slope of any setbacks (a greater runoff potential contributes to a higher area vulnerability factor), and the hydrological and hydrogeological conditions in the area that contributes water to the area through *transport pathways* (faster or more numerous *transport pathways* contributes to a higher area vulnerability factor).

The upland *IPZ-2* area of the Chatham/South Kent intake is comprised of more than 70% land of which less than 10% is impervious. These areas are characterized by flat topography with little relief. The land use activities within the upland area consist mostly of agricultural lands with minimal residential development along the shoreline. The pervious land is typically characterized by clay, clay loam, loam and silt loam soils. Seven constructed municipal drains as well as six storm sewer outlets discharge within the alongshore extent of the IPZ-2. A

moderate area vulnerability factor of 8 was selected for the Chatham/South Kent intake.

The upland *IPZ-2* area of the West Elgin primary intake is comprised of 59% land. The upland *IPZ-2* area of the West Elgin emergency intake is comprised of 80% land. The topography in both *IPZ-2* areas is gently sloping with generally well-drained sandy soils. Permeability is high due to natural land cover. The topography and the sandy soils support a lower area vulnerability factor. Six open watercourses located in the *IPZ-2* areas convey water to Lake Erie. While extensive agricultural activity is present within the *IPZ-2*s, the aerial photography shows that all of the open channels have vegetated buffers. These buffers reduce the potential of runoff. An area vulnerability factor of 7 was selected for the West Elgin primary intake, while an area vulnerability factor of 8 was selected for the West Elgin emergency intake.

The upland *IPZ-2* areas of both Wheatley intakes are comprised of more than 50% land of which less than 15% is impervious. These areas are characterized by flat topography with little relief. The land use activities within the upland area consist of agriculture lands, with minimal residential development along the shoreline and commercial development (contributing to impervious areas) within close proximity of Wheatley Harbour. The pervious land is composed predominately of clay, with sandy soils existing along the Lake Erie shoreline. There are seven municipal drains, six storm sewer outlets exist and one municipal storm water outlet in the upland *IPZ-2* areas of both intakes. A moderate area vulnerability factor of 8 was selected for the Wheatley intakes.

The methodology for determining the Area Vulnerability factor for the Stoney Point IPZ-3 is the same as that used for determining the IPZ-2 Area Vulnerability factors. The upland area in the IPZ-3 is composed of greater than 66% land. The area is very flat and mainly under agricultural production. Most of the area is tile drained. The dominant soil types in the area are clay with some loam type soils. The IPZ-3 is broken into zones of 6 hours of travel time. The zone immediately at the mouth of the Thames River starts with an Area Vulnerability factor of 7 which is consistent with the area vulnerability assigned in the ERSPA. From this score the value decreases by 1 for every additional 6 hours of travel time up the tributaries. These Area Vulnerability Factors are the same as those used on the Essex Region Source Protection Area side of the IPZ-3. Taken on its own, the 15,000 L IPZ-3 in the Lower Thames Valley Source

Protection Area would not be represented well by the above description as the area mostly covers the community Lighthouse Cove. However, when combined with the 15,000 L IPZ-3 on the Essex Region Source Protection Area, the values are likely representative of the whole of the 15,000 L IPZ-3, and for the sake of consistency, the same Area Vulnerability factors have been used.

Source Vulnerability factor: For a Great Lakes intake the source vulnerability factor is between 0.5 and 0.7 where a higher number corresponds to a higher vulnerability. According to the *technical rules 2013*, this is dependent on depth of the intake (deeper intake contributes to a lower source vulnerability factor), distance of the intake from shore (longer intake contributes to a lower source vulnerability factor), and the history of water quality concerns related to the intake (no concerns contributes to a lower source vulnerability factor). In addition to the factors required to be considered by the *rules*, the Ministry of Environment, Conservation and Parks (*MECP*) guideline for minimum submergence of an intake and the Michigan vulnerability categories for Great Lakes intakes (based on distance and depth) were considered for the Chatham/South Kent, West Elgin and Wheatley intakes in assessing the source vulnerability factor.

The intake depth and lengths are provided in Table 4-2 in this Section. The emergency intakes are typically closer to the shore and less deep than primary intakes, supporting a higher source vulnerability factor for the *IPZ-2* of the emergency intakes. However the primary intakes are far out enough into the Lake to support moderate source vulnerability factors.

For the Chatham/South Kent intake, raw (untreated) water quality review and plant operator opinions were considered. Overall there was not a large number of drinking water concerns identified for this intake. A source vulnerability factor of 0.5 was assigned to the Chatham/South Kent intake considering intake depth, length and number of water quality concerns.

For the West Elgin intakes, raw (untreated) water quality review and plant operator opinions were considered. High turbidity levels occur due to natural bluff erosion. Considering intake depth, length and number of water quality concerns, a source vulnerability factor of 0.6 was assigned to the West Elgin primary intake and a source vulnerability factor of 0.7 was assigned

to the West Elgin emergency intake.

For the Wheatley intakes, besides raw (untreated) water quality review and plant operator opinions, the historical concerns related to the previous Wheatley Harbour Area of Concern (*AOC*) (http://www.ec.gc.ca/raps-pas/default.asp?lang=En&n=96C6AD6F-1) are considered in assigning the source vulnerability factor. A factor of 0.6 was assigned to the Wheatley primary intake while a factor of 0.7 was assigned to the Wheatley emergency intake considering intake depth, length and number of water quality. The Source Vulnerability factor for the Stoney Point intake was determined by prior technical work conducted by the Essex Region Source Protection Authority and was determined to have a value of 0.9.

The Source Vulnerability factor is then multiplied by the Area Vulnerability factor to determine the Vulnerability Score of the zone. The vulnerability factors and scores of the *Intake Protection Zones* of the Lower Thames Valley Source Protection Authority are summarized in Table 4-3.

Table 4-3 Summary of Vulnerability Score of Intakes

Intake	Area Vulnerability Factor			Source Vulnerability Factor	Vulnerability Score		
	IPZ-1	IPZ-2	IPZ-3		IPZ-1	IPZ-2	IPZ-3
Chatham/South Kent Intake	10	8	na	0.5	5.0	4.0	na
Wheatley Primary Intake	10	8	na	0.6	6.0	4.8	na
Wheatley Emergency Intake	10	8	na	0.7	7.0	5.6	na
West Elgin Primary Intake	10	7	na	0.6	6.0	4.2	na
West Elgin Emergency Intake	10	8	na	0.7	7.0	5.6	na
Stoney Point intake (ERSPA)	na	na	7, 6, 5, 4, 3	0.9	na	na	6.3, 5.4, 4.5, 3.6, 2.7

Due to the nature of the *technical rules 2013* in assigning source vulnerability factors to Great Lakes intakes, the vulnerability scores would be below 8 in all cases. This influences the level of *threat* that could occur in a *vulnerable area* around a Great Lakes intake, as discussed in the Threats and Risk Assessment Section of this Assessment Report. In the Lower Thames Valley

Source Protection Area, the vulnerability scores of the Lake Erie *IPZ-1*s range from 5.0 to 7.0, and for *IPZ-2*s, range from 4.0 to 5.6. Activities in these Great Lakes intakes vulnerable areas are not classified as *significant threats* because for a Great Lakes intake, the vulnerability scores that can be assigned are less than 8. Similarly, even though intakes on Lake St. Clair are considered Type D and not Great Lakes intakes, the Vulnerability Scores start at 6.3 and decrease from there. Consequently, there can be no significant threats in the IPZ-3 based on the Vulnerability Scoring. In *IPZ-2* for the Chatham/South Kent Intake there can be no *threats* as the *rules* require that for an activity to be considered a *threat* it must occur in an area with a vulnerability score greater than 4. This is discussed in more detail in Section 7 - Threats and Risk Assessment.

4.2.7. Uncertainty in Intake Protection Zone delineation

The *technical rules* 2013 require that an analysis of the uncertainty, characterized by 'high' or 'low' be made in respect of the delineation and vulnerability assessment of surface water *intake protection zones*. The factors to be considered in the analysis include:

- the distribution, variability, quality and relevance of data used;
- the ability of the methods and models used to accurately reflect the flow processes in the hydrological system;
- the quality assurance and quality control procedures applied;
- the extent and level of calibration and validation achieved for models used or calculations or general assessments completed;
- the accuracy to which the area vulnerability factor and the source vulnerability factor effectively assess the relative vulnerability of the hydrological features.

Table 4-4 below summarizes the uncertainty assessed for the Chatham/South Kent and Wheatley IPZ-1s and IPZ-2s as identified by the consultants involved in the studies.

Table 4-4 Uncertainty Analysis for the Chatham/South Kent Intake, Wheatley Primary and Emergency Intakes

Component		IPZ-1	IPZ-2
Intake Protection Zone Delineation	In-Water	LOW	HIGH
	Upland	LOW	HIGH

	Overall	LOW	HIGH
Vulnerability Assessment		LOW	LOW
Overall Uncertainty Level		LOW	HIGH*
* A combined rating defaults to high level with presence of high in any component.			

Based on the data, model, model application, and model calibration, Baird and Associates, who did the hydrodynamic modelling (to delineate the in-lake *IPZ-2*) recommended that a high level of uncertainty be assigned to the Wheatley and Chatham/South Kent intakes *IPZ-2* in-water delineations. According to Baird, the uncertainty is not a reflection of the quality of work, but recognition of the limitations presented. Data gaps include recent bathymetry data and local (at the intake) wind data. MISED model limitations include it being a partial-lake model (hence cannot model lake-wide circulation movements) and not considering wave-induced currents. Further details are available in the Stantec Consulting Ltd. vulnerability assessment technical report on the Wheatley and Chatham/South Kent. The uncertainty associated with the Wheatley IPZ-3 and the Stoney Point IPZ-3 is high. These IPZ-3s were determined using the same models as was used for the IPZ-2 modelling. Therefore, the discussion above regarding why the IPZ-2s were assigned an uncertainty of high are equally applicable to the IPZ-3 delineations.

Table 4-5 below summarize the uncertainty assessed for the West Elgin *Intake Protection Zones*.

Table 4-5 Uncertainty Analysis for the West Elgin Intakes

Component		IPZ-1 (Primary and Emergency Intakes)	IPZ-2 (Primary Intake)	IPZ-2 (Emergency Intake)
Intake Protection Zone Delineation	In-water	LOW	LOW	HIGH
	Upland	LOW	LOW	LOW
	Overall	LOW	LOW	HIGH
Vulnerability Score		LOW	LOW	LOW
Overall Uncertainty Level		LOW	LOW	HIGH*
* A combined rating defaults to high level with presence of high in any component.				

The modeller of the in-lake *IPZ-2* for the West Elgin intakes has assigned a moderate to low level of uncertainty in the ECOMSED model to suitably represent the in-water conditions and shoreline connection required to model the in-water *IPZ-2* for the primary intake. The model was validated. The magnitude of simulated currents was in agreement with the currents

presented by *HCCL* for the Port Stanley *IPZ-2* (approximately 33 km southeast of the intake) and Acoustic Doppler Current Profiler (ADCP) derived surface currents were comparable to the ECOMSED model derived currents. Assumptions made due to unavailable information (strength of rip currents, horizontal momentum transfer parameters) were of a conservative nature and based on values that have been used in other surface waters where formal calibration was completed and/or on the modeller's experience in application of the 3-dimensional models to surface systems. Considering this, the modeller has assigned a moderate to low level of uncertainty in the delineation of the in-water *IPZ-2* for the primary intake. The *technical rules* 2013 require an uncertainty value of either 'high' or 'low' and as such, the modeller has selected 'low' as the reported uncertainty level.

A higher uncertainty was associated with the in-water portion of the West Elgin emergency intake *IPZ-2*. Due to the intake location in the surf zone, considerable uncertainty existed with regard to the alongshore extent of the model result. This uncertainty may be reduced in the future by visual observation of rip currents and calibration with ADCP data.

The peer reviewers have had considerable discussion with the consultants who have undertaken the studies for both surface water and ground water vulnerability assessment. Through that discussion it has become apparent that there is considerable subjectivity to the assignment of the *uncertainty* factors. It has been suggested that upon completion of the peer review of all of the reports that an overall assessment and comparison of the *uncertainty* be undertaken so that relative comparison between studies can be made and priorities for future assessment can be identified. It is important to understand that a high *uncertainty* associated with any aspects of the work does not suggest that the conclusions are inappropriate for the purposes that the results are being used. This is merely an acknowledgement of the potential for a better understanding with further analysis or data. If it were identified that the *uncertainty* was too great, additional work would have been undertaken to reduce the level of *uncertainty* if data were available to support the additional work. Even with the completion of additional work, it is unlikely that all *uncertainty* can be eliminated.

As described above, due to such things as data gaps and model limitations, there is *uncertainty* with the delineation of the *vulnerable areas*. In areas of lower *vulnerability*, this *uncertainty*

would not affect assessment of *risk* or the types of policies which would be developed in the *Source Protection Plan*. However, in areas of higher *vulnerability* which require *threats* assessments and policy development, the *Source Protection Committee* is satisfied that the *uncertainty* for all three intakes in the *SPA* is low enough for the purposes intended.

4.3 Wellhead Protection Areas

Wellhead Protection Areas or *WHPAs*, as they are often referred to, are the *vulnerable areas* which are delineated around groundwater sources of drinking water. Wells are used to extract the water from aquifers in the ground where water is contained in spaces, voids or fractures in the soil or rocks. Often many wells are used in an area to extract sufficient water to supply the needs of the customers. Multiple wells in an area are often referred to as a well field.

A *WHPA* can be delineated through one of the methods identified in rule 42:

- A computer based three-dimensional groundwater flow model;
- Two-dimensional analytical model;
- Uniform flow method; or
- Calculated fixed radius method.

In the Lower Thames Valley Source Protection Area, *WHPAs* have be delineated using computer based three-dimensional groundwater flow models as discussed in the Technical Studies section below. The models are used to calculate the time it takes for water to travel to the wells through the aquifer. For each well or well field, three areas are delineated based on the time of travel, while one is a fixed radius around the wells.

WHPA-A – 100 m fixed radius around each well
WHPA-B – 2 year time of travel to the well, excluding the area of WHPA-A
WHPA-C – 2 to 5 year time of travel to the well
WHPA-D – 5 to 25 year time of travel to the well

4.3.1. Technical Studies

The models used to delineate the time of travel based zones were originally developed through the county groundwater studies. The models for the systems in the Lower Thames Valley Source Protection Area were developed in the Essex Region/Chatham-Kent Region Groundwater Study (Volume 1: Geologic/Hydrogeologic Evaluation), December 2004. Through *MECP* technical studies the models were updated and refined by Dillon Consulting Limited as part of a project led by the Chatham-Kent Public Utilities Commission. The results of this work are included in the Source Protection Study: Ridgetown and Highgate Municipal Systems Vulnerability Assessment Report (Final Draft Report October 2009). All groundwater vulnerability assessment projects were subject to the peer review process described in Section 4.1 above.

4.3.2. WHPA-A

WHPA-A is a fixed radius around the well(s). Location of the wells were confirmed with the municipality and compared against orthographic imagery. A circle with a 100 m radius was delineated around the well using Geographic Information System (GIS) tools. This zone is shown with the other parts of the *WHPAs* in Map 4-5 and 4-6.

4.3.3. WHPA-B, WHPA-C and WHPA-D

The *WHPAs* in the Lower Thames Valley Source Protection Area were delineated with computer models as discussed earlier in the technical studies section. This work involved the development of a conceptual groundwater flow model based on current understanding of the local groundwater flow conditions and the aquifer properties. The aquifer locations and extents are conceptualized at this stage. A computer model is then developed based on the conceptual understanding. United States Geologic Survey (*USGS*) *MODFLOW* numerical groundwater flow model was developed through the previous Essex Region/Chatham-Kent Region Groundwater Study (2004). The models were calibrated and *MODPATH* was used to simulate particle movement in the capture zones and determine the extent of the travel time based *WHPA*. This estimates the horizontal travel time (within the aquifer) to the well. The model is run in reverse to determine where particles arriving at the well within the specified travel time could have originated.

The *WHPAs* in the Lower Thames Valley Source Protection Area are illustrated in Map 4-5 and

4-6.

4.3.4. WHPA-E and WHPA-F

Two other *WHPAs* can be delineated for wells which are under the direct influence of surface water (*Groundwater Under the Direct Influence* or *GUDI*). Systems are assessed to determine if they are *GUDI* through requirements of the Safe Drinking Water Act, 2002 (subsection 2(2) of O. Reg 170/03). Should a surface water body effectively bypass the aquifer's protection, a *WHPA-E* must be delineated. Rule 49(3) states that a *WHPA-E* is to be defined if the interaction between surface water and groundwater has the effect of decreasing the time of travel of water to the well when compared to the time it would take water to travel to the well if the raw water supply for the well was not under the direct influence of surface water. Rule 50 requires that a *WHPA-F* be delineated if the *WHPA-E* was delineated, and if the well is subject to *issues* which originate from outside the other parts of the *WHPA*. There are no GUDI municipal drinking water systems in the LTVSPA.

4.3.5. Vulnerability Assessment of the WHPA

Within the *WHPA* zones, the vulnerability must be assessed using one of the four methods described in Rule 37 of the *Technical Rules 2013: Assessment Report*:

- *Intrinsic susceptibility index* (*ISI*).
- Aquifer vulnerability index (*AVI*).
- Surface to aquifer advection time (*SAAT*).
- *Surface to well advection time* (*SWAT*).

Rule 15.1 also allows the use of a method which is equivalent or better than these methods provided the reason for the use of this method is documented in the Assessment Report and the Director has provided approval for the use of the alternative method.

In the *WHPAs* in the Lower Thames Valley Source Protection Area, two methods have been used. Intrinsic Susceptibility Index (*ISI*) was used for the vulnerability assessment of Highgate (now decommissioned). This method uses an index of depth and permeability of the materials which offer protection to the aquifers. The permeability of the material overlying the aquifer supplying the well is assessed at each location with a well record. The Ministry of the

Environment, Conservation and Parks (*MECP*) Water Well Information System (*WWIS*) contains borehole information collected at the time of the well construction. The province undertook a project to characterize the materials identified in this database so that a 'k' value can be assigned to each material identified in the well log. The 'k' value is then multiplied by the thickness of the material in metres and summed over the depth to the aquifer of interest. It results in a score which is then categorized as high, medium or low as identified in rule 38 (1). A high vulnerability is assessed where the sum of the thickness times the k value is less that 30. A medium vulnerability is assessed in areas where the sum of the products of thickness and k is less than 80 and greater than or equal to 30. Higher scores are considered low vulnerability.

At Ridgetown, Surface to Well Advection Time (*SWAT*) was used to assess the vulnerability of the municipal groundwater wells. *SWAT* is the time it takes for a particle of groundwater to move from the ground's surface to the well. The *SWAT* is comprised of two major components: (1) the time it takes for a particle to move from the ground's surface to the water table in the unsaturated zone (UZAT), and (2) the time it takes for a particle of water to move from the water table to the well (WWAT). Ridgetown has a relatively high water table (<3 m) and the additional travel time in the unsaturated zone is considered insignificant, therefore only the WWAT analysis was performed. The groundwater flow models developed to delineate the Ridgetown capture zones (MODFLOW and MODPATH) were also used in the *SWAT* analysis. *WWIS* data was used for static water levels. A grid of particles to be released at the water table was established. Particles were spaced 100 metres apart in the upgradient area of each well. The travel time of each particle to move from its original position to the well was then calculated, in order to determine WWAT. Travel time is represented in years and is mapped as: less than 5 years, 5 to 25 years, or greater than 25 years. A *SWAT* of greater than 25 years represents a low intrinsic vulnerability as illustrated in Map 4-6. Like the *ISI*, the *SWAT* is also categorized into high, medium, or low vulnerability.

Vulnerability of an area within a *WHPA* is assigned a score of 2 to 10 dependent on the *WHPA* zone that it is within (*WHPA-A*, *WHPA-B*, *WHPA-C*, *WHPA-D*, *WHPA-E* or *WHPA-F*), the method used to assess vulnerability (such as *ISI* or *SWAT*), and the vulnerability category (high, medium or low). Table 4-6 summarizes the possible vulnerability scoring using *ISI* or *SWAT*, according to the *Technical Rules 2013: Assessment Reports*. A higher score signifies a greater

vulnerability to contamination. For *GUDI* systems, *WHPA-E* is assessed similar to the methods of assessing *IPZ-2* and *WHPA-F* is assessed similar to the methods of assessing *IPZ-3*.

Table 4-6 WHPA vulnerability scoring (Technical Rules 2013)

Groundwater Vulnerability Category	Vulnerability Score			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Using ISI				
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	4	2
Using SWAT				
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	2	2

The results of the vulnerability assessment for the *WHPA* in the Lower Thames Valley Source Protection Area are shown in Maps 4-5 and 4-6. Vulnerability scores are summarized below in Table 4-7.

Table 4-7 WHPA vulnerability scores in LTVSPA

Well Supply System	Vulnerability Score			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Ridgetown wells (Erie and Scane well fields)	10	6	2	2

4.3.6. Adjustments to vulnerability to reflect transport pathways

Following the assessment of intrinsic vulnerability, information on constructed *transport pathways* is reviewed in order to examine whether an increase in the vulnerability score due to the presence of the *transport pathways* is needed. *Transport pathways* are man-made constructions such as oil wells, pipelines or excavations that may circumvent the natural protective layers above a groundwater aquifer. Factors such as hydrogeological conditions, type and nature of *transport pathways*, and cumulative impact of these pathways are considered. Water wells can also be *transport pathways* if they are not properly constructed or maintained.

An inventory of *transport pathways* was completed by the consultant and reviewed with the system operators. Natural *transport pathways* such as fracturing and karst are already considered, where appropriate, under the intrinsic vulnerability assessment.

For the Ridgetown system, the vulnerability of the pumped aquifer was not increased. Most of the identified *transport pathways* were not deemed *significant*, as these features are of shallow construction relative to the thickness (30 to 50 m) of the clay till aquitard that overlies the pumped aquifer. *Transport pathways* that are deemed to penetrate into the aquifer include both potable water wells and oil and gas wells. The density of these wells appears to be low based on the available data, and therefore an increase in the vulnerability of the aquifer is not considered necessary. Potential areas that may warrant a vulnerability increase include former and current well fields where the potential for yet to be discovered former wells exists. The Chatham-Kent Public Utilities Commission has informed Dillon that over the last number of years, abandoned wells associated with the municipal water supply have been identified, and properly decommissioned to *MECP* requirements.

Other identified *transport pathways* are not deemed *significant* with respect to their ability to degrade the protection that the overlying aquitard provides. These features, such as sewers, water main, and septic systems are relatively shallow, and would not compromise the integrity of the aquitard.

4.3.7. Uncertainty in the Vulnerability Assessment of WHPA

The *technical rules* 2013 state that an analysis of the uncertainty, characterized by 'high' or 'low' shall be made in respect of the delineation and assessment of groundwater *wellhead protection areas*. The factors to be considered in the analysis include:

- the distribution, variability, quality and relevance of data used;
- the ability of the methods and models used to accurately reflect the flow processes in the hydrological system;
- the quality assurance and quality control procedures applied;
- the extent and level of calibration and validation achieved for models used or calculations or general assessments completed;

- the accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of underlying hydrogeological features.

As stated in Source Protection Study, Ridgetown and Highgate Municipal Systems, Vulnerability Assessment Report, Final Draft Report (October 16, 2009):

> "The delineation of *wellhead protection areas* comprises a number of assumptions and estimates based on data such as lithology described in water well records and hydrogeological information provided from pumping test reports. Examples include the assumption that hydraulic properties such as permeability and porosity do not vary within a hydrostratigraphic unit (i.e., the aquifer). The boundary conditions are also assumptions that are based on the conceptual model. Each model was developed using the available data and, therefore, the model results represent an estimate based on that data. In general, the results of models can always be improved by incorporating additional information as it becomes available in the future. Even with this uncertainty, the wellhead delineation process provides a good indication of the source of the water for the water supply system, which can facilitate the development of a water resource protection policy."

Modelling

For the Ridgetown system, the most significant limitation for the groundwater flow model is the unpredictable/unknown nature of the regional groundwater flow at the site. The static water levels recorded in the water well records are notably erratic. Although uncertainty in water well record data is quite well known, the Ridgetown well data is particularly erratic. However, the certainty of the model is deemed to increase in the immediate vicinity of the well field.

For the Ridgetown system, there is a high uncertainty associated with hydraulic head levels (taken at different times of the year over several decades), groundwater recharge values (which are not measured directly), and the heterogeneity of the overburden aquifer hydraulic conductivity (could not be completely identified based on the data available).

Intrinsic Vulnerability Assessment

The results of the Ridgetown *WHPA* model using *SWAT* are consistent with the *GUDI* assessment of 2002. Overall, the uncertainty associated with the vulnerability assessment of the Ridgetown System is low.

Transport Pathways

Some uncertainty is associated with the mapping of transport pathway information for the Ridgetown well systems. Since information on the presence or absence of *transport pathways* did not involve confirmatory site visits, the actual presence of the identified *transport pathways* is unknown. Therefore, the mapped extent of the area where these *transport pathways* exist is deemed conservative. The only features of concern would be poorly maintained water wells or oil and gas wells. Many of these locations are unknown.

Overall Uncertainty

Based on the discussion above, the uncertainty associated with the vulnerability assessment of the Ridgetown *Wellhead Protection Areas* is deemed 'High', as defined by the *technical rules 2013*. The ranking is based largely on the uncertainty associated with the *wellhead protection area* modelling rather than the aquifer vulnerability assessment for the system.

As discussed above in the Surface Water section, the peer reviewers have had considerable discussion with the consultants who have undertaken the studies for both surface water and ground water vulnerability assessment. Through that discussion it has become apparent that there is considerable subjectivity to the assignment of the uncertainty factors. It has been suggested that upon completion of the peer review of all of the reports that an overall assessment and comparison of the uncertainty be undertaken so that relative comparison between studies can be made and priorities for future assessment can be identified. It is important to understand that a high uncertainty associated with any aspects of the work does not suggest that the conclusions are inappropriate for the purposes that the results are being used. This is merely an acknowledgement of the potential for a better understanding with further analysis or data. If it were identified that the uncertainty was too great, additional work

would have been undertaken to reduce the level of uncertainty if data were available to support the additional work. Even with the completion of additional work, it is unlikely that all uncertainty can be eliminated.

4.4 Highly Vulnerable Aquifers

As discussed earlier, there are four methods with which the vulnerability of an aquifer can be assessed. These methodologies were applied to the assessment of the *wellhead protection areas* as discussed above. These same methodologies can be applied, on a much larger scale, to the assessment of the vulnerability (or intrinsic susceptibility as it is also referred to) of the first significant aquifer across the entire Source Protection Region. Areas which are identified through these methods as being highly vulnerable, and the aquifers beneath them, are to be identified as *Highly Vulnerable Aquifers* according to rule 43 of the *Technical Rules 2013: Assessment Report*.

In the Thames-Sydenham and Region, *Highly Vulnerable Aquifers* (*HVA*) were mapped using the Intrinsic Susceptibility Index described above. *ISI* was available across the entire region from the county groundwater studies. In some areas the other vulnerability assessment methodologies (*AVI*, *SWAT* or *SAAT*) have been calculated and mapped, however they have not been applied across the entire region. A seamless product across the region is needed. It is acknowledged that there will likely be challenges in matching the vulnerability assessment map discussed here, with the mapping products developed by neighbouring source protection regions. This will need to be considered in subsequent assessment reports after all of the neighbouring regions' products have been developed. This will present a challenge for municipalities which are within more than one Source Protection Region. These differences will also need to be considered in the development of the *Source Protection Plan* in those areas. In determining which vulnerability assessment method to apply in the region it was also important to consider the data which is available to support the methodology. As the data necessary to apply these other methods is not available in many of the areas, it was not possible to apply the other methods across the entire region without undertaking considerably more work. As such, *ISI* was used to assess the vulnerability in the Thames-Sydenham and Region.

Although the county groundwater studies followed a consistent terms of reference and

methodology and were reviewed through an *MECP* developed peer review process, there were significant challenges when edge matching the work between adjacent studies. Many of the products developed through the groundwater studies (such as water table elevation and overburden thickness) were edge matched in the Southwest Region Edge-Matching Study Results (Waterloo Hydrologic Inc., 2005). *ISI*, however, was not able to be seamlessly matched throughout the region. Instead, a product was developed which identified the areas of overlap between study areas where the *ISI* index was one or two levels different (Map 18 of Appendix 5). In order to use this product to describe the intrinsic vulnerability in the region, it needed to be updated to ensure seamless mapping across the entire region. Further, it is important that consistent methodologies be applied to all areas within the region. The work described in this section is described in detail in the *Highly Vulnerable Aquifer* Identification (Upper Thames River Conservation Authority, November 2009) report.

The *ISI* scores from the wells across the region were obtained from the data of the county groundwater studies. This data covered most of the region, however it was identified that in the western end of Elgin County there were very few points where the *ISI* had been calculated. Updated Water Well Information System (*WWIS*) data was reviewed in the hopes that it contained additional information in this area which was not used during the county groundwater studies. The updated *WWIS* had been corrected to reduce the locational uncertainty of many of the data points. This newer data resulted in very few additional points in the western end of Elgin County. Therefore it was necessary to reconsider the location screening which was applied to the data. In the previous study, lot centroid values were removed from the interpolation due to the level of uncertainty in the location of the well. Due to the lack of data in this area, it was determined that it was better to use the lot centroid information than have the entire area interpolated based on data from outside this area, as was done in the previous study. As a result, the wells with a modest level of locational uncertainty were included in the analysis. Dillon was contracted to undertake the *ISI* calculations for the wells in this area so that they could be included in the regional interpolation of the *ISI* scores. These points, when supplemented with the surficial geology discussed below, result in significant improvements in the assessment of the vulnerability in this area from that which was available from the county groundwater studies.

The *ISI* calculations consider the vulnerability only at points where information on the depth and type of materials overlaying the water table is available. The information source for this geologic interpretation was the Water Well Information System (*WWIS*). This database includes a characterization of the materials encountered in the drilling of water wells. Materials are described by the drillers and then entered into this information system along with other details associated with the well, such as the static level of the water in the completed well. As discussed earlier, the *ISI* score had previously been calculated at each well. This data, augmented with the newly calculated *ISI* in the parts of western Elgin County, was used as the basis for the initial vulnerability map. Geographic Information System (*GIS*) tools are often used to interpolate values between the discrete points where the value is known. These tools determine the best fit of a surface through the thousands of values across a region. Various computer algorithms are available in the *GIS* programs to undertake this interpolation or smoothing. The county groundwater studies used different tools to undertake this smoothing of the *ISI*. For a seamless product across the entire Source Protection Region it was necessary to use the same algorithms across the entire region. The 'Natural Neighbour' method was used by many of the studies to provide an interpolation of data between neighbouring water well locations. In some of the studies, the results were similar to the 'Kriging' method. Natural Neighbour is, however, simpler to apply with fewer options as to how to apply the method. This is an advantage as this method will be better able to be reproduced and updated in the future. Natural Neighbour was therefore used for the seamless update of the *ISI* across the region.

Another difference between the studies was in which values of intrinsic vulnerability were interpolated. In some studies the *ISI* scores were interpolated, whereas other studies interpolated an index which represented whether the score was high, medium or low. As discussed above, an *ISI* score of less than 30 results in a high vulnerability. These were assigned an index value of 1, whereas medium vulnerabilities were assigned an *ISI* of 2 and lows were assigned an *ISI* of 3. In many of the county groundwater studies, these 1, 2 and 3 values were interpolated across the study areas. This resulted in a continuously variable surface with values ranging from less than 1 to greater than 3. It was therefore necessary to determine the breakpoints between high, medium and low within this continuous surface to determine where the lines should be between the high, medium or low area. In investigating this, the study team found that this was not well documented and that it was apparent that

various breakpoints were used for the separation of high, medium and low areas. For the purposes of this update, the scores were interpolated rather than the index values, allowing the breakpoints specified in the *rules* to be used in the delineation between high, medium and low vulnerability.

As discussed above, an *ISI* score is only calculated at points where the WWIS contained information. Even with the extensive number of wells which were used, there are areas where there are no wells to define the vulnerability. A simple illustration of this is to consider where wells are generally located. They will normally be located in an area where there are homes or other buildings. The buildings tend to be located close to the roads. As a result, areas between the roads tend not to have many wells. Sand and Gravel information from the surficial geology (*OGS*) was used to define features which were not well represented in the *ISI* data. In some areas, the surficial geology sand and gravel areas suggests that small areas of high vulnerability identified through the *ISI* mapping may be more extensive or connected to other areas which the *ISI* had identified as high vulnerability. This required professional judgment through an extensive comparison of the well records within and around these features to determine whether areas of *highly vulnerable aquifers* were missed in the *ISI* mapping that was developed. This work was undertaken by the region's staff hydrogeologist and was peer reviewed as described in the peer review section above. Where the sand and gravel information agreed with the water well records, the extent of the surficial geology feature (sands and gravels) was used to connect smaller pockets of high vulnerability. Where water well information did not seem to agree with the surficial geology information, examination of the well record and air photo interpretation were used to determine if the well record should be included in the *ISI* interpolation. Further, an assessment as to whether the sand and gravel area identified in the surficial geology features is likely to contain an aquifer was also undertaken where these areas were being added to the highly *vulnerable areas* identified through the seamless *ISI*. Where individual pixels smaller than 200 m square were identified in the seamless *ISI* mapping they were screened out.

The areas where the *ISI* score was calculated or interpolated to be less than 30 are identified as *Highly Vulnerable Aquifers*. The use of a second data source (surficial geology features) and professional judgment to supplement and confirm the results of the *ISI* work give more certainty

to the areas delineated as *Highly Vulnerable Aquifers*. This also resulted in a more comprehensive identification of *highly vulnerable aquifers* across the region than could be provided by the *ISI* information calculated and interpolated from well locations. Map 4-7 illustrates the *highly vulnerable aquifers* within the Lower Thames Valley Source Protection Area.

These areas of high vulnerability identified as *HVA*s were overlaid over the areas of medium or low vulnerability from the seamless *ISI* developed as described above to produce a seamless vulnerability mapping across the region. In this manner, areas identified as *Highly Vulnerable Aquifers* were assigned a vulnerability of high. Those areas which were not identified as *highly vulnerable aquifers* retained the low or medium vulnerability from the seamless vulnerability mapping. The resulting regional scale map is included as Map 4-7a.

4.5 Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas or *SGRA*s are delineated through the Water Budget Process. In the Lower Thames Valley Source Protection Area these were delineated through the Tier 1 Water Budget. The delineation of the *SGRA*s are described in detail in Section 3 – Water Budget and Water Quantity Stress Assessment.

Rule 44 defines *Significant Groundwater Recharge Areas* as those areas where the recharge is:

- more than 1.15 times the average recharge in the area or
- 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.

The areas which meet either of these criteria are shown in Map 4-8 which shows the delineated *SGRA*. Map 4-8 filters out areas which are based on single grids from the analysis (less than 25 ha in area).

4.6 Data Gaps and Next Steps

The data gaps encountered in the assessment of vulnerability are listed in the Table 4-8.

Table 4-8 Vulnerability Assessment Data Gaps Relevant to the Lower Thames Valley SPA

Data Gap	Description
IPZ-3 for Lake Erie Intakes	Gap is allowed in technical rules 2013 provided a work plan is submitted. The work plan to fill the gap (in an amended Assessment Report) is in Section 9 - Data Gaps and Next Steps
Better drainage information to delineate IPZ-2 transport pathways and storm sewersheds	Adjustments may be made to IPZ-2 transport pathways and storm sewersheds as a result of better drainage information determined through site-specific (Tier 2) Risk Assessment
Groundwater model parameters (hydraulic conductivity, recharge, hydraulic head)	Lack of data; might be an opportunity for future monitoring
WHPA Transport Pathways	Locations of water, oil and gas wells in WHPA
Edge matching of HVA and SGRA with neighbouring regions	This work will be considered when neighbouring regions' HVA and SGRA maps are complete
Water well data in western portion of Elgin County, for HVA determination	Lack of data; might be an opportunity for future monitoring
Aquifer mapping	Better understanding of the conceptual geologic model including mapping of the lateral extent of the aquifers and aquitards and recharge areas feeding these aquifers

5.0 Issues Evaluation

Under the Clean Water Act (2006), drinking water quality *issues* must be identified for *drinking water systems* included in the Assessment Report. In the Lower Thames Valley Source Protection Area, there are surface and groundwater municipal *drinking water systems*, shown in Map 1-3. A drinking water quality *issue* is a *parameter* (substance) or *pathogen* (disease-causing microorganism) shown to deteriorate, or trend towards a deterioration of raw (untreated) water quality. This Section of the Assessment Report describes what substances in source (untreated) water may be considered *issues* as well as the methodology used to identify *issues*. A list of drinking water quality *issues* identified in the Lower Thames Valley Source Protection Area is also provided.

5.1 What is a Drinking Water Quality Issue?

The *Technical Rules 2013: Assessment Report* indicates which substances can be considered in the identification of drinking water quality *issues* in raw (untreated) source water. They are the Schedule 1, 2 and 3 *parameters* of the Ontario Drinking Water Quality Standards (Reg. 169/03 of the Safe Drinking Water Act, 2002) and Table 4 *parameters* of the Technical Support Document for the Ontario Drinking Water Standards, Objectives and Guidelines (an MECP publication, PIBS4449e01, June 2006). *Pathogens*, which are disease-causing organisms, can also be considered in the identification of drinking water quality *issues*.

The *Schedule 1 parameters* are the two indicator microorganisms, total coliform and *Escherichia coli (E. coli)*. These *parameters* are routinely tested in raw source and treated water, and also in distribution systems, under the Safe Drinking Water Act (2002). The testing of *Schedule 1 parameters* in raw water helps indicate possible pathogenic contamination in the raw water prior to treatment.

The *Schedule 2 parameters* are chemical substances such as lead, nitrate and atrazine. The *Schedule 3 parameters* are radio-active material such as uranium-235. The Schedule 1, 2 and 3 *parameters* have human-health based treated drinking water standards called *Maximum Acceptable Concentrations (MAC)*. The Schedule 1, 2 and 3 *parameters* and their safe levels (in

treated drinking water) are listed in Tables 5-1, 5-2 and 5-3.

The *Table 4 parameters* are physical (such as taste, colour and turbidity) and chemical (such as sodium, iron and chloride) substances. Some of these affect the aesthetic quality of the water (taste, odour), and hence their treated water criteria are called *Aesthetic Objectives (AO).* Yet other Table 4 substances may interfere with the efficient and effective treatment, disinfection and distribution of the water (alkalinity, hardness), and their treated water criteria are called *Operational Guidelines (OG).* The Table 4 *parameters* and their objectives and guidelines (in treated drinking water) are listed in Table 5-4.

Pathogens are disease-causing protozoa, bacteria or viruses. Protozoa and bacteria are single-celled microscopic living organisms, while viruses are smaller than, and can live in, a single cell. *Pathogens* can cause severe or fatal waterborne illness in humans. Some are resistant to commonly used disinfectants at water treatment plants. Examples of *pathogens* include *Salmonella, Campylobacter, E. coli* strain O157:H7, *Legionella* and *Helicobacter pylori* (waterborne bacteria), noroviruses, hepatitis A and rotaviruses (intestinal viruses), and *Giardia* and *Cryptosporidium* (protozoa). In the *Technical Rules2013: Assessment Report*, unlike *parameters* listed in Schedule 1, 2 and 3, and Table 4, *pathogens* are not limited to a specific list. The *Schedule 1 parameters* (total coliform and *E. coli*) are routinely monitored, as described earlier, to indicate possible pathogenic contamination of raw water sources. However, specific *pathogens* are not monitored routinely in raw water sources unless there is an indication that monitoring of a specific *pathogen* is warranted.

Table 5-1: Schedule 1 Parameters (from O. Reg. 169/03 of the Safe Drinking Water Act, 2002) and their Treated Drinking Water Quality Standards

Item	Microbiological Parameter	Standard (MAC, counts/100 mL)
1.	*Escherichia coli* (E. coli)	Non detectable
2.	Total coliforms	Non detectable

Table 5-2 Schedule 2 Parameters (O. Reg. 169/03 of the Safe Drinking Water Act, 2002) and their Treated Drinking Water Quality Standards

Item	Chemical Parameter	Standard (MAC, mg/L)	Item	Chemical Parameter	Standard (MAC, mg/L)
1.	Alachlor	0.005	40.	Diuron	0.15
2.	Aldicarb	0.009	41.	Fluoride	1.5 [b]
3.	Aldrin + Dieldrin	0.0007	42.	Glyphosate	0.28
4.	Antimony	0.006	43.	Heptachlor + Heptachlor Epoxide	0.003
5.	Arsenic	0.025	44.	Lead	0.010 [c]
6.	Atrazine + N-dealkylated metabolites	0.005	45.	Lindane (Total)	0.004
7.	Azinphos-methyl	0.02	46.	Malathion	0.19
8.	Barium	1.0	47.	Mercury	0.001
9.	Bendiocarb	0.04	48.	Methoxychlor	0.9
10.	Benzene	0.005	49.	Metolachlor	0.05
11.	Benzo(a)pyrene	0.00001	50.	Metribuzin	0.08
12.	Boron	5.0	51.	Microcystin LR	0.0015
13.	Bromate	0.01	52.	Monochlorobenzene	0.08
14.	Bromoxynil	0.005	53.	Nitrate (as nitrogen)	10.0 [d]
15.	Cadmium	0.005	54.	Nitrite (as nitrogen)	1.0 [d]
16.	Carbaryl	0.09	55.	Nitrate + Nitrite (as nitrogen)	10.0 [d]
17.	Carbofuran	0.09	56.	Nitrilotriacetic Acid (NTA)	0.4
18.	Carbon Tetrachloride	0.005	57.	N-Nitrosodimethylamine (NDMA)	0.000009
19.	Chloramines	3.0	58.	Paraquat	0.01
20.	Chlordane (Total)	0.007	59.	Parathion	0.05
21.	Chlorpyrifos	0.09	60.	Pentachlorophenol	0.06
22.	Chromium	0.05	61.	Phorate	0.002
23.	Cyanazine	0.01	62.	Picloram	0.19
24.	Cyanide	0.2	63.	Polychlorinated Biphenyls (PCB)	0.003
25.	Diazinon	0.02	64.	Prometryne	0.001
26.	Dicamba	0.12	65.	Selenium	0.01
27.	1,2-Dichlorobenzene	0.2	66.	Simazine	0.01
28.	1,4-Dichlorobenzene	0.005	67.	Temephos	0.28
29.	Dichlorodiphenyltrichloroethane (DDT) + metabolites	0.03	68.	Terbufos	0.001
30.	1,2-Dichloroethane	0.005	69.	Tetrachloroethylene (perchloroethylene)	0.03
31.	1,1-Dichloroethylene (vinylidene chloride)	0.014	70.	2,3,4,6-Tetrachlorophenol	0.1
32.	Dichloromethane	0.05	71.	Triallate	0.23
33.	2,4-Dichlorophenol	0.9	72.	Trichloroethylene	0.005
34.	2,4-Dichlorophenoxy acetic acid (2,4-D)	0.1	73.	2,4,6-Trichlorophenol	0.005
35.	Diclofop-methyl	0.009	74.	2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	0.28
36.	Dimethoate	0.02	75.	Trifluralin	0.045
37.	Dinoseb	0.01	76.	Trihalomethanes (THMs)	0.100 [e]
38.	Dioxin and Furan	0.000000015 [a]	77.	Uranium	0.02
39.	Diquat	0.07	78.	Vinyl Chloride	0.002

Notes: (a) Total toxic equivalents when compared with 2,3,7,8-TCDD. **(b)** When added to drinking water, it is recommended to adjust the fluoride concentration to be 0.5 to 0.8 mg/L for optimal level of tooth decay control. Where supplies contain naturally occurring levels higher than 1.5 mg/L but less than 2.4 mg/L, the Ministry of Health and Long Term Care recommends an approach through local boards of health to raise public and professional awareness to control excessive exposure to fluoride from other sources. **(c)** This standard applies to water at the point of consumption. **(d)** Where both nitrate and nitrite exist, the total of both should not exceed 10 mg/L. **(e)** This standard is expressed as the running annual average of quarterly samples measured at point reflecting the maximum residence time in the distribution system.

Table 5-3 Schedule 3 Parameters (O. Reg. 169/03 of the Safe Drinking Water Act, 2002) and their Treated Drinking Water Quality Standards

Item	Radiological Parameter	Standard (MAC, in becquerels per litre)	Item	Radiological Parameter	Standard (MAC, in becquerels per litre)
Natural Radionuclides			Artificial Radionuclides Continued		
1.	Beryllium-7	4000.0	40.	Iron-55	300.0
2.	Bismuth -210	70.0	41.	Iron-59	40.0
3.	Lead-210	0.1	42.	Manganese-54	200.0
4.	Polonium-210	0.2	43.	Mercury-197	400.0
5.	Radium-224	2.0	44.	Mercury-203	80.0
6.	Radium-226	0.6	45.	Molybdenum-99	70.0
7.	Radium-228	0.5	46.	Neptunium-239	100.0
8.	Thorium-228	2.0	47.	Niobium-95	200.0
9.	Thorium-230	0.4	48.	Phosphorus-32	50.0
10.	Thorium-232	0.1	49.	Plutonium-238	0.3
11.	Thorium-234	20.0	50.	Plutonium-239	0.2
12.	Uranium-234	4.0	51.	Plutonium-240	0.2
13.	Uranium-235	4.0	52.	Plutonium-241	10.0
14.	Uranium-238	4.0	53.	Rhodium-105	300.0
Artificial Radionuclides			54.	Rubidium-81	3000.0
15.	Americium-241	0.2	55.	Rubidium-86	50.0
16.	Antimony-122	50.0	56.	Ruthenium-103	100.0
17.	Antimony-124	40.0	57.	Ruthenium-106	10.0
18.	Antimony-125	100.0	58.	Selenium-75	70.0
19.	Barium-140	40.0	59.	Silver-108m	70.0
20.	Bromine-82	300.0	60.	Silver-110m	50.0
21.	Calcium-45	200.0	61.	Silver-111	70.0
22.	Calcium-47	60.0	62.	Sodium-22	50.0
23.	Carbon-14	200.0	63.	Strontium-85	300.0
24.	Cerium-141	100.0	64.	Strontium-89	40.0
25.	Cerium-144	20.0	65.	Strontium-90	5.0
26.	Cesium-131	2000.0	66.	Sulphur-35	500.0
27.	Cesium-134	7.0	67.	Technetium-99	200.0
28.	Cesium-136	50.0	68.	Technetium-99m	7000.0
29.	Cesium-137	10.0	69.	Tellurium-129m	40.0
30.	Chromium-51	3000.0	70.	Tellurium-131m	40.0
31.	Cobalt-57	40.0	71.	Tellurium-132	40.0
32.	Cobalt-58	20.0	72.	Thallium-201	2000.0
33.	Cobalt-60	2.0	73.	Tritium	7000.0
34.	Gallium-67	500.0	74.	Ytterbium-169	100.0
35.	Gold-198	90.0	75.	Yttrium-90	30.0
36.	Indium-111	400.0	76.	Yttrium-91	30.0
37.	Iodine-125	10.0	77.	Zinc-65	40.0
38.	Iodine-129	1.0	78.	Zirconium-95	100.0
39.	Iodine-131	6.0			

Table 5-4 Table 4 Parameters (from the Technical Support Document for the Ontario Drinking Water Standards, Objectives and Guidelines, MOE 2006) with their Treated Drinking Water Aesthetic Objectives and Operational Guidelines

Table 4 Parameter	AO	OG
1,2-Dichlorobenzene	0.003[a] mg/L	
1,4-Dichlorobenzene	0.001[a] mg/L	
2,4-Dichlorophenol	0.0003[a] mg/L	
2,3,4,6-Tetrachlorophenol	0.001[a] mg/L	
2,4,6-Trichlorophenol	0.002[a] mg/L	
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	0.02[a] mg/L	
Alkalinity (as $CaCO_3$)		30-500 mg/L
Aluminum		0.1 mg/L
Chloride	250 mg/L	
Colour	5 TCU	
Copper	1 mg/L	
Dissolved Organic Carbon	5 mg/L	
Ethylbenzene	0.0024 mg/L	
Hardness (as $CaCO_3$)		80-100 mg/L
Heterotrophic Plate Count (HPC)-General bacteria population expressed as colony counts on a heterotrophic plate count		f
Iron	0.3 mg/L	
Manganese	0.05 mg/L	
Methane	3L/ m^3	
Monochlorobenzene	0.03[a] mg/L	
Odour	Inoffensive	
Organic Nitrogen		0.15 mg/L
pH		6.5-8.5 (no units)
Pentachlorophenol	0.03[a] mg/L	
Sodium	b	
Sulphate	500[c] mg/L	
Sulphide	0.05 mg/L	
Taste	Inoffensive	
Temperature	15^0C	
Toluene	0.024 mg/L	
Total Dissolved Solids	500 mg/L	
Turbidity	5 NTU[d]	e
Xylenes	0.3 mg/L	
Zinc	5 mg/L	

Notes: (a) Refer to Table 5-2 (Schedule 2 parameters) for MAC standard. **(b)** The AO for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets. **(c)** When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people. **(d)** Applicable for all waters at the point of consumption. **(e)** The OGs for filtration processes are provided as performance criteria in the Procedure for Disinfection of Drinking Water in Ontario. **(f)** Increases in HPC concentrations above baseline levels are considered undesirable.

5.2 Impact of Identifying an Issue

Should an *issue* be identified as per Technical Rule 114, the *issue* contributing area must be delineated as per Rule 115. Also as per rule 115, activities that contribute to the *issue* within the *issue* contributing area must be identified and are deemed to be a *significant risk* to the source of drinking water for those systems included in the Terms of Reference for the LTVSPA. *Significant risks* must be mitigated through the *Source Protection Plan*. If the information required to delineate the ICA and identify the activities contributing to an issue are not readily ascertained, rule 116 allows for a work schedule to be identified to ascertain the information specified in rule 115.

As per Technical Rules (2013) 68, 130 and 131, a third intake protection zone (*IPZ-3*) for surface water intakes may be delineated to include the activity and area known to contribute to the drinking water quality *issue*. These tasks are yet to be completed and will be part of an amended Assessment Report.

In addition to the identification of an issue by rule 114, rule 115, 1 allows for the indentification of an issue which is not identified in accordance with rule 114. This is often referred to as an issue identified under the Act to differentiate it from an issue identified under the rules (specifically rule 114). Issues identified as per rule 115.1 do not require the delineation of an ICA and cannot have significant threats identified which contribute to the issue. They may however be addressed through specify action policies and be the subject of monitoring and reporting.

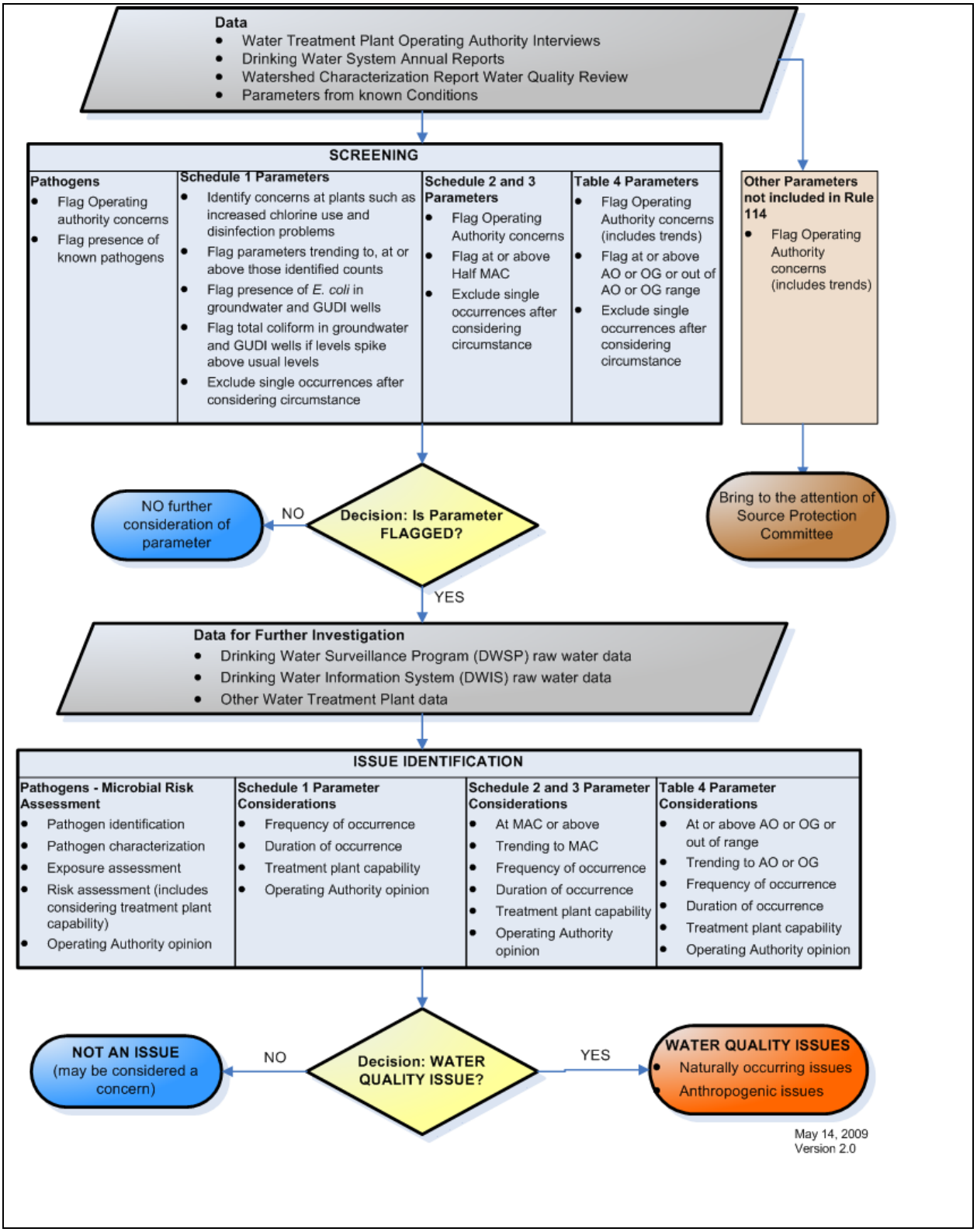
5.3 Issue Evaluation Methodology

Identifying *issues* is a key step in the overall process of protecting drinking water quality. *Issues* were identified in the Lower Thames Valley Source Protection Area by following the Thames-Sydenham and Region Issues Evaluation Methodology (May 14, 2009), depicted in Figure 5-1. This methodology was developed to guide the technical work to assess an issue under the Rules (rule 114.) The methodology is provided in Appendix 8. The evaluation is a two step process. Firstly, in the screening step, raw (untreated) water quality data is compared to a benchmark and *parameters* may be flagged if they meet the screening criteria. The benchmarks

for chemical, physical and radioactive *parameters* are generally half the applicable human health based Ontario drinking water standards (*Maximum Acceptable Concentrations,* or *MAC*), and the full levels of the *Aesthetic Objectives (AO) and Operational Guidelines (OG)*, and any plant operating authority concerns. Secondly, in the identification step, an investigation of the *parameters* flagged through the first step is undertaken. This includes a review of trends and spikes, frequency and duration of occurrence, presence at or trending towards the applicable *MAC*, *AO* or *OG* benchmark, consideration of existing water treatment plant capabilities and discussions with the water treatment plant operating authority.

Pathogens are also evaluated in a two step process that differs from the evaluation of the Schedule 1, 2, 3 and Table 4 *parameters*. In the first step (screening), *pathogens* are flagged if they are a concern to the operating authority, known to occur in raw water, persist in treated water, or have caused a waterborne outbreak in the past. A *pathogen* that is flagged through the screening process must be subject to a microbial risk assessment to identify whether it is an *issue*. This assessment involves *pathogen* characterization, exposure assessment and risk characterization. Some of the elements considered in a microbial risk assessment are: pathological characteristics, infection mechanisms, resistance to control or treatment, survival, persistence, seasonality, reliability of treatment processes and route of human exposure.

Figure 5-1: Thames-Sydenham and Region Issues Evaluation Methodology



5.4 Issues Evaluation Technical Studies

As described in Section 4 – Vulnerability Assessment, a large project, led by the Essex Region Conservation Authority (*ERCA*) was initiated through a partnership between *ERCA* and the Conservation Authorities in the Thames-Sydenham and Region and the plant operators. This project included 7 intakes in the Essex Region and 3 Chatham-Kent intakes in the Thames-Sydenham and Region. Stantec Consulting Limited was the primary consultant. The Municipality of Chatham-Kent Public Utilities Commission (*PUC*) was an active partner in the project and participated in the technical steering of the project.

Another project was led by the Municipality of West Elgin with the Ontario Clean Water Agency (*OCWA*) providing technical and project management services for the municipality. The West Elgin water treatment plant is owned by the Municipality of West Elgin and is managed by the Tri-County Water Management Committee.

The technical studies are listed below In Table 5-5.

Table 5-5 Technical Studies on Drinking Water Quality Issues Evaluation

Drinking Water Systems	Technical Study on Issues Evaluation
Wheatley, Chatham/ South Kent intakes	Technical Memorandum: Issues Technical Memorandum: Issues Identification for the Thames Sydenham Region Water Treatment Plants. Essex Chatham-Kent Source Protection Planning Technical Study. Stantec Consulting Ltd. February 2010.
West Elgin	1. Issues Evaluation Technical Memorandum: Issues Evaluation for the West Elgin Water Plant Treatment. Muncipaltiy of West Elgin Source Protection Planning Technical Study. Stantec Consulting Ltd.. March 2010. 2. Potential Threats Analysis and Issues Evaluation for the West Elgin Water Treatment Plant Emergency Intake. Municipality of West Elgin Source Protection Planning Technical Study Phase 2 – Potential Threats Analysis TM. Final Report. Stantec Consulting Ltd. June 2010
Wheatley and Chatham/South Kent Intakes	1. Technical Memorandum on Issue Evaluation for Microcystin-LR at Lake Erie Drinking Water Intakes in the Essex Region, ERSPA Assessment Report Appendix XV, November 2014 2. SPC Discussion Paper 2014.07.7a – Wheatley Microcystin Issue, July, 2014

5.5 Identified Issues

Certain *parameters* that met the screening criteria, in the first step of *issues* evaluation, were flagged. In the second step of *issues* evaluation, flagged *parameters* were further investigated to identify drinking water quality *issues* in the Lower Thames Valley SPA. The identified *issues* are listed as allowed under Technical Rule 115.1, and described in Table 5-6. In the Lower Thames Valley SPA, some of the *issues* are naturally occurring. The sources of the rest of the *issues* are yet to be determined, and may be wholly or partially *anthropogenic* (man-made sources, i.e. due to the activities on land). The sources may be determined as more information becomes available to the SPC, and included in a subsequent assessment report. No *pathogens* are identified as *issues* in the raw (untreated) source water in the Lower Thames Valley SPA.

It is important to note that the drinking water quality *issues* identified in Table 5-6 are based on raw (untreated) water quality and do not represent the quality of water after treatment. The operation of a water treatment plant including treatment and distribution are governed separately by the Safe Drinking Water Act (2002).

The flagged *parameters* that were not identified as drinking water quality *issues* include those of aesthetic concern, treated water disinfection by-products, microbial indicators and naturally occurring substances. More information on flagged *parameters* is provided in Appendix 9 of the Assessment Report. The identified *issues* and flagged *parameters* will be subject to a re-evaluation in subsequent assessment reports.

Table 5-6 Drinking Water Quality Issues Identified in the Lower Thames Valley Source Protection Area

System	*Issue**	Brief Description of Evaluation	Natural or *Anthropogenic* Source
Wheatley (Lake Erie intakes)	Turbidity	Over 3 years, 44 raw (untreated) water samples were collected and tested for turbidity. About 86% of the sampling results measure above the treated water AO of 5 NTU, with a highest value of 59 NTU. Prolonged elevated levels of turbidity are a cause of concern to the plant operator.	Possibly both natural and *anthropogenic* causes, further investigation required
	Microcystin LR	Microcystin LR, a neurotoxin, is released, when certain algae cells (blue-green) break down. If left intact the algae is able to be removed, with the microcystin remaining contained in the cells, through common filtration methods. Changes to water treatment processes are made to reduce the likelihood that cells would be ruptured before being removed from the water. For the past few years raw and treated water are tested during the algae bloom season for microcystin. Phosphorous is the limiting nutrient for algae growth and as such contributes to the growth of algae. Microcystin levels were reviewed for Wheatley and other intakes in the western basin of Lake Erie. (Microcystin data is available while micocystin LR data is not widely available as microcystin LR is only tested if microcystin levels are elevated) In the 3 years of data reviewed, a single exceedance and some levels of microcystin approaching the half MAC were measured in the raw water while treated water levels remain barely detectable at Wheatley. Although available data does not allow for a trend to be established, it is commonly though that the frequency and severity of algae blooms are getting worse. Although the levels did not satisfy the issues evaluation process developed to satisfy rule 114, Microcystin is however identified as an issue under the CWA as per rule 115.1. It is recommended that monitoring efforts be continued and improved to coordinate the various monitoring programs. Further, it is recommended that monitoring and research be continued into the relationship between microcystin and phosphorous levels. .	Anthropogenic factors (local and international) contribute excessive phosphorous which make it possible for excessive algae growth
Chatham/ South Kent (Lake Erie intake)	Aluminum	About 43% of the raw (untreated) water sample points were above the treated water OG benchmark of 0.1 mg/L, and 70% measured above 50% of the OG benchmark, highest measured value being 0.55 mg/L.	Possibly both natural and *anthropogenic* causes, further investigation required
	Microcystin LR	Microcystin LR, a neurotoxin, is released, when certain algae cells (blue-green) break down. If left intact the algae is able to be removed, with the	Anthropogenic factors (local and international) contribute excessive

		microcystin remaining contained in the cells, through common filtration methods. Changes to water treatment processes are made to reduce the likelihood that cells would be ruptured before being removed from the water. For the past few years raw and treated water are tested during the algae bloom season for microcystin. Phosphorous is the limiting nutrient for algae growth and as such contributes to the growth of algae. Microcystin levels were reviewed for Chatham/South Kent and other intakes in the western basin of Lake Erie. (Microcystin data is available while micocystin LR data is not widely available as microcystin LR is only tested if microcystin levels are elevated) In the 3 years of data reviewed, a single occurance of the half MAC and several levels of microcystin above the detection limit were measured in the raw water while treated water levels remain barely detectable at Chatham/South Kent. Although available data does not allow for a trend to be established, it is commonly though that the frequency and severity of algae blooms are getting worse. Although the levels did not satisfy the issues evaluation process developed to satisfy rule 114, Microcystin is however identified as an issue under the CWA as per rule 115.1. It is recommended that monitoring efforts be continued and improved to coordinate the various monitoring programs. Further, it is recommended that monitoring and research be continued into the relationship between microcystin and phosphorous levels.	phosphorous which make it possible for excessive algae growth
	Organic nitrogen	All (100%) of the available raw water data measured above the treated water OG of 0.15 mg/L, with the highest measured value being 0.48 mg/L. The trend line implies that the organic nitrogen levels have been slightly increasing over time.	Possibly both natural and *anthropogenic* causes, further investigation required
	Turbidity	About 47% of the raw water sampling results measured above the treated water AO benchmark of 5 NTU with the highest measured value being 75 NTU.	Possibly both natural and *anthropogenic* causes, further investigation required
	Hardness	All (100%) of the raw water samples collected and analyzed for hardness exceeded the treated water OG benchmark range of 80 to 100 mg/L, with the highest measured value being 143 mg/L.	Naturally occurring
West Elgin (Lake Erie intakes)	Turbidity	From review of raw (untreated) water sample turbidity data, 74% of the sampling results measured above the treated water benchmark AO of 5 NTU, with a highest turbidity level of 1408 NTU.	Possibly both natural and *anthropogenic* causes, further investigation required
Ridgetown (ground-water wells)	Fluoride	Since 2000, there have been 21 instances of fluoride concentrations in the raw water being above the treated water MAC of 1.5 mg/L, with a highest level of 2.05 mg/L.	Naturally occurring
	Methane	Dillon (2008) found methane levels to be regularly above the treated water AO of 3 L/m^3. A cascade aeration system is in place to address high methane levels.	Naturally occurring

*These issues are identified as allowed under Technical Rule 115.1

5.6 Work Plan

If a drinking water quality *issue* is identified as per Rule 114, the area and the activity contributing to a drinking water quality *issue* must also be identified as per Rule 115. In the Lower Thames Valley SPA, some of the *issues* are naturally occurring and are therefore understood to not be subject to Rule 115. The sources or causes of the rest of the *issues* are yet to be determined. If more information becomes available to the SPC it may be possible to determine the source or cause of an *issue*. If it is determined that an *issue* (identified as per Rule 114) is wholly or partially due to anthropogenic sources, the work (to identify the area and activities contributing to the *issue*, as per Rule 115), or the work plan (as per rule 116) would be included in a subsequent assessment report.

5.7 Data Gaps

Schedule 2 and 3 (chemical and radiological) data for the West Elgin and Wheatley intake raw water were not available. Additional data collection would facilitate future *issues* evaluation.

There is no long-term (more than ten years) groundwater quality data available for *parameters* that can be considered *issues* under the Clean Water Act. Continued data collection in the future would aid in determining trends and better facilitate future *issues* evaluation.

As mentioned in Section 5.5, the sources or causes of some of the *issues* are yet to be determined. This is a data gap. Details of how to accomplish this determination is provided in Table 5-7. Filling of this data gap, as more information becomes available to the SPC, may help identify *issues* as per Rule 114, and therefore lead to identifying the area and activity contributing to those *issues* as required by rule 115.

Table 5-7 : Determination of Sources of an Issue

System	*Issue*	Brief Description of Work
Wheatley, Chatham, West Elgin (Lake Erie intakes)	Turbidity	This *issue* is possibly due to both natural and *anthropogenic* causes. Natural causes of turbidity may be erosion, natural decay of plants and animals, and algal growth. Human activities that could contribute to turbidity include runoff from cultivated fields or construction sites, waste discharges and dredging. Other information on possible causes of turbidity, provided at the public open houses, would be reviewed. A study of correlation between wind or runoff events and the intake turbidity levels

Table 5-7 : Determination of Sources of an Issue

System	*Issue*	Brief Description of Work
		may need to be conducted. Similarly, a correlation between the in-land drains (natural or man-made) turbidity just before the outlet, and the intake turbidity (after an event) may need to be done. Aerial photos showing plumes after an event may help or sampling along drains and at their outlets may be needed. An examination of the composition of the turbidity (organic, inorganic) and its occurrence with other naturally occurring substances may also help determine the cause of turbidity. Turbidity at Lake Erie intakes was also discussed at a Lake Erie working group. Future efforts of the working group may include considering this as a lake-wide *issue*.
Chatham/ South Kent (Lake Erie intake)	Aluminum	This *issue* is possibly due to both natural and *anthropogenic* causes. This *issue* seems common to western Lake Erie intakes. Therefore, work will be undertaken with neighbouring regions. Further investigation of this *parameter* at other intakes may also be required to determine if Aluminum is an *issue* at those locations as well. The amount of *anthropogenic* aluminum released nationally in Canada is small compared with estimated natural aluminum releases; however, *anthropogenic* releases can dominate near strong point sources (CEPA Environmental Registry Substance Lists. Environment Canada, 2008). The aluminum levels in water and sediments near the intake, and the current land use activities that may cause aluminum to be released into the surface water will need to be investigated to help determine the source(s) of aluminum.
	Organic nitrogen	This *issue* is possibly due to both natural and *anthropogenic* causes. Organic nitrogen may be attributed to natural sources such as forests and atmospheric deposition (dry deposits or in the form of precipitation) or by *anthropogenic* sources such as animal pastures, agricultural systems, urban/suburban storm water runoff (Bioavailability of DON from natural and *anthropogenic* sources to estuarine plankton. Limnology and Oceanography 47(2):353-366.Seitzinger S.P., R.W. Sanders, and R. Styles. 2002) and wastewater treatment plant effluent (Dissolved organic nitrogen characterization and bioavailability in wastewater effluents. Water Environment Research Foundation Report 02-CTS-1a. Pagilla, K. May 31 2010). Within the Chatham/South Kent intake vulnerable areas, there are seven main storm sewer outfalls with mainly residential parcels along the shoreline and agricultural systems or pastures occupying most of the upland vulnerable area. Sampling for organic nitrogen at the sewer outfalls, in the sediments, near shore and in the intake raw water would need to be conducted to help determine the cause of organic nitrogen.
	Hardness	Identified to be naturally occurring. No further action required for this *issue* according to MOE guidance.
Ridgetown (ground-water wells)	Fluoride	Identified to be naturally occurring. No further action required for this *issue* according to MOE guidance.
	Methane	Identified to be naturally occurring. No further action required for this *issue* according to MOE guidance.

6.0 Conditions Assessment

In order to protect drinking water sources, it is necessary to identify the *threats* that pose a *risk* to drinking water sources. The drinking water threats that may be considered in identified *vulnerable areas* are those due to: *prescribed activities*, *other activities*, *conditions* (past activities) and activities (including *conditions*) contributing to identified drinking water quality *issues*. A *condition* is the result of a past activity and may pose a *risk* to a drinking water source. This Section of the Assessment Report describes the criteria for a *condition* to exist, as per Technical Rule 126, and the preliminary investigation made in assessing *conditions* in the Lower Thames Valley Source Protection Area. Section 5 – Issues Evaluation describes the drinking water quality *issues* identified in this source protection area, while Section 7 – Threats and Risk Assessment describes the assessment of *risks* due to *prescribed activities* and *other activities*.

The Source Protection Committee is required to identify, as a drinking water *threat*, any *Condition* of which it is aware. The *Source Protection Plan* is focused on reducing the level of *risk* associated with *threats*. The identification of *threats* in *vulnerable areas*, including those due to *conditions*, is an important step in the development of the *Source Protection Plan*. The Clean Water Act requires that *significant threats* be managed to the point that they no longer become significant. The Source Protection Committee may also develop policies for *moderate and low drinking water threats*, however it is anticipated that the types of policies which can be applied to *moderate and low threats* will not be as broad as for the *significant threats*. Policies for conditions are however anticipated to be significantly different than those for *prescribed activities* as a result of the fact that the *activity* is no longer being undertaken and that the contaminant has already been released into the environment.

Conditions must be identified in *vulnerable areas*. The vulnerable areas are *Intake Protection Zones (IPZ), Wellhead Protection Areas (WHPA), and Highly Vulnerable Aquifers (HVA)*.The delineation and assessment of these *vulnerable areas* is described in Section 4 - Vulnerability Assessment of the Assessment Report. In the Lower Thames Valley Source Protection Area, *Intake Protection Zones* are delineated around intakes of three drinking water systems that use Lake Erie as a source, and *Wellhead Protection Areas* are delineated around the wellheads of

two groundwater drinking systems. Map 4-1 shows the location of the *IPZ* around the municipal intakes, and the *WHPA* around municipal wellheads. Map 4-7 show the *HVA* delineations in the Lower Thames Valley Source Protection Area.

Through the technical work on Threats and Risk Assessment, a preliminary review of data made available by the Ministry of Environment, Conservation and Parks (*MECP*) for the assessment of *conditions* was undertaken. The Threats and Risk Assessment studies involved the operating authorities of the drinking water systems and were undertaken through partnerships involving the Conservation Authorities in the region. As described in Section 4, a project led by the Essex Region Conservation Authority (*ERCA*) was initiated through a partnership between ERCA and the Conservation Authorities in the Thames-Sydenham and Region and the plant operators. This project included two drinking water systems in the Lower Thames Valley Source Protection Area that draw water from Lake Erie. The Chatham-Kent Public Utilities Commission (*PUC*) was an active partner in this project and participated in the technical steering of the project.

Another project was led by the Municipality of West Elgin with the Ontario Clean Water Agency (*OCWA*) providing technical and project management services for the municipality. This project included one drinking water system in the Lower Thames Valley Source Protection Area that draws water from Lake Erie. Stantec Consulting Ltd. was the primary consultant for the projects led by *ERCA* and the Municipality of West Elgin, and completed the threats risk assessment technical studies for these three surface water systems.

The Municipality of Chatham-Kent *PUC* led technical studies on the two groundwater systems in the Lower Thames Valley Source Protection Area. Dillon Consulting Ltd. was the primary consultant who completed the threats and risk assessment work for these groundwater systems.

The technical reports for the above described studies are listed in Table 6-1 below.

Table 6-1 Technical Studies on Drinking Water Threats and Risk Assessment

Drinking Water Systems	Technical Study on Threats and Risk Assessment
Wheatley, Chatham and South Chatham-Kent	Potential Threats Analysis for the Thames Sydenham Region Water Treatment Plants. Essex Chatham-Kent Source Protection Planning Technical Study Potential Threats Analysis Technical Memorandum. Final Report. Stantec Consulting Ltd. November 2009
West Elgin	1. Potential Threats Analysis for the West Elgin Water Treatment Plant. Municipality of West Elgin Source Protection Planning Technical Study Phase 2 – Potential Threats Analysis TM. Final Report. Stantec Consulting Ltd. November 2009 2. Potential Threats Analysis and Issues Evaluation for the West Elgin Water Treatment Plant Emergency Intake. Municipality of West Elgin Source Protection Planning Technical Study Phase 2 – Potential Threats Analysis TM. Final Report. Stantec Consulting Ltd. June 2010
Ridgetown	1. Water Quality Threats and Risk Assessment Draft Report. Ridgetown and Highgate Municipal Drinking Water System Source Protection Study. Municipality of Chatham-Kent PUC. Dillon Consulting Limited. January 29, 2010. 2. Updated Significant Threats Tables. Highgate and Ridgetown Systems. Dillon Consulting Limited. Technical Memorandum dated October 7, 2010.

6.1 Conditions Assessment Methodology

6.1.1. Occurrence of Conditions

As per the *Technical Rules (2017): 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,* 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,* 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 presence of a contaminant in groundwater that is discharging into an intake protection zone, if the contaminant is listed in Table 2 of the Soil, Ground Water and Sediment Standards, the concentration of the contaminant exceeds the potable groundwater standard set out for that contaminant in the Table, and the presence of the contaminant in groundwater could result in the deterioration of the surface water for use as a source of drinking water.

Conditions may exist as a result of the presence of non-aqueous phase liquids in groundwater in a *HVA* or *WHPA*. Non-aqueous phase liquids do not mix with water. Light Non-Aqueous Phase Liquids (*LNAPLs*) float on top of water, and examples are oil and gasoline. *Conditions* may also exist due to the presence of more than 100 litres of Dense Non-Aqueous Phase Liquids (*DNAPLs*) in the surface water of an *IPZ*. *DNAPLs* are liquids that do not mix with water and are heavier than water. *DNAPLs* are of concern in groundwater since they sink into the ground, settle at the bottom of and contaminate an aquifer. Examples of where *DNAPLs* are used include: dry cleaning, pesticides, brake cleaners, glues, varnishes, automotive coolant and nail polish.

The Soil, Ground Water and Sediment Standards refer to an MECP publication, 'Soil, Ground Water and Sediment Standards for Use under Part XV.1 of the Environmental Protection Act' (March 9, 2004). This document, consisting of 6 tables (called Tables 1 to 6), sets out the prescribed contaminants and the applicable site condition standards for those contaminants for the purposes of Part XV.1 ('Records of Site Condition') of the *Environmental Protection Act*. The prescribed standards for contaminants are set out by indicating the maximum concentrations of the contaminants in soil, groundwater and sediment for a type of property use (such as agricultural or commercial). These are expressed in microgram per gram (µg/g) dry weight for soil and sediment, and as microgram per litre (µg/L) for groundwater, unless otherwise indicated in the table. Contaminants listed in the tables include metals, nutrients, polyaromatic

hydrocarbons, pesticides, petroleum constituents and dense non-aqueous phase liquids.

Under the Clean Water Act, conditions may be identified if a contaminant in sediment exceeds its applicable standard from Table 1 of the *MECP* publication Soil, Ground Water and Sediment Standards. The sediment standards in Table 1 (Full Depth Background Site Condition Standards) are values within the range of measured background sediment where data is available in the 1993 Sediment Guidelines and are considered to provide a level of human health and ecosystem protection consistent with background, and protective of sensitive ecosystems. These sediment standards are for all property uses.

Table 2 ('Full Depth Generic Site Condition Standards in a Potable Ground Water Condition') is used to determine if a condition exists in the groundwater of a *WHPA* or *HVA*, by comparing the contaminant concentration with the standard for potable groundwater, which applies to all property uses.

Table 4 ('Stratified Site Condition Standards in a Potable Ground Water Condition') is used to determine if a condition exists in the surface soil of an IPZ, in properties used for industrial, commercial or community purposes.

6.1.2. Information Used to Identify Conditions

A preliminary investigation of potential *conditions* has been undertaken based on information available. To date, investigation of *conditions* includes the following measures:

- Those undertaking municipal technical studies were requested to determine if there are *conditions* which the plant operating authorities are aware of, and the consultants were to investigate to determine if it was in fact a *condition*.
- *MECP* provided information from their local offices to determine if their files contain any information which might lead to identifying a *condition*. This information was restricted to a fixed radius around intakes and wells. Although it has been provided to the consultants for their consideration, not all of the consultants have been able to review the information. Further, the information does not include the entire *vulnerable areas*.
- It is anticipated that stakeholders, including the public, may bring up information on potential *conditions* and an investigation will be required to determine if they are

conditions. Some of these have been noted in this report, but are yet to be reviewed to determine if they should be considered a *condition*.

The two sets of data made available by the Ministry of Environment, Conservation and Parks (*MECP*) to check for *conditions* are data from the 'Brownfields Registry' and '*MECP* Data Scanning'. Brownfields are lands on which industrial or commercial activity took place in the past and that may need to be cleaned up before they can be redeveloped. The Brownfields Registry data from *MECP* contained summarized information from individual Records of Site Condition (*RSC*) available on the Brownfields Site Registry. The Brownfields Environmental Site Registry provides access to the individual *RSCs* where contamination information about each individual *RSC* property is documented. Records of Site Condition are not a listing of all contaminated sites in the province (no such list exists). The information provided is only applicable to properties that have undergone a land use change and for which an *RSC* has been accepted. The Brownfields data from *MECP* contained all records up to December 11, 2008. The *MECP* Data Scanning information included all Ministry of the Environment, Conservation and Parks files pertaining to water, within 500 metres around a groundwater wellhead and 1000 m around a surface water intake.

6.1.3. Risk Assessment Methodology for Conditions

Should the committee become aware of a *condition* as described above, the *condition* is to be considered a *drinking water threat*. As with all *drinking water threats*, the *risk score* of a *condition* is identified in the *Technical Rules 2013: Assessment Report*, as the product of the *vulnerability score* and *hazard score*.

Risk = Vulnerability X Hazard

The assessment of *prescribed activities*, *other activities* and a description of the *MECP Table of Drinking Water Threats* (2013/2017) is provided in Section 7 – Threats and Risk Assessment of this Assessment Report. As per Technical Rule 139 (Nov. 2009), the *hazard score* of a *condition* is:

(a) **10**, if there is evidence that the situation is causing off-site contamination

(b) **10**, if the *condition* is on a property where a well, intake or monitoring well (existing and

planned drinking water systems that are major residential, included in the Terms of Reference by resolution or upon order of the Director, or serve reserves) is located

(c) **6**, if (a) and (b) do not apply.

The *risk score* of a *threat* due to a *condition* in *IPZ, WHPA, HVA* would depend on the *vulnerability scores*, and whether the *hazard score* of the *condition* is 6, or 10. Table 6-2 shows the general relationship between the *hazard score* and the resulting *threat* level for *conditions*.

Table 6-2 Threat Level Determination for Conditions

Hazard score	Vulnerability Score	Risk Score	Threat Level
10	8 or greater	80 or greater	Significant*
	6 to less than 8	60 to less than 80	Moderate
	Greater than 4 but less than 6	Greater than 40 but less than 60	Low
	4 or less	40 or less than 40	No threat
6	Not possible	80 or greater	Significant*
	10	60 to less than 80	Moderate
	7 to less than 10	Greater than 40 but less than 60	Low
	Less than 7	40 or less than 40	No threat

Notes:
*There are additional scenarios where, regardless of the risk score, a threat is considered significant

A *condition* is a *significant threat*, if the risk score is at or above 80 (as per Rule 140). According to Rule 141, a *condition* resulting from a past *activity* would also be deemed a *significant threat* if:

- it is associated with an identified drinking water quality *issue*;
- it is identified as a *threat* that contributes (or may contribute) to an *issue*;
- it is located in an identified *issue*-contributing area within a *vulnerable area*; and
- there is evidence that the *condition* is or may be causing off-site contamination, or the

condition is on a property where a well, intake or monitoring well is located. As well, as per Rule 140.1, a *condition* is deemed a *significant threat* if it is demonstrated that a chemical or pathogen release due to a *condition* results in a deterioration to intake drinking water quality in an *IPZ-3* based on an extreme event approach (rule 68).

6.2 Conditions Assessment Findings

The efforts completed to date serve as a preliminary investigation for identifying conditions. A more comprehensive investigation will be conducted when more information is available, and the Source Protection Committee would consider conditions identified as per Rule 126 while developing a *Source Protection Plan* for the area. In the Lower Thames Valley Source Protection Area, two potential *conditions* are as described below.

Public concerns about the increased activity at the Cedar Springs Rifle Range (federal land in the Chatham/South Kent *Intake Protection Zone-1 and 2*) and its possible effects on lead levels in the soil, sediments and intake raw water were brought to the *SPC's* attention. Through the *issues* evaluation (see Section 5 - Issues Evaluation), lead levels in the raw (untreated) water to the intake were investigated and not found to be a drinking water quality *issue*. Lead levels in the soil and sediments will be reviewed through the *conditions* identification work as per Rule 126, upon receipt of the soil and sediment lead data from the Ministry of National Defense.

Wheatley Harbour is within the Wheatley drinking water system Intake Protection Zone. The Wheatley Harbour was previously identified as an Area of Concern (*AOC*) under the Canada-Ontario Water Quality Agreement, and a Remedial Action Plan (*RAP*) was established. The *AOC* is delisted in April 2010 due to improvements in sediment and water quality. Existing information on sediment and water quality may be reviewed to determine if it should be considered a *condition* in the Assessment Report for the Lower Thames Valley Source Protection Authority as per Rule 126. The Wheatley *Intake Protection Zone* spans both the Lower Thames Valley and the Essex Region Source Protection Authorities; hence, both Source Protection Authorities and Source Protection Committees will be involved in discussions on potential *conditions* in the Wheatley *Intake Protection Zone*.

6.3 Data Gaps and Next Steps for Conditions

Data on past activities that may have resulted in *conditions* is sparse, thus a comprehensive investigation is yet to be conducted. If information such as:

- data from the Spills Action Centre of the *MECP*;
- additional data from *MECP* regional files (*MECP* Data Scanning) for *WHPA , IPZ , HVA* where the vulnerability is greater than 4

were made available to the Source Protection Committee, this information would be reviewed to determine if the data reviewed might meet the criteria of a *condition* as per Rule 126. Findings would be included in an amended assessment report. The Source Protection Committee will continue to investigate any information on potential *conditions* that are brought to their attention. Should any *conditions* be identified as per Rule 126, it will be necessary to amend the Assessment Report to include those *conditions*.

7.0 Threats and Risk Assessment – Water Quality

In order to protect drinking water sources, it is necessary to identify the *activities* within *vulnerable areas* that pose a *threat* to drinking water sources. It is also necessary to assess the *risks* due to the identified *threats*. This section describes the *threats* and *risk* assessment work pertaining to water quality, conducted in the Lower Thames Valley Source Protection Area. The *risk* associated with water quantity *threats* is considered in Section 3 - Water Budget and Water Quantity Stress Assessment of the Assessment Report.

A drinking water *threat* is an "*activity* or *condition* that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as source of drinking water" (Clean Water Act, 2006). *Risk* Assessment is the process of assessing the *threats* to determine their relative *risk* to the drinking water source. It considers the vulnerability of the area that the *activity* is being undertaken in. It also considers the hazard associated with the *activity*.

Following the completion of the Assessment Report, a *Source Protection Plan* must be developed by the Source Protection Committee. The focus of the *Source Protection Plan* is to reduce *risks* to drinking water sources by managing the *threats* causing those *risks*. The *Source Protection Plan* will contain policies focused on *activities* which are identified as *threats* within the *vulnerable areas*. Hence, the identification of the *threats* and the assessment of *risks* due to the *threats* are key to the development of the Source Protection Plan. Further, the *Source Protection Plan* must mitigate those *risks* to drinking water sources that are deemed to be *significant*. The policies related to *significant threats* are mandatory and must be implemented. Source protection policies may include incentive programs, education and outreach, new or amended provincial instruments, and *risk* management plans.

The *Threats* and *Risk* Assessment studies involved the operating authorities of the drinking water systems and were undertaken through partnerships involving the Conservation Authorities in the region. As described in Section 4, a project led by the Essex Region Conservation Authority (*ERCA*) was initiated through a partnership between *ERCA* and the Conservation Authorities in the Thames-Sydenham and Region and the plant operators. This project included

two drinking water systems in the Lower Thames Valley Source Protection Area that draw water from Lake Erie. The Chatham-Kent Public Utilities Commission (*PUC*) was an active partner in this project and participated in the technical steering of the project. Another project was led by the Municipality of West Elgin with the Ontario Clean Water Agency (*OCWA*) providing technical and project management services for the municipality. This project included one drinking water system in the Lower Thames Valley Source Protection Area that draws water from Lake Erie. Stantec Consulting Ltd. was the primary consultant for the projects led by *ERCA* and the Municipality of West Elgin, and completed the *threats risk* assessment technical studies for these three surface water systems. The Municipality of Chatham-Kent PUC led technical studies on the two groundwater systems in the Lower Thames Valley Source Protection Area. Dillon Consulting Ltd. was the primary consultant who completed the *threats* and *risk* assessment work for these groundwater systems. Threats and risk assessment in the EBA and IPZ-3 were completed by LTVCA staff based on the event modelling in the EBA. Threats and risk assessment in the IPZ-3 for the Stoney Point intake were also undertaken by LTVCA staff based on an extension of the IPZ-3 delineation and vulnerability scoring in the Essex Region SPA. LTVCA staff created mapping products needed in threats analysis, and analysed certain types of threats.

The technical reports for the above described studies are listed in Table 7-1 below:

Table 7-1 Technical Studies on Drinking Water Threats and Risk Assessment

Drinking Water Systems	Technical Study on Threats and Risk Assessment
Wheatley, Chatham and South Chatham-Kent	Potential Threats Analysis for the Thames-Sydenham Region Water Treatment Plants. Essex Chatham-Kent Source Protection Planning Technical Study Potential Threats Analysis Technical Memorandum. Final Report. Stantec Consulting Ltd. November 2009
West Elgin	1. Potential Threats Analysis for the West Elgin Water Treatment Plant. Municipality of West Elgin Source Protection Planning Technical Study Phase 2 – Potential Threats Analysis TM. Final Report. Stantec Consulting Ltd. November 2009 2. Potential Threats Analysis and Issues Evaluation for the West Elgin Water Treatment Plant Emergency Intake. Municipality of West Elgin Source Protection Planning Technical Study Phase 2 – Potential Threats Analysis TM. Final Report. Stantec Consulting Ltd. June 2010
Ridgetown	1. Water Quality Threats and Risk Assessment Draft Report. Ridgetown and Highgate Municipal Drinking Water System Source Protection Study. Municipality of Chatham-Kent PUC. Dillon Consulting Limited.January 29, 2010

Table 7-1 Technical Studies on Drinking Water Threats and Risk Assessment

Drinking Water Systems	Technical Study on Threats and Risk Assessment
	2. Updated Significant Threats Tables. Highgate and Ridgetown Systems. Dillon Consulting Limited. Technical memo dated October 7, 2010 3. Technical Memo regarding the Assessment of Chemical Threats from the Use of Land as Livestock Grazing, Pasturing Land, and Outdoor Confinement Area or a Farm-Animal Yard. Thames-Sydenham and Region. Jason Wintermute. September 29, 2010.
Wheatley, Chatham and South Chatham-Kent, West Elgin and Ridgetown	Technical Memo regarding Creation of Impervious, Managed Land and Livestock Density Maps. Thames-Sydenham and Region. Jason Wintermute. February 2, 2010.
Wheatley	.IPZ-3 Delineation Support for ERCA Source Water Studies: Colchester, Union, Wheatley and Pelee Island Intakes, W.F. Baird & Associates Coastal Engineers Ltd., August 14, 2013 – 11061.210 Delineation of a Fuel Spill Related Intake Protection Zone 3(IPZ-3) for the Wheatley Drinking Water Intake Extending up the Two Creeks Watershed. Thames-Sydenham and Region. Jason Wintermute. December, 2014.
Stoney Point	IPZ-3 Delineation for ERCA Source Water Studies: Stoney Point, Belle River and Windsor Intakes, W.F. Baird & Associates Coastal Engineers Ltd. April 26, 2011 – 111061.206 IPZ-3 Delineation, Vulnerability Scoring, Threats Analysis and Uncertainty Level Assessment for the A.H. Weeks, Lakeshore and Stoney Point Water Treatment Plants, Stantec, April 2011. Delineation of a Fuel Spill Related Intake Protection Zone 3(IPZ-3) for the Stoney Point Drinking Water Intake Extending up the Thames River Watershed. Thames-Sydenham and Region. Jason Wintermute. December 2014.

From these technical studies, information is compiled and provided in this section of the Assessment Report. This section is organized into discussions on the types of *activities* that may be considered as drinking water quality *threats*, the methodology used to identify *threats* and assess *risks*, the lists of *threats* in *vulnerable areas* with maps showing these, and lastly the next steps and data gaps.

7.1 Drinking Water Quality Threat Identification and Risk Assessment Methodology

Drinking water quality *threats* in *vulnerable areas* must be identified and assessed as to their *risk* to the drinking water source. The *vulnerable areas* are *Intake Protection Zone (IPZ), Wellhead Protection Area (WHPA), Highly Vulnerable Aquifers (HVA)*. *IPZ* are comprised of *IPZ-1, IPZ-2* and *IPZ-3*, while *WHPA* are comprised of *WHPA-A, WHPA-B, WHPA-C, WHPA-D, WHPA-E* (related to *GUDI* systems) and *WHPA-F* (related to *GUDI* systems). The vulnerability assessment (including delineation and assignment of vulnerability scores) of these *vulnerable areas* is described in Section 4 - Vulnerability Assessment of this Assessment Report. Work related to *IPZ-3* has been undertaken on the Wheatley intake and the IPZ-3 from the Stoney Point intake in Essex Region SPA has been extended into the Lower Thames Valley SPA. In the Lower Thames Valley Source Protection Area, three drinking water systems draw their source water from Lake Erie and one systems draw from groundwater aquifers. Map 4-1 shows the location of the *IPZ* around the municipal intakes, and the *WHPA* around municipal wellheads. Map 4-7 shows the delineated *HVA* in the Lower Thames Valley Source Protection Area.

The drinking water quality *threats* that may be considered in the identified *vulnerable areas* are those due to: *prescribed activities*, *other activities*, *conditions* (past *activities*) and *activities* contributing to identified drinking water quality *issues*. The *Technical Rules2013: Assessment Report* Part XI describes the listing of drinking water quality *threats*. In the Thames-Sydenham and Region, a local guidance document was developed to provide clarification and local interpretation of the relevant sections in the Clean Water Act, its regulations and the associated *technical rules* pertaining to the *threats* and *risk* assessment. The methodology is included in Appendix 10.

To identify where low, moderate and significant threats can be identified it is recommendated to use both the Ontario Drinking Water Threats and Circumstances Table and Tool link for the WHPAs and IPZs scoring maps. The sections below summarize the types of *threats* and the methodology followed in the region to identify *threats* and assess *risks*.

7.1.1. Prescribed Drinking Water Threats

Through the Clean Water Act and General Regulation 287/07, a list of 22 *prescribed* drinking water *threats* is provided. That list is reproduced in Table 7-2.

Table 7-2 Activities Prescribed as Drinking Water Threats

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. O. Reg. 385/08, s. 3.
22. The establishment and operation of a liquid hydrocarbon pipeline. O.Reg. 206/18, s.1.

The *risk* associated with *activities prescribed* as water quantity related *threats* (numbers 19 and 20 in the above table) are considered in the Section 3 - Water Budget and Water Quantity Stress Assessment of this Assessment Report. The *activities* 1 to 18 and 21 are *prescribed drinking water threats* related to drinking water quality and are discussed in this section. They

may be summarized into:

- Application, handling and storage of *agricultural source material* (manure), *non-agricultural source material* (bio-solids), commercial fertilizer, pesticide or road salt
- Handling and storage of fuel, *dense non-aqueous phase liquids*, or organic solvents
- Management of runoff that contains aircraft de-icing chemicals
- Livestock grazing or pasturing land, outdoor confinement areas or farm-animal yards
- Snow storage
- Systems that collect, store, transmit, treat or dispose of sewage
- Waste disposal sites

An *activity* may be pose a *risk* to drinking water quality based on the following factors which are described further in this section:

- The type of *vulnerable area* where the *activity* is located;
- the vulnerability score assigned to that area;
- the *circumstances* related to the *activity*; and
- the *hazard score* resulting from the *activity* under the *circumstances* related to the *activity*.

An *activity* is deemed to be a significant, moderate or low *threat* depending on the calculated *risk* score. The *risk* score is calculated by multiplying the vulnerability score assigned to a *vulnerable area* with the hazard score of the *activity*.

Risk = Vulnerability X Hazard

Table 7-3 shows the relationship between the *risk* score calculated and the resulting *threat* level. The highest possible *risk* score is 100. A *risk* score of 80 or greater results in a *significant threat* level. Some exceptions include *issue*-based *threats* which are deemed *significant* regardless of the vulnerability area and score, and *activities* related to *Dense Non-Aqueous Phase Liquids* (*DNAPLs*) which are *significant threats* in *WHPA-A* (100 m radius), *WHPA-B* (2 year capture zone excluding A), and *WHPA-C* (2 to 5 year capture zone) regardless of the vulnerability score. In *WHPA-D* (5 to 25 year capture zone), *WHPA-E* and *WHPA-F*, *dense non-*

aqueous phase liquids (*DNAPLs*) are considered under chemical *threats*. *Pathogens* are not viewed as *threats* at all, outside of *WHPA-A, WHPA-B, WHPA-E* and *IPZ-1* and *IPZ-2*.

Table 7-3 Threat Level Determination

Risk Score	Threat Level
80 or more	Significant
60 or greater, but less than 80	Moderate
Greater than 40, but less than 60	Low
40 or less than 40	No threat

As mentioned earlier, the *vulnerable areas* are *IPZ, WHPA, HVA*. According to the *Technical Rules: Assessment Report*, vulnerability scores for Great Lakes *IPZ-1 and IPZ-2* range from 3.5 to 7.0 (depending on whether it is for *IPZ-1* or *IPZ-2*). For Intakes in Lake St. Clair, vulnerability scores for IPZ-3 must be lower than the score for IPZ-2 and vary depending on the travel time to the intake. For *WHPA*, vulnerability scores range from 2 to 10 (depending on whether it is for *WHPA-A, WHPA-B, WHPA-C* or *WHPA-D*). An *activity* can only be identified as a *threat* if it is occurring in a *vulnerable area* and the vulnerability score of the area is greater than 4. In an area where the vulnerability score is 8 or greater, the *threat* may be *significant* (dependent on the *circumstances* associated with the *activity*). The highest vulnerability score possible for a Great Lakes *IPZ* is 7, while *WHPA-A*, *WHPA-B* and *WHPA-C* can have vulnerability scores of 8 or greater. Through vulnerability scoring of the Great Lakes *IPZ*s, it is not possible to identify *significant threats*. However, through issues and event based threats and risk assessment (see Sections 7.1.3 and 7.1.4), it may be possible to identify *significant threats*. It is also possible to have *significant threats* in *WHPA-A, WHPA-B* and *WHPA-C*, dependent upon the assigned vulnerability score. *HVA* are assigned a vulnerability score of 6 as described in Section 4 – Vulnerability Assessment. Hence there can be no *significant threats* in these *vulnerable areas*.

In order to assess the *risks* due to the *prescribed* drinking water quality *threats*, the Ministry of Environment, Conservation and Parks (*MECP*) has developed '*Tables of Drinking Water Threats*' based on the 21 *prescribed threats*. The *MECP tables of drinking water threats* include

the results of the *risk* score calculation and identify the *threat* level associated with an *activity* based on the vulnerability score of the area in which the *activity* is being undertaken. The *MECP tables of drinking water threats* provide the *circumstances* under which an *activity* may be categorized as a low, moderate or *significant threat*. Hence, the *circumstances* of the *activity* are considered to determine the level of *risk* associated with a *drinking water threat*. The *circumstances* to be considered include the type of material, the quantity of material and whether it might be released to surface water or groundwater. Each combination of *circumstances* for an *activity* is assigned a hazard score. The hazard score ranges between 4.1 to 10 for chemical *threats*, 5 to 10 for *pathogens*, and 8.3 to 10 for *DNAPLs*.

The tables in the *tables of drinking water threats* cover activities related to both chemicals and pathogens. Chemicals include, but are not limited to, nitrogen and phosphorus (related to the application of commercial fertilizers, and *agricultural source material and non-agricultural source material* to land), atrazine, dicamba, glyphosate (related to the application of pesticide on land), trichloroethylene, vinyl chloride (related to the handling and storage of *dense non-aqueous phase liquids*), *BTEX(*Benzene,Toluene, Ethylbenzene, and Xylene), certain petroleum hydrocarbons (related to the handling and storage of fuel), chloroform (related to the handling and storage of organic solvent), sodium and copper (related to the storage of snow). *Dense non-aqueous phase liquids* (*DNAPLs*) are considered under chemical related *activities* except in *WHPA-A, WHPA-B* and *WHPA-C* where they are considered separately, as explained in the *risk* determination discussion below. *DNAPLs* are heavier than water and do not mix with water. They are of concern in groundwater since they sink into the ground, settle at the bottom of and contaminate an aquifer. Examples of *activities* or products containing *DNAPLs* include: dry cleaning, pesticides, brake cleaners, glues, varnishes, automotive coolant and nail polish. Pathogens are disease-causing microorganisms and in the *tables of drinking water threats*, they are not limited to a specific list of types of pathogens. *Activities* that may cause the presence of pathogens include, but are not limited to, the application of *agricultural source material and non-agricultural source material* to land, livestock grazing, and sewage discharge.

The Clean Water Act requires the enumeration of locations at which a *significant threat* is thought to occur. Also, a list of *activities* which are or 'would be' *threats* is to be included. Generally, this is addressed by including all *activities* listed in the *prescribed* lists even if they

are not currently occurring in an area. *Activities* not currently occurring in the *vulnerable areas*, 'would be' *threats* if the *activity* was to occur in the future. The *circumstances* which result in *significant threats* must also be identified in the Assessment Reports.

As part of the identification of certain *prescribed* chemical drinking water *threats*, an intermediate step involving the creation of maps showing impervious area, managed lands and livestock density is necessary. A determination of the percentage of impervious area is needed to determine the level of *threat* associated with the application of road salt. Also, the percentage of managed lands is required, as this is related to the level of *threat* for the application of *agricultural source material* (*ASM*), commercial fertilizer or *non-agricultural source material* (*NASM*). The *technical rules* also require that the livestock density for an area, expressed in terms of nutrient units/acre, be determined as a means of estimating the potential for the generation, storage and application of *agricultural source materials* (*ASM*) in an area.

Any pathogen *threats* associated with these *activities* (application of road salt, *agricultural source material*, commercial fertilizer or *non-agricultural source material*) are assessed separately using the pathogen table of the *tables of drinking water threats*. The calculations made to map the impervious area, managed lands and livestock density are described briefly below.

Impervious Area

For determining the risk level associated with the application of road salt, the percentage of impervious area must be determined. Impervious areas related to application of road salt include roads, parking areas and sidewalks. The percentage of impervious surface areas must be calculated within each square kilometre of *vulnerable areas* (Rule 16). The percentage impervious is calculated for each square kilometre as determined by overlaying a 1 kilometre by 1 kilometre grid over the *vulnerable area* with a node of the grid located at the centroid of the Source Protection Area. Geographic Information System (GIS) tools were used to undertake this calculation for each grid which touched a *vulnerable area*.

Managed Lands

In determining the percentage of managed lands, Source Protection committees must

determine the areas where there may be application of *agricultural source material* (*ASM*), commercial fertilizer, or *non-agricultural source material* (*NASM*). These areas are expressed as percentages of the total area being evaluated. Mapping the percentage of managed lands is not required where the vulnerability score for an area is less than the vulnerability score necessary for the *activity* to be considered a *threat* in the Table of Drinking Water *Threats (2017)*. Managed lands can be broken into two types: agricultural managed land and non-agricultural managed land. Agricultural managed land includes areas of cropland, fallow and improved pasture that may receive nutrients. Non-agricultural managed lands include golf courses (turf), sports fields, lawns (turf) and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer). Both managed land and agricultural managed lands are to be delineated within each of the *vulnerable areas* (individually for each *WHPA*-A, B, C, D, E, F, *IPZ*-1, 2, and 3 as well as for *HVA*).

The percentage of managed land area within a *vulnerable area* is the sum of agricultural managed land and non-agricultural managed land, divided by the total area of all land within a *vulnerable area*, multiplied by 100. This was undertaken for each part of the *WHPA* and *IPZ* where the vulnerability could result in the activities being a drinking water threat. This evaluation was completed for parts of the IPZ-3 where the application of ASM, NASM or commercial fertilizer could be a threat. Where a parcel of managed land is partially within a *vulnerable area*, only the portion of the parcel within the *vulnerable area* is used in the calculations.

Livestock Density

Livestock density is used as a surrogate measure of the potential for generating, storing, and land applying *Agricultural Source Material* (*ASM*) as a source of nutrients within a defined area. The livestock density is expressed in nutrient units per acre. The calculation of livestock density in a specified area requires the following steps:

1. Estimate the number of each category of animals present within the specified area,
2. Convert the number of each category of poultry and livestock present into nutrient units (NU), to enable all livestock to be compared on an equivalent unit of measure in terms of the nutrients produced by each type,
3. Sum the total NU of all categories of poultry and livestock within the specified area and

then divide this NU value by the area of agricultural managed land within the same specified area.

For the assessment of chemical threats related to the land application of nutrients, the "specified area" mentioned above refers to the vulnerable area being examined (only if a threat can exist there), while the agricultural managed land refers to all agricultural managed land including cropland and pastureland.

For the assessment of chemical threats related to the use of land for livestock grazing, pasturing or outdoor confinement area or animal yard, the "specified area" mentioned above refers to the whole of the farm itself being examined, while the agricultural managed land refers to only that agricultural managed land being assessed, i.e. grazing land, pasture land, outdoor confinement area or animal yard.

Risk Assessment using Managed Lands and Livestock Density

The percentage of managed land and the livestock density of an area are used together as a surrogate for representing the quantity of nutrients present as a result of nutrient generation, storage, and land application within an area. The *risk* assessment using managed lands and livestock density calculations is described below.

Chemical Threats Related to the Land Application of Nutrients

Table 1 of the *tables of drinking water threats* requires that the maps for both percentage of managed lands and livestock density be considered when evaluating the *circumstances* with regard to each of the thresholds for land application of nutrients. Table 7-4 summarizes the chemical hazard scores for various combinations of percentage of managed lands and livestock densities. These are the consolidated hazard scores, incorporating the quantity, toxicity and fate scores. The highlighted combinations of percentage of managed land and NU/Acre give a hazard rating for land application of nutrients that, when combined with the area vulnerability scores of 9 or 10, would result in *significant risk* to source waters. To calculate *risk*, the hazard score is multiplied by the vulnerability score for the area.

Table 7-4 Chemical Hazard Scorings for Various Combinations of Percentage of Managed Lands and Livestock Densities

Percentage Managed Land of Total Land	Nutrient Units (NU) per Acre of Cropland		
	< 0.5 NU/acre	0.5 to 1.0 NU/acre	> 1.0 NU/acre
GROUNDWATER			
> 80%	**8 Significant in areas of Vulnerability Score 10**	**8.4 Significant in areas of Vulnerability Score 10**	**8.4 Significant in Areas of Vulnerability Score 10**
40 to 80%	6.8	7.6	**8.4 Significant in areas of Vulnerability Score 10**
< 40%	6	6.8	**8 Significant in areas of Vulnerability Score 10**
SURFACE WATER			
> 80%	**8.8 Significant in areas of Vulnerability Score 10**	**9.2 Significant in areas of Vulnerability Score 10 or 9**	**9.2 Significant in areas of Vulnerability Score 10 or 9**
40 to 80%	7.6	**8.4 Significant in areas of Vulnerability Score 10**	**9.2 Significant in areas of Vulnerability Score 10 or 9**
< 40%	6.8	7.6	**8.8 Significant in areas of Vulnerability Score 10**

Chemical Threats Related to the Use of Land for Livestock Grazing, Pasturing or Outdoor Confinement Area or Farm-Animal Yard

In general, the use of land as livestock grazing or pasture land will be a *significant* chemical *threat* in:

- *Vulnerable Areas* scoring 9 if the livestock density is sufficient to generate nutrients at an annual rate that is more than 1.0 Nutrient Units per acre (NU/acre); or
- *Vulnerable Areas* scoring 10 if the livestock density is sufficient to generate nutrients at an annual rate that is at least 0.5 NU/acre for surface water (in an *IPZ*) or more than 1.0 NU /acre for groundwater; and
- if the land use may result in the presence of Nitrogen or Phosphorus in surface water or

Nitrogen in groundwater. The *tables of drinking water threats* refer to Phosphorus in groundwater, but do not identify any *threats* associated with it in a *WHPA*.

The use of land as livestock outdoor confinement area or a farm-animal yard will be a *significant* chemical *threat* in:

- *Vulnerable Areas* scoring 10 if the number of animals confined in the area at any time is sufficient to generate nutrients at a rate of more than 300 nutrient units (NU) per hectare of the area annually for groundwater and at a rate of more than 120 NUs per hectare of the area annually for surface water (*IPZ*); or
- *Vulnerable Areas* scoring 9 if the number of animals confined in the area at any time is sufficient to generate nutrients at a rate of more than 120 NUs per hectare of the area annually for surface water (in an *IPZ*); and
- the land use may result in the presence of Nitrogen or Phosphorus in surface water or Nitrogen in groundwater. The *tables of drinking water threats* refer to Phosphorus in groundwater, but do not identify any *threats* associated with it in a *WHPA*.

Chemical Threats Related to Agricultural Source Material Storage

The *technical rules* and associated *tables of drinking water threats* state that the use of land to store *Agricultural Source Material* (*ASM*) would be a *significant* chemical *threat* in *Vulnerable Areas* scoring 9 or 10 if the weight or volume of manure stored annually on a farm parcel is sufficient to annually land apply nutrients at a rate that is more than 1.0 Nutrient Units per Acre (NU/Acre) of the farm parcel. Under the Table of Drinking Water *Threats* this is determined by the NU stored on farm parcel divided by the size of farm parcel. Furthermore, another *circumstance* for *ASM* storage is that a spill of the material or runoff from the area where the material is stored (i.e. a point source release) may result in the presence of Nitrogen or Phosphorus in groundwater (*WHPA*) or surface water (*IPZ*).

Liquid Hydrocarbon Pipelines

As part of the updates to the Table of Drinking Water Threats in 2017, "the establishment and operation of liquid hydrocarbon pipelines' has been identified as a new prescribed threat. TSR staff have reviewed these changes and determined that although there are pipelines extending through some wellhead protection areas and Intake Protection Zones in the region, the vulnerability scores of those areas are such that the pipelines would only constitute a low or moderate threat. No new significant threats have been identified as a result of liquid hydrocarbon pipelines being added as a prescribed threat.

7.1.2. Other Activities

The Clean Water Act also allows the Source Protection Committee, upon approval of the Director, to include *activities* that they consider drinking water *threats* but are not *prescribed* drinking water *threats.* These are called *other activities* (Rule 119) and are often referred to as local threats. The SPC has requested permission to consider transportation of fuel as a threat. Appendix 13 contains the director's letter granting that request. The Source Protection Committee can also identify additional *circumstances* (not already in the *tables of drinking water threats*) under which they consider the *activity* to be a *prescribed* drinking water *threat*. The Source Protection Committee is considering a few such *other activities*, as discussed in Section 7.3. These include geothermal systems (harnessing underground temperature), transportation corridors (shipping or road transport of materials) and rifle ranges (shooting practice areas).

Other activities may be listed as *threats* only if the Source Protection Committee identifies them as drinking water *threats*, and similar to the *prescribed threats*, if the hazard score is greater than 4 and the *risk* score calculated is greater than 40, and if the hazard score (calculated based on certain criteria set out in the *technical rules*) is agreed upon by the Director (*MECP*). These other activities may be considered low, moderate or significant drinking water threats based on the vulnerability score of the area and the hazard score included in the Director's letter which can be found in Appendix 13 MECP communications. The tables included in Appendix 10 indicate in which areas these other activities can be considered threats. Event based modelling may be used to determine if these other activities (local threats), or prescribed drinking water threats, are considered significant drinking water threats.

7.1.3. Threats Arising from Conditions

Conditions are a result of past *activities*. In general, *conditions* are the presence of:

- non-aqueous phase liquids in *WHPA*, and *HVA*
- a single mass of more than 100 litres of *dense non-aqueous phase liquids* in surface water in an *IPZ*
- a contaminant in the groundwater of an *HVA* or *WHPA*, in surface soil of an *IPZ*, or in sediments in a *vulnerable area*, that exceeds a certain *MECP* 'criteria' for different land uses

The list above is only a summary of the types of situations that can be considered *conditions*. The actual list of situations are as per Technical Rule 126, and provided in Section 6 - Conditions Assessment of the Assessment Report, along with what the *MECP* 'criteria' are from *MECP* published tables of standards for soil, groundwater and sediments for land uses such as commercial, residential and industrial.

If *Conditions* (resulting from past *activities*) are identified, the hazard score is either 6 or10 depending on certain factors (Rule 139). A *condition* is a *significant threat*, if the risk score is at or above 80 (as per Rule 140), or if it is related to a drinking water quality *issue* (as per Rule 141) or using an extreme event based approach, it is demonstrated that a condition results in a deterioration to intake drinking water quality in an *IPZ-3* (as per Rules 68 and 140.1). For more information, refer to Section 6 – Conditions Assessment of this Assessment Report.

7.1.4. Threats Arising from Issues

A drinking water *issue* is a *parameter* (a substance) or *pathogen* (a disease-causing microorganism) which is shown to deteriorate, or trends towards a deterioration of raw (untreated) water quality for the purposes of drinking. The *issues* identified in the Lower Thames Valley Source Protection Area are summarized in the Section 5 - Issues Evaluation of the Assessment Report. They are identified as per Rule 115.1. The sources of some of the issues are yet to be determined.

Should an *issue* be identified as per Technical Rule 114, the *issue* contributing area must be delineated as per Rule 115. Also as per rule 131, activities that contribute to the *issue* within the

issue contributing area must be identified and are deemed to be a *significant drinking water threat* for systems included in the Terms of Reference for an *SPA*. These *activities* may be *prescribed* or *other threats* or *conditions* as per Rule 115 (4). *Significant threats* must be mitigated or prevented through the *Source Protection Plan*.

As per Technical Rules 68, 130 and 131, a third intake protection zone (*IPZ-3*) for surface water intakes may be delineated, based on an extreme event, to include the activity and area known to contribute to the drinking water quality *issue*. These tasks are yet to be completed and will be part of an amended Assessment Report if an ICA is delineated for an issue under the rules (115).

7.1.5. Local Guidance and Technical Studies

In the Thames-Sydenham and Region, the *threat* and *risk* assessment work was done according to the *Threats* and *Risk* Assessment Local Guidance Version 1.2 (September 9, 2009). This guidance document provides clarification and local interpretation of the relevant sections in the Clean Water Act, its regulations and the associated *technical rules* pertaining to the *threats* and *risk* assessment. It is provided in Appendix 10.

The *threats* analysis for *IPZ-1 and IPZ-2* of the West Elgin, Wheatley and Chatham/South Kent intakes on Lake Erie was based on reviewing the Ministry of Environment, Conservation and Parks *tables of drinking water threats* and the vulnerability scores of the *IPZ*. The vulnerability scores and *vulnerable areas* were considered to generate the listing of land use *activities* that are or would be drinking water *threats* in each *vulnerable area*. The listing details land use *activities* that, given the vulnerability score for each specific *vulnerable area*, would present low, moderate, or significant drinking water *threats*. In the Events Based Areas, activities are identified as significant drinking water threats through the event based modelling which is described in Section 4.

For the *threats* analysis in the Ridgetown and Highgate (now decommissioned) *WHPAs*, an inventory of land use *activities* that may be associated with *prescribed* drinking water *threats* was conducted. The inventory was based on a review of multiple data sources including public records, data provided through questionnaires completed by municipal officials, previous

contaminant/historical land use information, and data collected during windshield surveys. No site specific information was collected; therefore, all *prescribed* drinking water *threat activities* are considered potential rather than confirmed. Due to the transient nature of the transportation threats it is not possible to inventory people engaged in these activities. In summary, evaluation followed a multi-step process including:

- assigning land use *activity*
- assigning vulnerability scores
- relating land use *activity* to *threat* category
- relating land use *activity* to *prescribed* drinking water *threat* and
- determining applicable *circumstances*.

Determining the applicable *circumstances* is based on a combination of site-specific knowledge of *activities* on the property, available information on local/regional characteristics, and on professional opinion. Where possible, site-specific data from information provided through available public records and interviews are considered. In many cases, selection of the relevant *circumstance* is based largely on professional opinion as to the likelihood of a *circumstance* being applicable, as site inspections have not been conducted to date.

A site-specific *risk* assessment to confirm the existence of significant threats will be necessary as part of implementation.

7.2 Drinking Water Quality Threats and Risk Assessment

From the *prescribed* list of *activities*, the drinking water *threats* and their *circumstances* are identified in *vulnerable areas* of each drinking water system. They are described further in this section and can also be found on the provinces' Table of Drinking Water Threats under the 2017 Techncial Rules website at https://www.ontario.ca/page/tables-drinking-water-threats or through the Threats Tool website at https://swpip.ca/.

The Source Protection Committee has been approved to consider transportation of fuel as a local threat. As part of the updates to the Tables of Drinking Water Threats in 2017, the establishment and operation of liquid hydrocarbon pipelines' has been identified as a new prescribed threat and not a local threat. The Source Protection Committee has also expressed

a concern over the potential *risk* that geothermal systems pose to groundwater sources of drinking water and is also considering rifle ranges in *vulnerable areas* as a potential *threat*. The Source Protection Committee will give further consideration to these *activities* and may include them in an amended Assessment Report if they cannot be adequately addressed through other means.

The investigation to determine if there are any *conditions* (*threats* resulting from past *activities*) is yet to be completed at the time of drafting this Assessment Report. However, a couple of potential *conditions* in the Lower Thames Valley Source Protection Area are being considered for further work. More studies will be undertaken on identifying and assessing *conditions* and the Assessment Report will be amended if necessary. These are discussed in Section 6 – Conditions Assessment.

Activities that contribute to *issues* within an ICA are deemed a *significant* threat by the Clean Water Act. The area and *activities* contributing to a drinking water quality *issue* must both be identified. This work has yet to be completed and will be part of an amended Assessment Report. A work plan to conduct this work is included in the Section 5 - Issues Evaluation of the Assessment Report.

The following subsections describe the findings of the *threats* identification, and results of the *risk* assessment for each drinking water system. This includes the identification of *significant threats*, number of locations at which *significant threats* are or would occur, and areas within *vulnerable areas* where low, moderate or *significant threats* could occur.

7.2.1. Threats Identified through Calculation and Mapping of Impervious Surfaces, Managed Lands and Livestock Density

The maps indicating impervious surfaces, managed lands and livestock density in the region were updated based on *MECP* guidance received during the drafting of this Assessment Report. These are Maps 7-1a-c, 7-2a-d, 7-3a-d of Appendix 1. The identification of the *threats* related to these mapped areas is complete. The *threats* related to these mapping products are the application of *agricultural source material and non-agricultural source material* to land, the application of commercial fertilizer to land, and the application of road salt. Livestock density

and agricultural managed land are also used in the farm-level risk assessment related to the *threat* 'use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard'.

Significant threats related to some of the activities described above were identified within the *WHPAs* of the Ridgetown and Highgate (now decommissioned) systems, as described in Section 7.2.4 and 7.2.5. Due to the vulnerability scoring of the *IPZ* for Great Lakes intakes, and for *HVA*, the analysis did not result in the identification of any *significant threats* in these *vulnerable areas*.

For activities related to the use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard, no chemical or pathogen *threats* were identified in *IPZ-1 or IPZ-2* with vulnerability scores at or greater than 4.5 (chemical) and 4.2 (pathogen) (scores lower than these do not result in these activities being identified as *threats* in *IPZ*s). These activities have not been inventoried in the IPZ-3, however in this area they cannot be considered significant drinking water threats due to the vulnerability scoring of the area.

7.2.2. Number of Locations of Significant Threats

Table 7-5 provides the number of locations where *significant threats* are thought to occur, based on current land use, within the *vulnerable areas* of the Lower Thames Valley Source Protection Area. These numbers include *threats* due to chemical and pathogen-related *activities*. As can be seen from Table 7-5, there are no locations of *activities* that 'are or would be' *significant threats* within the *IPZ-1 and IPZ-2*, and the *HVA*. This is due to the range of vulnerability scores allowed for Great Lakes intakes, and *HVA* as discussed in Section 7.1.1. There are however locations where *significant threats* 'are or would' occur in the *WHPA-A*, *WHPA-B* and *WHPA-C* as well as IPZ-3 where events based modelling has identified significant threats (in an EBA).

Table 7-5 : Number of Locations of Significant Drinking Water Threats

System and Vulnerable Area	Vulnerability Score	Number of Locations of Significant Threats
Chatham/South Kent Water Treatment Plant		

Table 7-5 : Number of Locations of Significant Drinking Water Threats

System and Vulnerable Area	Vulnerability Score	Number of Locations of Significant Threats
IPZ-1	5.0	0
IPZ-2	4.0	0
Ridgetown Well Supply System		
WHPA - A	10	25
WHPA - B	6	0
WHPA - C	2	0
WHPA - D	2	0
West Elgin Water Treatment Plant – Primary Intake		
IPZ-1	6.0	0
IPZ-2	4.2	0
West Elgin Water Treatment Plant – Emergency Intake		
IPZ-1	7.0	0
IPZ-2	5.6	0
Wheatley Water Treatment Plant – Primary Intake		
IPZ-1	6.0	0
IPZ-2	4.8	0
IPZ-3	n/a	14*
Wheatley Water Treatment Plant – Emergency Intake		
IPZ-1	7.0	0
IPZ-2	5.6	0
IPZ-3	n/a	14*
Stoney Point Intake (Essex Region SPA)		
IPZ-3	2.7 to 6.3	18
HVA		
HVA	6.0	0
* Event modelled threats only (fuel storage and handling)		

7.2.3. Threats in Chatham/South Kent IPZs

Table 7-5 indicates the number of locations where *significant threats* could occur in the *vulnerable areas* of the Lower Thames Valley Source Protection Area based on current land use. The land use *activities* within the upland area of the Chatham/South Kent *IPZ* consist mostly of agricultural lands with minimal residential development along the shoreline (Potential Threats Analysis for the Thames-Sydenham Region Water Treatment Plants. Essex Chatham-Kent Source Protection Planning Technical Study Potential Threats Analysis Technical Memorandum. Final Report. Stantec Consulting Ltd., November 2009).

Through vulnerability scoring of these areas, there are no *significant threats* in either *IPZ-1 or 2*. Through issues and event based threats and risk assessment (see Sections 7.1.3 and 7.1.4), it may be possible to identify *significant threats*. The Map 7-4 in Appendix 1 identifies the areas in the Chatham/South Kent *IPZ* where activities 'are or would be' low, moderate or *significant threats*. The table on the map and the Table 7-6 below indicate the vulnerability score and vulnerable area in which the activities 'are or would' be low, moderate or *significant threats*. The level of *threat* is dependent upon the *vulnerable area* (*IPZ-1 or 2*) where the *activity* is occurring, the vulnerability score and the *circumstances* associated with the *activity*.

To see a list of the activities which are or would be low, moderate or *significant threats* in this vulnerable area shown on Map 7-4, refer to the Tables A10-1-I1-5 and A10-1-I2-4 in Appendix 10 Threats and Circumstances Tables. To see the *circumstances* which would result in the activity being a low, moderate or *significant threat*, refer to the Table of Drinking Water Threats (2017) at https://www.ontario.ca/page/tables-drinking-water-threats or the Threats Tool at https://swpip.ca/. To see drinking water threats and *circumstances* for all vulnerable areas and scores, refer to the Province's tables of drinking water threats at http://www.ontario.ca/environment-and-energy/tables-drinking-water-threats

Table 7-6 Levels of Threats Related to Pathogens and Chemicals in the Chatham/South Kent IPZs

Vulnerable Area	Vulnerability Score	Level of Threat for Activities Related to Pathogens			Level of Threat for Activities Related to Chemicals		
		Significant	Moderate	Low	Significant	Moderate	Low
IPZ-1	5.0	No	No	Yes	No	No	No
IPZ-2	4.0	No	No	No	No	No	No

7.2.4. Threats in Highgate Wellhead Protection Areas – WELLS DECOMMISSIONED

The Highgate wells were decommissioned in the fall of 2019, as per information from the

Municipality of Chatham-Kent. The Village of Highgate is now supplied by the Ridgetown Drinking Water System.

Table 7-7 Number of Locations of Significant Threats in the Highgate WHPAs – WELLS DECOMMISSIONED

Vulnerable Area	Vulnerability Score	Significant Threats Related To		
		Pathogens	Chemicals	DNAPLs
Not Applicable* (NA)	NA	NA	NA	NA

* The Highgate wells were decommissioned in the fall of 2019 and therefore information on the wells is removed from this Assessment Report

Table 7-8 Significant Threats in the Highgate WHPA – WELLS DECOMMISSIONED

Prescribed Drinking Water Threat	Type (Chemical, Pathogen or DNAPL)	WHPA
Not Applicable* (NA)	NA	NA

* The Highgate wells were decommissioned in the fall of 2019 and therefore information on the wells is removed from this Assessment Report

7.2.5. Threats in Ridgetown Wellhead Protection Areas

Table 7-9 indicates the number of locations where *significant threats* could occur in the Ridgetown *WHPAs*, based on current land use. The *WHPA-A* land use is a mix of mainly light commercial and residential. The *WHPA-B* land use is mainly residential and portions of the sewage treatment lagoons. Land use in the *WHPA-C* and *WHPA-D* is mainly rural, with the exception of a part of the Ridgetown campus in *WHPA-D* (Water Quality Threats and Risk Assessment Draft Report. Ridgetown and Highgate Municipal Drinking Water System Source Protection Study. Municipality of Chatham-Kent PUC. Dillon Consulting Limited. October 19, 2009).

The Map 7-6 in Appendix 1 identifies the areas in the Ridgetown *WHPAs* where activities 'are or would be' low, moderate or *significant threats*. The table on the map and the Table 7-9 below indicate the vulnerability score and vulnerable area in which the activities 'are or would' be low, moderate or *significant threats*. The level of *threat* is dependent upon the *vulnerable area* (*WHPA-A, WHPA-B, WHPA-C* or *WHPA-D*) where the *activity* is occurring, the vulnerability score and the *circumstances* associated with the *activity*. In *WHPA-A, WHPA-B* and *WHPA-C*,

activities related to *dense non-aqueous phase liquids* (*DNAPLs*) are considered separately from those related to chemical *threats*, and are deemed *significant threats* in these areas. Table 7-10 below indicates the activities that are *significant threats* in the Ridgetown *WHPAs*, and whether they are chemical, *DNAPL* or pathogen *threats*.

To see a list of the activities which are or would be low, moderate or *significant threats* in this vulnerable area shown on Map 7-6, refer to the Tables A10-1-WA-10, A10-1-WB-6, A10-1-WC-2 and A10-1-WD-2 in Appendix 10 Threats and Circumstances Tables. To see the *circumstances* which would result in the activity being a low, moderate or *significant threat*, refer to the Table of Drinking Water Threats (2013/2017) at https://www.ontario.ca/page/tables-drinking-water-threats or the Threats Tool at https://swpip.ca/.

Table 7-9 Number of Locations of Significant Threats in the Ridgetown WHPAs

Vulnerable Area	Vulnerability Score	Significant Threats Related To		
		Pathogens	Chemicals	DNAPLs
WHPA-A	10	15	42	10
WHPA-B	6	0	0	2
WHPA-C	2	0	0	0
WHPA-D	2	0	0	0

Table 7-10 Significant Threats in the Ridgetown WHPA

Prescribed Drinking Water Threat	Type (Chemical, Pathogen or DNAPL)	WHPA
Erie Street System		
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	Chemical, Pathogen	A
The application of agricultural source material to land	Pathogen	A
The storage of agricultural source material	Chemical, Pathogen	A
The application of non-agricultural source material to land	Chemical, Pathogen	A
The handling and storage of commercial fertilizer	Chemical	A
The handling and storage of pesticide	Chemical	A
The handling and storage of dense non aqueous phase liquids	DNAPL	A, B
The handling and storage of fuel	Chemical	A
The application of fertilizer	Chemical	A

Table 7-10 Significant Threats in the Ridgetown WHPA

Prescribed Drinking Water Threat	Type (Chemical, Pathogen or DNAPL)	WHPA
The handling and storage of organic solvents	Chemical	A
The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard	Pathogen	A
Scane Road System		
The handling and storage of fuel	Chemical	A
The application of pesticide	Chemical	A
The application of agricultural source material to land	Pathogen	A
The application of non-agricultural source material to land	Pathogen	A
Number of occurences of significant prescribed drinking water threats		71
Total number of locations of significant prescribed drinking water threats		25*

*some parcels may have more than one activity occurring

7.2.6. Threats in West Elgin IPZs

Table 7-5 indicates the number of locations where *significant threats* could occur in the *vulnerable areas* of the Lower Thames Valley Source Protection Area based on current land use. Land use within the West Elgin upland *IPZ-2* for both the primary and emergency intakes is primarily cropland agriculture (Potential Threats Analysis for the West Elgin Water Treatment Plant. Municipality of West Elgin Source Protection Planning Technical Study Phase 2 – Potential Threats Analysis TM. Final Report, Stantec Consulting Ltd., November 2009).

Through vulnerability scoring of these areas, there are no *significant threats* in either *IPZ-1 or 2*. Through issues and event based threats and risk assessment (see Sections 7.1.3 and 7.1.4), it may be possible to identify *significant threats*. The Map 7-7 in Appendix 1 identifies the areas in the West Elgin *IPZ* where activities 'are or would be' low, moderate or *significant threats*. The table on the map and the Table 7-11 below indicate the vulnerability score and vulnerable area in which the activities 'are or would' be low, moderate or *significant threats*. The level of *threat* is dependent upon the *vulnerable area* (*IPZ-1 or 2*) where the *activity* is occurring, the vulnerability score and the *circumstances* associated with the *activity*.

To see a list of the activities which are or would be low, moderate or *significant threats* in this vulnerable area shown on Map 7-7, refer to the Tables A10-1-I1-6, A10-1-I1-7, A10-1-I2-4.2 and A10-1-I2-5.6 in Appendix 10 Threats and Circumstances Tables. To see the *circumstances* which would result in the activity being a low, moderate or *significant threat*, refer to the Table of Drinking Water Threats (2017) at https://www.ontario.ca/page/tables-drinking-water-threats or the Threats Tool at https://swpip.ca/.

Table 7-11 Levels of Threats Related to Pathogens and Chemicals in the West Elgin IPZs

Vulnerable Area	Vulnerability Score	Level of Threat for Activities Related to Pathogens			Level of Threat for Activities Related to Chemicals		
		Significant	Moderate	Low	Significant	Moderate	Low
West Elgin Primary Intake							
IPZ-1	6.0	No	Yes	Yes	No	Yes	Yes
IPZ-2	4.2	No	No	Yes	No	No	Yes
West Elgin Emergency Intake							
IPZ-1	7.0	No	Yes	Yes	No	Yes	Yes
IPZ-2	5.6	No	Yes	Yes	No	Yes	Yes

7.2.7. Threats in Wheatley IPZs

Table 7-5 indicates the number of locations where *significant threats* could occur in the *vulnerable areas* of the Lower Thames Valley Source Protection Area based on current land use. The land use *activities* within the upland area of the Wheatley *IPZ* consist of agriculture lands with minimal residential development along the shoreline and commercial development within close proximity of Wheatley Harbour (Potential Threats Analysis for the Thames-Sydenham Region Water Treatment Plants. Essex Chatham-Kent Source Protection Planning Technical Study Potential Threats Analysis Technical Memorandum. Final Report. Stantec Consulting Ltd. November 2009).

Through vulnerability scoring of these areas, there are no *significant threats* in either *IPZ-1 or 2*. Through issues and event based threats and risk assessment (see Sections 7.1.3 and 7.1.4), some *significant threats* were identified. The Map 7-8 in Appendix 1 identifies the areas in the

Wheatley *IPZ* where activities 'are or would be' low, moderate or *significant threats*. The table on the map and the Table 7-12 below indicate the vulnerability score and vulnerable area in which the activities 'are or would' be low, moderate or *significant threats*. The level of *threat* is dependent upon the *vulnerable area* (*IPZ-1 or 2*), where the *activity* is occurring, the vulnerability score and the *circumstances* associated with the *activity*. In the EBA significant threats are determined through the use of event based models.

To see a list of the activities which are or would be low, moderate or *significant threats* in this vulnerable area shown on Map 7-8, refer to the Tables A10-1-I1-6, A10-1-I1-7, A10-1-I2-4.8 and A10-1-I2-5.6 in Appendix 10 Threats and Circumstances Tables. To see the *circumstances* which would result in the activity being a low, moderate or *significant threat*, refer to the Table of Drinking Water Threats (/2017) at https://www.ontario.ca/page/tables-drinking-water-threats or the Threats Tool at https://swpip.ca/.

Table 7-12 Levels of Threats Related to Pathogens and Chemicals in the Wheatley IPZs

Vulnerable Area	Vulnerability Score	Level of Threat for Activities Related to Pathogens			Level of Threat for Activities Related to Chemicals		
		Significant	Moderate	Low	Significant	Moderate	Low
Wheatley Primary Intake							
IPZ-1	6.0	No	Yes	Yes	No	Yes	Yes
IPZ-2	4.8	No	No	Yes	No	No	Yes
IPZ-3	n/a	No	No	No	Yes*	No	No
Wheatley Emergency Intake							
IPZ-1	7.0	No	Yes	Yes	No	Yes	Yes
IPZ-2	5.6	No	No	Yes	No	No	Yes
IPZ-3	n/a	No	No	No	Yes*	No	No

* storage and handling of fuel in EBA only

7.2.8. Threats in HVA

Table 7-5 indicates the number of locations where *significant threats* could occur in the *vulnerable areas* of the Lower Thames Valley Source Protection Area based on current land use. Due to the low to moderate vulnerability scoring of the *HVA*, it is not possible to have *significant threats* in these *vulnerable areas*. Map 4-7 show the *HVA* delineations in the Lower Thames Valley Source Protection Area

Table 7-13 shows the levels of *threats* that could occur in these *vulnerable areas*. The level of *threat* is dependent upon the *vulnerable area* (*HVA*) where the *activity* is occurring, the vulnerability score and the *circumstances* associated with the *activity*. As can be seen from Table 7-13, there are no *significant threats*, and no pathogen related *threats* in *HVA* in the Lower Thames Valley Source Protection Area. It is possible however to have low and moderate levels of chemical *threats*, including *dense non-aqueous phase liquids* (*DNAPLs*), for a vulnerability score of 6 in *HVA*.

Table 7-13 Levels of Threats Related to Pathogens, Chemicals and DNAPLs in HVAs

Vulnerable Area	Vulnerability Score	Level of Threat for Activities Related to Pathogens			Level of Threat for Activities Related to Chemicals			Level of Threat for Activities Related to DNAPLs		
		Significant	Moderate	Low	Significant	Moderate	Low	Significant	Moderate	Low
HVA	6	No	No	No	No	Yes	Yes	No	Yes	Yes

To see a list of the activities which are or would be low, moderate or *significant threats* in these vulnerable areas, refer to the Tables A10-1-HV-6, A10-1-SG-2, A10-1-SG-4 and A10-1-SG-6 in Appendix 10 Threats and Circumstances Tables. To see the *circumstances* which would result in the activity being a low, moderate or *significant threat*, refer to the Table of Drinking Water Threats (2017) at https://www.ontario.ca/page/tables-drinking-water-threats or the Threats Tool at https://swpip.ca/.

7.2.9. Threats in Events Based Area

Tables 7-14 and 7-15 identify the numbers of suspected significant threats in the Event Based Areas (EBA) for Wheatley and Stoney Point intakes. These threats are considered significant threats as a result of the events based modelling used to delineate the IPZ-3 as described in Section 4.2.5. An IPZ-3 is created to contain the parts of the EBA which extend beyond the IPZ-1 and IPZ-2. These EBAs are based on the specific circumstances (chemical and quantity) modelled under an extreme event. For both intakes fuel spills of 15,000 and 34,000 L (15 cubic meters and 34 cubic meters) were considered. Within this area the modelling has identified that the chemical can arrive at the intake at a concentration which would result in the deterioration of the water as a drinking water source and as such can be identified as a significant drinking water threat in that area. The EBA may contain all or parts of the IPZ-1, 2 and 3.

Table 7-14 Significant Threats in the Stoney Point EBA

Prescribed Drinking Water Threat	Type (Chemical, Pathogen or DNAPL)	IPZ
The handling and storage of fuel	Chemical	3
Number of occurrences of significant prescribed drinking water threats		18
Total number of locations of significant prescribed drinking water threats		18

*some parcels may have more than one activity occurring

Table 7-15 Significant Threats in the Wheatley EBA

Prescribed Drinking Water Threat	Type (Chemical, Pathogen or DNAPL)	IPZ
The handling and storage of fuel	Chemical	1,2,3
Number of occurrences of significant prescribed drinking water threats		16
Total number of locations of significant prescribed drinking water threats		16

*some parcels may have more than one activity occurring

7.3 Site Specific Assessment of Risk

A site-specific, assessment of *risk* to confirm the existence of significant threats will be necessary as part of implementation. Although additional efforts have been made to verify

significant threats, this has not included on site verification of the threat. Although this level of effort was considered as part of the threats verification, it would still be necessary during implementation. Further, it will also be necessary as part of compliance monitoring for Part IV implementation in both locations where significant threats have been identified and those where threats have not been identified but could occur. This is due in part to the potential for activities and circumstances to change at any location without any regulatory approval process. As part of the consultation on this assessment report, those who are believed to be engaging in a *significant threat* will be notified.

7.4 Data Gaps

A preliminary investigation has been completed to determine if there are any *conditions*. A couple of potential *conditions* in the Lower Thames Valley Source Protection Area are being considered. If warranted more work will be undertaken on identifying and assessing *conditions* for potential *threats*, and the Assessment Report will be amended if necessary.

8.0 Great Lakes

The Clean Water Act (2006) requires that the Great Lakes Agreements be considered in an Assessment Report and *Source Protection Plans*, if a Source Protection Area (*SPA*) contains water that flows into a Great Lake (Section 14). The *Technical Rules: Assessment Report* also requires that a description be provided on how the Great Lakes Agreements were considered in work undertaken (Rule 9) towards the Assessment Report.

The Lower Thames Valley Source Protection Area (*LTVSPA*) is one of the three SPAs that the Thames-Sydenham and Region Source Protection Region (*SPR*) is comprised of. This *SPA* is based on the Lower Thames Valley Conservation Authority jurisdiction. Conservation Authorities are established on a watershed basis. The *LTVSPA* contains 120 kilometers of Lake Erie shoreline. Within the Lower Thames Valley Source Protection Area, there are three main subwatersheds: Lake Erie, Thames River and the Lake St. Clair subwatersheds. Tributaries in each of these subwatersheds drain to Lake Erie, the Thames River, or Lake St. Clair. The Thames River outlets into Lake St. Clair, which in turn outlets into Lake Erie through the Detroit River.

Lake St. Clair is not a Great Lake but it is included while considering Great Lakes in the source protection planning process. For source water protection purposes, the Lake Erie basin is considered to be comprised of Lake St. Clair, the Detroit River and Lake Erie.

In the *LTVSPA*, several communities receive their drinking water from Lake Erie and Lake St. Clair, through municipal water treatment plants located both in and outside of this *SPA.* There are three municipal primary intakes in the *LTVSPA* that draw water from Lake Erie. Map 1-3 shows the watershed boundary of the *LTVSPA*, and the location of the surface water intakes that serve communities in the watershed. Two communities also receive water from groundwater sources.

8.1 Impact of Considering Great Lakes

The Clean Water Act requires *Source Protection Plans* to consider policies that relate to the Great Lakes. The Ministry of Environment, Conservation and Parks (*MECP*) document 'A Discussion Paper on Requirements for the Content and Preparation of Source Protection Plans' (June 2009) provides some details on how Great Lakes policies may be included in the Source Protection Plan. Those details are reproduced below.

The Clean Water Act gives the Minister of the Environment the authority to set targets for the Great Lakes or any part thereof, to address any water quality or quantity issue related to the use of the Great Lakes as a source of drinking water (Section 85). Targets are anticipated to direct and coordinate action on a drinking water source protection issue or an emerging Great Lakes problem. The Minister also has the option of establishing a Great Lakes target for a group of source protection areas. If a target applies to multiple source protection areas, the Minister may direct the source protection authorities to jointly decide on what the relative target should be for each individual source protection area, to contribute to the overall target.

The Clean Water Act also provides that the source protection plan may identify one or more Great Lakes target policies as a "designated Great Lakes policy" (Section 22). Where a *source protection plan* does not designate any of the Great Lakes policies, the Minister may direct a source protection authority to do so during the process of reviewing and approving the *source protection plan*.

Also, policies that govern monitoring to assist in implementing and in determining the effectiveness of a Great Lakes target policy may be established.

8.2 Great Lakes Agreements

Under the Clean Water Act, the Great Lakes Agreements to be considered (Section 14) are listed below:

1. The Great Lakes Water Quality Agreement of 1978 between Canada and the United States of America, signed at Ottawa on November 22, 1978, including any amendments

made before or after this section comes into force.

2. The Great Lakes Charter signed by the premiers of Ontario and Quebec and the governors of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin on February 11, 1985, including any amendments made before or after this section comes into force.
3. The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem 2002 entered into between Her Majesty the Queen in Right of Canada and Her Majesty the Queen in Right of Ontario, effective March 22, 2002, including any amendments made before or after this section comes into force.
4. The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement.
5. 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.

The first four Agreements are discussed below. At the time of drafting of this report, the Source Protection Committee is not aware of any other Agreement, signed by the Government of Ontario or the Government of Canada, related to the Great Lakes and prescribed by the regulations.

8.2.1. Great Lakes Water Quality Agreement

Negotiations to amend the GLWQA were launched in early 2010. On February 12, 2013, the Governments of Canada and the United States ratified the Great Lakes Water Quality Agreement of 2012. The Agreement facilitates binational action on threats to water quality and ecosystem health. Under the Great Lakes Water Quality Agreement, the governments of Canada and the United States agreed “to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem”. This is accomplished in part through the development and implementation of binational Lakewide Management and Action Plans (LAMPs) for each lake. Through the development of issue related strategies, the LAMP will identify actions required to restore and protect the lakes and evaluate the effectiveness of those actions.

The Thames-Sydenham and Region Source Protection Region is straddled by Lakes Erie and

Huron. Lake Erie's ecosystem and economy are threatened by algal blooms that have become a regular occurrence throughout the Western basin of the lake during summer months, leading to poor aesthetics, recreational beach closures and reduced tourism revenue. The blooms are attributed primarily to excessive nutrient inputs from urban and rural land uses. In addition, Lake Erie water quality is affected by habitat loss and degradation and the introduction of non-native aquatic and terrestrial plant species. The top priority for Lake Erie Lakewide Action and Management Plan (LAMP) partners is to address excess algal blooms by reducing nutrient inputs to the lake. The Lake Erie LAMP is coordinated by a committee of water quality and natural resource managers from both Canada and the United States, with participation from federal, provincial, state and local governments that have a role in implementation.

Although no formal Lakewide Management Plan exists for Lake Huron, the Lake Huron Binational Partnership was formed in 2002 to meet commitments in the Canada-United States Great Lakes Water Quality Agreement for lakewide management. The Partnership facilitates information sharing, sets priorities, and coordinates binational environmental protection and restoration activities. The U.S. Environmental Protection Agency, Environment Canada, Michigan Departments of Natural Resources and Environmental Quality, and the Ontario Ministries of Environment and Natural Resources form the core of the Partnership. The Lake Huron Binational Partnership focuses on key priorities and on the ground actions that help to improve and protect the overall quality of Lake Huron including controlling non-point source pollution and improving fish spawning and nursery habitat.

As mentioned before, the Thames River originates in the *UTRSPA* and continues to flow through the *LTVSPA* where it outlets into Lake St. Clair, which in turn outlets into Lake Erie. The Great Lakes Water Quality Agreement (*GLWQA*) has been considered in the Lower Thames Valley Source Protection Area Assessment Report. Under the Great Lakes Water Quality Agreement, the Four Agency Management Committee established a framework for binational coordination of environmental issues on Lake St. Clair (U.S. Environmental Protection Agency, Environment Canada, Ontario Ministry of Environment, Conservation and Parks, Michigan Department of Environmental Quality. 2004). It is called the Lake St. Clair Management Plan. Lake St. Clair intakes in the Essex Region SPA supply some communities in the Lower Thames Valley Source Protection Area.

Areas of Concern (AOC) are locations within the Great Lakes identified as having experienced high levels of environmental harm. Under the 1987 Great Lakes Water Quality Agreement between Canada and the United States, 43 such areas were identified, 12 of which were Canadian and 5 of which were shared binationally. The 2012 Great Lakes Water Quality Agreement reaffirms both countries' commitments to restoring water quality and ecosystem health in Great Lakes Areas of Concern. The St. Clair River, a binational AOC is located within the Thames-Sydenham and Region Source Protection Region.

In order to improve the environmental conditions of the AOC, a Remedial Action Plan (RAP) has been developed for the St. Clair River. The St. Clair River RAP is a partnership between Canadian and U.S. federal governments, provincial (Ontario) and state (Michigan) governments, with cooperation from the public and stakeholders through the St. Clair Binational Public Advisory Committee. Environment Canada and the Ontario Ministry of the Environment and Climate Change are the lead government agencies for the Canadian side of the St. Clair River Remedial Action Plan. The St. Clair Region Conservation Authority is working with these agencies to assist in the local implementation of the plan. At the time of writing of this report, it is understood that the Lake Huron Bi-national Partnership Action Plan is not prescribed by the Regulations.

8.2.2. The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem

Information on this Agreement is reproduced from the Ministry of Environment, Conservation and Parks website (http://www.ene.gov.on.ca/en/news/2007/081602mb.php). The governments of Canada and Ontario have signed an agreement to protect the Great Lakes that includes cleaning up 15 Areas of Concern where the natural environment has been severely degraded, reducing harmful pollutants, and improving water quality. The Agreement also aims to conserve fish and wildlife species and habitats, lessen the threat of aquatic invasive species and improve land management practices within the Great Lakes Basin. The Agreement, which is valid until 2010, contains new areas of cooperation such as protecting sources of drinking water,

understanding the impacts of climate change and encouraging sustainable use of land, water and other natural resources. The implementation of this Agreement helps fulfill the obligations of the Great Lakes Water Quality Agreement.

The Agreement contains four Annexes, the first of which focuses on efforts to complete the actions necessary to restore the degraded ecosystems in Areas of Concern. Therefore this Agreement is relevant to the current Assessment Report, and its consideration is described in Section 8.2.1.

8.2.3. The Lake St. Clair Management Plan

Under the Great Lakes Water Quality Agreement, the Four Agency Management Committee established a framework for binational coordination of environmental issues on Lake St. Clair (U.S. Environmental Protection Agency, Environment Canada, Ontario Ministry of Environment, Conservation and Parks, Michigan Department of Environmental Quality. 2004). There are no intakes within the Lower Thames Valley SPA that draw water from the Lake St. Clair. However Lake St. Clair intakes in the neighbouring Essex Region SPA supply some communities in the Lower Thames Valley SPA. Information on the Lake St. Clair Management Plan is reproduced below, from the Lake St. Clair Canadian Watershed Management Plan report (Lake St. Clair Canadian Watershed Coordination Council, 2009).

The purpose of the Canadian Lake St. Clair Management Plan is to recommend actions required to address identified ecosystem management issues affecting the sustainability of the Lake St. Clair ecosystem. Under the Lake St. Clair management framework the Lake St. Clair Canadian Watershed Coordination Council (*LSCCWCC*) undertakes the coordination of ecosystem management activities within the Canadian portion of the lake and subwatershed. The Watershed Coordination Councils undertake the coordination of activities within their respective Canadian and U.S. watersheds that support the management of the Lake St. Clair ecosystem. The Lake St. Clair Canadian Coordination Council is comprised with representatives from the following organizations: Environment Canada (co-chair), Fisheries and Oceans Canada, Walpole Island First Nation, Ontario Ministry of Environment, Conservation and Parks (co-chair), Ontario Ministry of Natural Resources, Ontario Ministry of Agriculture, Food and

Rural Affairs, St. Clair Region Conservation Authority, Upper Thames River Conservation Authority, Lower Thames Valley Conservation Authority and the Essex Region Conservation Authority. The goals of the Canadian Lake St. Clair Management Plan are to identify management issues and develop recommendations pertinent to the Canadian portion of the subwatershed, and to provide a basis for the development of detailed implementation strategies and action plans.

8.2.4. The Great Lakes Charter and the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement

The Great Lakes Charter contains agreements between the eight Great Lakes states in the United States and the Province of Ontario and the Government of Quebec. 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" (http://www.cglg.org/pub/charter/index.html).

The Great Lakes Charter was supplemented in 2001 by the Great Lakes Charter Annex, and its implementing agreements, including the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, pertaining to the watershed of the Great Lakes and the St. Lawrence River upstream from Trois-Rivières, Québec within the jurisdiction of eight states in the United States and the Province of Ontario and the Government of Quebec (http://www.mnr.gov.on.ca/en/Business/Water/2ColumnSubPage/STEL02_164560.html).

These Agreements are not considered relevant to the work conducted for the Lower Thames Valley Source Protection Area Assessment Report. The Water Budget and Water Quantity Stress Assessment included in this Assessment Report consider supply and *demand* within the watersheds of the Thames-Sydenham and Region. Great Lakes water budgeting must be undertaken on a much larger scale. The information developed through the Water Budget work in the Thames-Sydenham and Region, along with those developed in the other Source

Protection Regions, can be used by others when considering the larger scale Great Lake basin water budgets. This work is beyond the scope of the Assessment Report and *Source Protection Plan* in the Thames-Sydenham and Region.

8.3 Lake Erie Basin Working Group

The formation of a Lake Erie Basin working group was discussed in October 2009. This group could bring together interested parties within the Source Protection Regions (*SPRs*) that have intakes which rely on water from the Lake Erie basin as their source of drinking water. This working group would provide a forum to discuss drinking water specific matters relevant to the Clean Water Act. The Lake Erie Basin is comprised of Lake Erie, Lake St. Clair and the Detroit River. The proposed working group members would include system operator, Conservation Authority and Source Protection Committee representation from the Niagara Peninsula *SPR*, Lake Erie *SPR,* Thames-Sydenham and Region *SPR* and the Essex Region Source Protection Area.

At the preliminary meeting held in October 2009 at Woodstock, discussions took place on lake-wide and local water quality issues identified through draft assessment report work. The group also discussed general source water quality concerns. From preliminary information being compiled through the Assessment Reports, turbidity, aluminium, algal growth and nutrients appear to be common to many of the intakes in the southwestern part of Lake Erie. At the time the meeting was held, the drinking water quality issue identification (as per the Clean Water Act and *technical rules*) was not complete. Once the *Issues* identification process has been completed and *issues* contributing areas and activities have been identified it will be possible to consider whether issues are lake-wide or due to local activities at a subwatershed scale. In the Thames-Sydenham and Region the *issues* contributing areas and activities would be determined as part of an amended Assessment Report.

The group also discussed how existing Great Lakes groups and agreements are relevant to the requirements of the Clean Water Act. This will require further consideration in future meetings of the group.

A more formal working group was considered. At this time, however, the group decided to

correspond with neighbouring Source Protection Regions as needed and to hold another meeting in 2010, after the submission of Assessment Reports. This would help bring forward for discussion the findings of each Source Protection Authority's Assessment Report, especially as they pertain to *issues*.

8.4 Next Steps for Great Lakes

The Thames-Sydenham and Region will continue to be involved in the Lake Erie Basin working group if formed. Dealing with lake-wide issues, investigating local activities, and formation of Great Lakes related policies will be discussed with other members of the working group. The Lake Erie *LaMP* technical subcommittee may be consulted to help identify causes of issues or concerns at raw water intakes. If the *MECP* identifies Great Lakes targets, policies specific to those targets will need to be developed under the Source Protection Plan. Further, if the *MECP* identifies targets that apply across several Source Protection Regions and Source Protection Areas, the Lake Erie working group may provide an opportunity to work together to satisfy shared regulatory requirements.

9.0 Data Gaps and Next Steps

The development of Assessment Reports is required by the Clean Water Act, the related regulations and the *Technical Rules: Assessment Report*. Together these documents outline the materials which are required in the Assessment Reports. The Clean Water Act and the regulations also outline the process for developing, consulting on, submitting, and revising the Assessment Reports.

Through information from various technical studies, the Assessment Report must identify and assess *vulnerable areas*, evaluate drinking water quality *issues*, and identify and assess *threats* to the sources of drinking water. This section of the Assessment Report describes the known data gaps in the technical studies conducted, the plans to fill the gaps and the next steps in the *Source Protection Planning* process.

9.1 Data Gaps

The different types of data gaps summarized in this section relate to the availability of information and the timing of Provincial guidance updates, such as the *Technical Rules*.

The *Technical Rules: Assessment Report* identifies many of the requirements of the Assessment Report. For some of these requirements, the *technical rules* allow for the submission of a work plan if the information necessary to complete the item is not available. Of the items which allow for work plans to the included the only item which remains relevant to the LTVSPA is work related to threats contributing to *issues*. While microcystin was identified as an issue under the CWA (rule 115.1) and as such does not allow for the establishment of an ICA, results from further monitoring may in the future suggest that it should be identified as an issue under the rules (114) and an ICA and threats contributing to the issue would then be required.

Other gaps identified throughout the Assessment Report are a result of information or guidance not being available, or not available in time, to be included in the Assessment Report. In other cases, the analysis required to include the item in the Assessment Report could not be

completed in time to be included.

Table 9-1 provides the work plan to fill the identified gaps in the Lower Thames Valley Source Protection Area Assessment Report. This Table identifies the gap, provides a description of the gap and its current status, lists the steps to be undertaken in the work plan to fill the gap, and provides the anticipated work plan completion date.

Table 9-1 Work Plan to fill Data and Analysis Gaps

Gap	Description	Work Plan	Planned Completion Schedule
Better drainage information	▪ Better drainage information to refine IPZ-2 transport pathways and storm sewersheds	▪ Obtain better drainage information determined through a site-specific (Tier 2) Risk Assessment ▪ Adjustments may be made to IPZ-2 transport pathways and storm sewersheds	Next updated AR
IPZ-3 for Lake Erie Intakes	▪ Gap is allowed in *technical rules*, provided the work plan is included to fill the gap and included in an amended Assessment Report submitted	▪ Continue working with Essex Region Source Protection Authority and its Source Protection Committee to consider extent of IPZ-3 along shoreline ▪ Consider wind events and conditions to be used as the "extreme event" ▪ Delineate extent of contributing subwatersheds with the offshore IPZ-3 ▪ Review land use within the areas to determine if containment specific modelling is required	Next updated AR
Edge matching of HVA and SGRA with neighboring regions	▪ Edge matching of HVA and SGRA with neighboring regions is to be completed in order to form seamless mapping between source protection regions	▪ This work will be considered when neighboring regions' HVA and SGRA maps are complete ▪ Methodologies will be determined in consultation with the neighbouring regions once the extent of the challenges are known. ▪ Dependent on when neighboring regions complete HVA and SGRA maps	Next updated AR

Table 9-1 Work Plan to fill Data and Analysis Gaps

Gap	Description	Work Plan	Planned Completion Schedule
Lake Erie Lake-wide Issues	▪ Regions with drinking water systems using Lake Erie as a source have met together with the system operators to consider lake-wide issues ▪ Group will meet again once Assessment Reports have been completed so that issues have been identified ▪ Potential to establish a more formal working group to consider lake-wide issues if warranted	▪ Continue to collaborate with other regions ▪ Participate in next meeting and working group if established ▪ Focus on algae growth and phosphorous contributions to microcystin levels	Next updated AR
Conditions Assessment	▪ MECP data delivered to consultants, but not all consultants have reviewed or considered it ▪ A few potential conditions have been identified which require further investigation	▪ Have consultants review and report on data distributed by MECP ▪ Request same data for the rest of the vulnerable areas ▪ Investigate potential conditions ▪ Submit report to Source Protection Committee for consideration ▪ Include in amended Assessment Report if appropriate	Next updated AR
Impact of Climate Change	▪ Little work related to climate change in the Lower Thames Valley Source Protection Area ▪ Work undertaken in Upper Thames River Source Protection Area although focused more on flooding and infrastructure than on water supply ▪ Impact on source water protection is unknown	▪ Revisit this section following the completion of this section in the Upper Thames River Source Protection Area Assessment Report to determine the relevance to the Lower Thames Valley Source Protection Area ▪ Amend Assessment Report if warranted	To be determined
Inland takings drawing from Great Lakes	▪ Determine Inland takings that draw from Great Lakes	▪ Confirm location and watercourse conditions related to water takings near Lake Erie and Lake St. Clair ▪ Recalculate percent water demand ▪ Reassess potential for stress in these areas ▪ Update Assessment Report only if warranted ▪ This work would be dependant on other programs as the potential stress does not impact drinking water systems included in the Terms of Reference, however if updated information becomes available future Assessment Reports should be updated to reflect that information	Subsequent Assessment Report, dependant on other programs

Table 9-1 Work Plan to fill Data and Analysis Gaps

Gap	Description	Work Plan	Planned Completion Schedule
Improved understanding of water use	▪ Use actual water use data in water budget work	▪ Obtain actual water use data from all significant water users through the PTTW reporting system ▪ Requires reassessment after sufficient data has been reported, perhaps when Assessment Report requires future update ▪ This work would be dependant on other programs as the potential stress does not impact drinking water systems included in the Terms of Reference, however if updated information becomes available future Assessment Reports should be updated to reflect that information	Subsequent Assessment Report, dependant on other programs

9.2 Next Steps

Prior to the submission of the Assessment Report to the Director, the Clean Water Act identifies consultation requirements. The required consultation is part of a more comprehensive consultation plan being conducted in the Thames-Sydenham and Region involving local and regional consultation on the draft proposed, proposed and updated Assessment Report, and the technical work that has informed these reports. See Section 1 - Introduction and Background for more information on the Assessment Report consultation process. Once consultation is complete and the Source Protection Committee has considered input received through the consultation, the Assessment Report is submitted to the Director (Ministry of Environment, Conservation and Parks) for approval. The Director can approve the Assessment Report or request amendments to it. Amendments which the Director requests will not require consultation.

Following submission of the Assessment Report, work will continue on filling the data gaps discussed above. That work will require amendments to the Assessment Report which will also be consulted on. The amended Assessment Report will then be submitted to the Director for approval.

The Source Protection Committee has identified that the Assessment Report is, in fact, a living document which will require periodic amendments and updates. Review and update of the Assessment Report will be required as identified in the Clean Water Act. The period of the review will be determined by the Director in its approval of the Assessment Report. Aside from the required review of the Assessment Report, the Source Protection Committee has the ability to amend the Assessment Report at such time when it becomes aware that the material in the Assessment Report has an effect on the *Source Protection Plan* developed. Any amendments to the Assessment Report will require consultation of those affected by the amendments.